PITCH VARIATIONS IN BANGLA SPEAKING CASES OF RHD

Thesis submitted to Jawaharlal Nehru University
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DECLARATION

This thesis titled "**Pitch Variations in Bangla Speaking Cases of RHD**" submitted by me for the award of the degree of Doctor of Philosophy, is an original work and has not been submitted so far in part or in full, for any other degree or diploma of any University or Institute.

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DEDICATED TO MY PARENTS,

GRANDMOTHER,

UNCLE AND AUNT

AND

MY LITTLE SISTER

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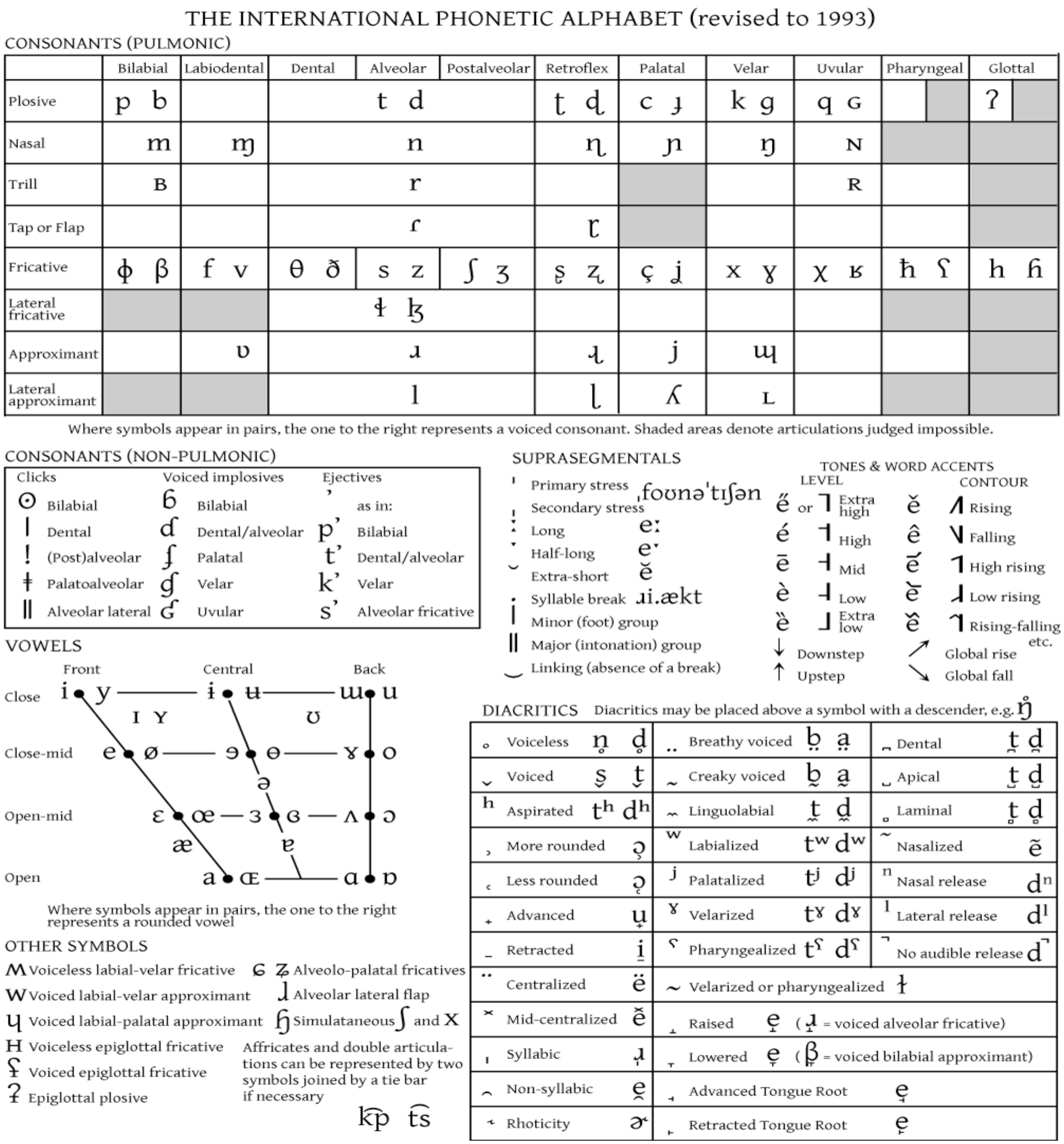
THE INTERNATIONAL PHONETIC ALPHABET

The International Phonetic Alphabet revised to 2005 (The International Phonetic Alphabet and the IPA Chart, 2015) is a notable standard for denoting all the physiologically possible sounds a human being can create in all possible languages. The IPA chart contains all consonants and all vowels.



THE INTERNATIONAL PHONETIC ALPHABET (revised to 1993)

CONSONANTS (PULMONIC)

	Bilabial	Labiodental	Dental	Alveolar	Postalveolar	Retroflex	Palatal	Velar	Uvular	Pharyngeal	Glottal
Plosive	p b			t d		ʈ ɖ	c ɟ	k ɡ	q ɢ		ʔ
Nasal	m	ɱ		n		ɳ	ɲ	ŋ	ɴ		
Trill	ʙ			r					ʀ		
Tap or Flap				ɾ		ɽ					
Fricative	ɸ β	f v	θ ð	s z	ʃ ʒ	ʂ ʐ	ç ʝ	x ɣ	χ ʁ	ħ ʕ	h ɦ
Lateral fricative				ɬ ɮ							
Approximant		ʋ		ɹ		ɻ	j	ɰ			
Lateral approximant				l		ɭ	ʎ	ʟ			

Where symbols appear in pairs, the one to the right represents a voiced consonant. Shaded areas denote articulations judged impossible.

CONSONANTS (NON-PULMONIC)

Clicks		Voiced implosives		Ejectives	
ʘ	Bilabial	ɓ	Bilabial	ʼ	as in:
ǀ	Dental	ɗ	Dental/alveolar	pʼ	Bilabial
ǃ	(Post)alveolar	ʄ	Palatal	tʼ	Dental/alveolar
ǂ	Palatoalveolar	ɠ	Velar	kʼ	Velar
ǁ	Alveolar lateral	ʛ	Uvular	sʼ	Alveolar fricative

VOWELS

Where symbols appear in pairs, the one to the right represents a rounded vowel

OTHER SYMBOLS

ʍ Voiceless labial-velar fricative
w Voiced labial-velar approximant
ɥ Voiced labial-palatal approximant
ʜ Voiceless epiglottal fricative
ʢ Voiced epiglottal fricative
ʡ Epiglottal plosive
ɕ ʑ Alveolo-palatal fricatives
ɺ Alveolar lateral flap
ɧ Simultaneous ʃ and x

Affricates and double articulations can be represented by two symbols joined by a tie bar if necessary k͡p t͡s

SUPRASEGMENTALS

ˈ Primary stress
ˌ Secondary stress ˌfoʊnəˈtɪʃən
ː Long eː
ˑ Half-long eˑ
˘ Extra-short ĕ
. Syllable break ɹi.ækt
| Minor (foot) group
‖ Major (intonation) group
‿ Linking (absence of a break)

TONES & WORD ACCENTS

LEVEL
e̋ or ˥ Extra high
é ˦ High
ē ˧ Mid
è ˨ Low
ȅ ˩ Extra low
↓ Downstep
↑ Upstep

CONTOUR
ě Rising
ê Falling
e᷄ High rising
e᷅ Low rising
e᷈ Rising-falling etc.
↗ Global rise
↘ Global fall

DIACRITICS Diacritics may be placed above a symbol with a descender, e.g. ŋ̊

̥	Voiceless	n̥ d̥	̤	Breathy voiced	b̤ a̤	̪	Dental	t̪ d̪
̬	Voiced	s̬ t̬	̰	Creaky voiced	b̰ a̰	̺	Apical	t̺ d̺
ʰ	Aspirated	tʰ dʰ	̼	Linguolabial	t̼ d̼	̻	Laminal	t̻ d̻
̹	More rounded	ɔ̹	ʷ	Labialized	tʷ dʷ	̃	Nasalized	ẽ
̜	Less rounded	ɔ̜	ʲ	Palatalized	tʲ dʲ	ⁿ	Nasal release	dⁿ
̟	Advanced	u̟	ˠ	Velarized	tˠ dˠ	ˡ	Lateral release	dˡ
̠	Retracted	i̠	ˤ	Pharyngealized	tˤ dˤ	̚	No audible release	d̚
̈	Centralized	ë	̴	Velarized or pharyngealized ɫ				
̽	Mid-centralized	e̽	̝	Raised e̝ (ɹ̝ = voiced alveolar fricative)				
̩	Syllabic	ɹ̩	̞	Lowered e̞ (β̞ = voiced bilabial approximant)				
̯	Non-syllabic	e̯	̘	Advanced Tongue Root e̘				
˞	Rhoticity	ɚ	̙	Retracted Tongue Root e̙				

LIST OF ABBREVIATIONS

ABBREVIATION	FULL FORM
RHD	Right Hemisphere Disorder
f0	Fundamental frequency in human voice
f1	The first formant in human voice
f2	The second formant in human voice
B.I.N.S.	Bangur Institute of Neurosciences, Kolkata

1. INTRODUCTION AND LITERATURE REVIEW

'Pitch Variations in Bangla Speaking Cases of RHD' studies right hemisphere damaged Bengali participants (has been further referred to as RHD participants). This study discerns the variations in pitch, as in fundamental frequency (to be referred to as f0) at the level of sentences, at the level of words and at the level of discourse. This is a neurolinguistic and empirical study. This is not a longitudinal study but a cross sectional one.

The right hemisphere of the brain primarily controls the voluntary activities in the left side of the body. Apart from that it imparts personalities to human beings, making us unique and novel and different from each other. The right hemisphere of the brain is also responsible for helping us comprehend the theme of situations, in particular, of discourses. It helps in understanding what is being spoken about, so that we can speak relevant things. The right hemisphere further helps with understanding metaphors and imageries. The right hemisphere is responsible for giving us the sense of perception and when it is damaged the subjects affected can lose the sence of perception. Left side of the body neglect is very common among subjects with right hemisphere damage. The right hemisphere helps use recognise tones in voices as well as other para-linguistic cues in voice which help us understand conversations better. The right hemisphere also gives us the ability to use the frequency modulations, we do, in normal conversations to express various para-linguistic messages along with normal speech (Springer, Deutsch, 1993, Weisenberg, 1935, Rachel and Crow, 2005, Metcalfe, Funnell and Gazzaniga, 1995, Moor, 1982, Robinson, Kubos, Starr, Rao, Price, 1984, Vallar, Perani, 1986, Bihrlea, Brownell, Powelsona and Gardnerc, 1986, Ozonoff, Miller, 1996, Gordon, Hewer, Wade, 1987, Narang, 2009). This is why the study of the right hemisphere of the brain is important and necessary.

1.1. A CHRONOLOGICAL ACCOUNT OF BRAIN STUDIES

The book **Left Brain, Right Brain: Perspectives From Cognitive Neuroscience** gives us a wonderful insight into the evolution of the study of the brain. It narrates the events which follow chronologically till the present. Brain studies began with a general physician named Marc Dax, when he claimed that the left hemisphere of the brain controls speech (Springer and Deutsch, 1993, p. 10) in 1836. Dax claimed that he had checked around forty patients with loss of speech and discerned that they had some damage in the left hemisphere. He concluded by stating that the left brain must control language and speech. According to the book, Left Brain

Right Brain by Springer and Deutsch, it is important to know that the claim of Dax did not find much interest and the claim was left to rot. It was only after Paul Broca, another physician did a post mortem on a patient who had right hemiplegia and had loss of speech. Broca found out that the deceased had a lesion in the left frontal lobe. With time Paul Broca was deemed correct by the society and other scientists. The area in the frontal lobe started being called Broca's area. Each hemisphere is responsible for different body functions and skills. The Cerebrum of the brain is divided into two halves, or hemispheres, which are connected together by neuronal fibers, the most important of which is the corpus callosum. Evolution had a long time to shape the two hemispheres in human beings. A division of labor takes place between the two hemispheres of the brain. This is called lateralization of the brain functions. Evolution has assigned different functions to the hemispheres of the brain. There are common things which both the hemispheres do but there are specific activities which only either the left brain does or the right brain does. Localization of the brain functions on the other hand refer to the localization of functions at various places of the brain making it easier for the whole brain to work modularly. Scientific experimentations have made it possible to understand the rough schematics of the working abilities in the hemispheres of the brain. The left brain and the right brain functions are lateralized for more efficient workflow. The left hemisphere of the brain is responsible for analytic thought, logic, language, reasoning, science and math, quantitative ability and the contralateral control over the right side. The right hemisphere on the other hand controls and helps holistic mechanisms and in turn helps in the smooth running of the left hemisphere functions by completing them. The right hemisphere of the brain takes care of the senses of perception, the ability to think and be creative, intuition or the sixth sense, music, art, ability to understand metaphors and imageries, ability to understand 3-D forms both in abstract thought and in real vision and the contralateral control over the left side of the body. All these abilities of the right hemisphere also help a person undersand the context or theme of a discourse and the ability to speak on the same theme, as being spoken on. According to the authors of the book, Left Brain Right Brain by Springer and Deutsch, Gustav Dax, a physician and the son of Marc Dax wrote a letter to the medical press trying to state the fact that lateralization of speech to the left hemisphere had already been claimed by his father before PaulBroca by almost three decades. Broca mentioned that he was never acquainted to Marc Dax. In 1864 Broca claimed that he had tested even more patients with speech related disorders and concluded that all of the lesions were to the left hemisphere of the brain for the patients to have speech disorders. It was found out that most patients with damage to the left brain also ended up having problems to move their body parts in the right hemisphere of the body. Some patients also were under complete hemiplegia or total absence of control of the right hemisphere of the body. It was also concluded that the left side of the brain controls the voluntary activities in the right side of the body and the brain functions were lateralized in such a manner. Paul Broca further went ahead linking handedness with asymmetry of the brain. He stated that in right handers, the left brain was the superior brain and controlled speech. Broca mentioned that the hemisphere controlling speech was the hemisphere opposite to the body half that was more dominant in an individual. (Springer and Deutsch, 1993, 11)

The concept of a 'leading hemisphere' was put forward by John Hughlings Jackson in 1868 as cited in the book, Left Brain Right Brain by Springer and Deutsch. It was stated that one of the two hemispheres had more dominance over the other. Jackson further said that some damage to one side of the brain can make a man speechless, hence this would mean that the specific brain hemisphere with brain damage would be the highest seat of speech control. Jackson concluded that it should be the leading side which controls speech in an individual and that the left hemisphere is the leading hemisphere in most people. Later in the 1870s another neurologist from Germany, fund out that damage to the temporal lobe of the left hemisphere creates problems in understanding speech. Innumerous other scientists claimed that damages to different parts of the left brain caused different kinds of problems in not only speech but language in general. It was soon understood that the left hemisphere was responsible for various facets of language and that damage to it can cause problems in language comprehension or production or speech in general. Hugo Leipmann studied patients who could not move body parts purposefully in their right hemisphere under command. The disorder, now knows as Apraxia (Sally P Springer, 1993, 13) disables patients from voluntarily moving their limbs or other body parts when needed. Leipmann stated that the patients could move their body parts involuntarily like when they brush their teeth after waking up but when asked to do the same in a different setting and backdrop, they failed. He further stated that these problems are not connected to speech disorders in any way but these point to the fact that the left hemisphere of the brain helps in voluntary activities and that brain areas for speech and voluntary actions are different. The idea of Cerebral Dominance emerged and it stated that one hemisphere of the brain is the one directing behavior. It states that the dominant hemisphere controls speech and other higher functions whereas the less dominant hemisphere did not contain any special functions and remained subordinate to the 'left' dominant hemisphere. This idea greatly undermines the ability and functions of the left hemisphere. John Hughlings Jackson was one of the first persons to consider that the right hemisphere deserved more attention than it was being given at that time. The right hemisphere must be containing various specialized functions that were not controlled by the left hemisphere. Jackson stated that a one sided view of one hemisphere being the dominant hemisphere without knowing the functions of the other hemispheres was wrong. It was Jackson who found support to this idea when he met a patient who had a tumor in the rear lobes of the right hemisphere. The patient could not recognize people, items and places. It was too early for Jackson's claims to be hailed and the claims were left unattended till the 1930s. The first study to understand and research brain damage was conducted in 1935 (T Weisenberg, 1935) on 200 patients with more than 40 different kind of brain damages. It involved monitoring each patient for 19 hours. The results found were significant. The patients with damage to the left brain were found to have difficulties in language related faculties. They either had difficulty in comprehension or difficulty in production, difficulty in articulation and so on. The patients with damage to the right brain had problems in orientation. These patients performed really bad in nonverbal tasks and had huge difficulties in solving visual puzzles or arranging geometric figures and so on. It was found that these patients frequently lost their way home. It was also found that these patients neglected things in their left hemisphere as if they were not their own. They even ignored things seen or felt with their left hemisphere. (Springer and Deutsch, 1993, 1-30)

Damage to the left hemisphere of the brain causes left hemisphere disorder in persons. The damage can be by injury or insult. LHD can cause problems in language and communication if the language centers of the brain get affected. LHD can also cause paralysis without any adverse effect to the language of a person. According to the book, *Left Brain Right Brain* by Springer and Deutsch, aphasia is a symptom which is discernible after any kind of damage that happens to the language centers of the brain. Aphasia is a language disorder and is an envelope term for a wide variety of disorders. Aphasia can be caused due to a stroke to the left or the right hemisphere or an accident that haemorrhages the brain, lesions, and tumours to the brain or other pre-natal. When Paul Broca came up with a term to describe the loss of speech in human beings for damage in the left hemisphere he coined 'aphemia' as the correct term. His terminology was replaced by 'aphasia', a term coined by Trousseau. Aphasia can be of various types depending on the region of damage in one's brain. Aphasia to the left hemisphere of the brain are most common causing either Broca's aphasia or Wernicke's aphasia and aphasia caused by damaged to the right hemisphere are less common. (Springer and Deutsch 1993, 42)

Expressive aphasia or Broca's aphasia refers to a kind of aphasia that happens when the frontal lobe of a person is damaged in the left hemisphere of the brain. This kind of aphasia, as the name suggests creates problems in an individual to speak out an express. The speech of an aphasic in this category, is stopped due to damage in the left prefrontal cortex. The speech of such an individual is fragmented and the subject halts while speaking. The person affected by the aphasia knows what they want to communicate but they have a huge problem in articulating their problems through speech or expressions. Aggramatism and paragrammatism are specific symptoms associated with Broca's aphasia. Broca's aphasia is mostly complimented by weakness in the right hemisphere of the body or hemiparesis. (Springer and Deutsch 1993, 151)

According to the book, *Left Brain Right Brain* by Springer and Deutsch, damage to the posterior left temporal cortex or Wernicke's area causes problems in speech comprehension. Participants with such an aphasia have problems in understanding what is being told to them. They have major problems in understanding communication, yet they have no problems in speaking correct sentences, no matter how absurd they sound. Their sentences are grammatically correct. Anomic aphasia refers to a condition of an individual who has problems in recalling words. Any person who is affected by anomic aphasia has extreme problems in remembering names and coming up with words for a sentence they are speaking. Primary progressive aphasia refers to a condition where an individual gradually loses the ability to read, write, and speak or to comprehend. While the wide horizon of communication windows slowly lessens down for such participants they develop new ways to communicate with other human beings like gestural communication. Deaf people use sign language to speak. Sign language is a fully developed way of speaking for deaf signers. It has been noted that deaf people with aphasia have similar problems as normal participants with aphasia. Global aphasia refers to a condition when a person has a widespread brain damage and two or more symptoms and kinds of aphasias take place at once. Participants with global aphasia can have symptoms of both Broca's aphasia and Wernicke's aphasia with the effects of right hemisphere damage added to it. The subject at times might not be able to move a complete body hemisphere or be under hemiplegia. (Springer and Deutsch 1993, 153-55)

1.2. LITERATURE REVIEW

1.2.1. LEFT BRAIN, RIGHT BRAIN STUDIES

The paper **One Brain—Two Minds? The behavioral consequences of sectioning the cerebral** (Gazzaniga, 1972) describes how the corpus callosum of the brain is responsible in helping a human being function properly. The left hemisphere of the brain analyses a few aspects of the sensory raw data that are collected by our sense organs and the rest are analysed by the right hemisphere. The corpus callosum acts like the mediator of imformation inside the brain and helps one hemisphere of the brain communicate with the other half. If the corpus callosum is damaged, a subject will have problems in the communication between his brain hemispheres. This situation will lead to two minds inside one brain. The left hemisphere wouls analyse everything literally and make sense from word to word. The right hemisphere of the brain would not be able to make sense of the words spoken without the left hemisphere and there would be chaos. The two minds inside one brain would not be able to communicate with each other at all. The connections between the hemispheres of the brain are the parts responsible for making human beings conscious because, without them, the person would not be able to function properly.(Gazzaniga, 1972, 311-17)

The paper **Split Brains and Atomic Persons** (Moor, 1982) states that a person who has undergone cerebral commisurotomy would end up having two consciousness in his or her mind. This would let him or her to a condition where a singular body would be shared by two persons. This is a rare condition and happens to a few sujects who have undergone commisurotomy. Such surgeries are required for the healing of epileptic feats. The author mentions that subjects who have complete cerebral integrity but have undergone some sort of commissurotomy can end up having two separate minds sharing one body. Kinds of commissurotomy may include frontal, central and complete. The psychological damage increases from frontal to central and the damage is the maximum in complete commissurotomy. Subjects with partial damage or removal, suffer disconnected reactions from their body hemispheres. Vision disconnection might happen, in which a person would have perfect sight but would not be able to recall an object because the nervous pathways required for recalling the object do not exist anymore, even though the vision pathways exist. A certain subject, as mentioned by the author, was pulling his pants down with one hand, while pulling them up with another. (Moor, 1982, 91-106)

Doctors sometime, decide to severe the corpus callosum in an individual, when a patient is suffering from epileptic seizures and fits. The paper **Language, the Brain, and the Question of Dichotomies** speaks about the lateralisation of functions in the human brai and how each of the brain hemispheres are responsible for tasks localised for them. In the long process of human evolution, the brain has developed certain localised functions which are lateralised to each sides of the brain. The left brain is responsible for language, math, analogy and reasoning while the right brain is responsible for the creative nature, metaphors, para-linguistic cues, discourse understanding and pragmatics. The voluntary activities of the brain are all contralateral, that is, the left hemisphere of the brain controls the right hemisphere of the body and vice versa. The involuntary functions of the brain are mostly ipsilateral like the heart and the involuntary breathing. Present researches are more thorough and are trying to scan each and every localised and lateralised ability of each hemisphere with advanced technologies like the fMRI. The involvement of the right brain hemisphere in language production and understanding has been proved by many researched like that of Gazzaniga (Gazzaniga, 1972) and that subjects like P.S. who had a an operation in which their corpus callosum was removed, rendered them inable to do many functions normal adults do. (Thompson, 1984, 98-105)

It has been noticed that right hemisphere damaged subjects in comparison with left hemisphere damaged subjects have much lesser chances of going into permanent depression after suffering a stroke. A study on 184 patients in the University of Mayland Hospital has given an insight to the authors of the paper **Mood Disorders in Stroke Patients: Importance of Locations of Lesions** (Robert G Robinson, 1984). The authors have found out that subjects with stroke to the left himsphere of the brain can enter a phase of severe depression after six months of the stroke. They have also found out thet subjects with stroke to the right hemisphere of the brain generally grow a tendency to simplify things after the stroke. It has also been noticed that some subjects displayed themselves to be much more merrier after the stroke in comparison with left hemipshere damaged subjects who had sustained strokes. (Robert G Robinson, Kenneth L Kubos, Book Starr, Krishna Rao, Thomas R price, 1984, 81-93)

Subjects with damage to the right hemisphere of the brain face problems in recognising or viewing things in the left side of their body. For example, when a person has a damage to the right hemisphere of the brain, he or she will mostly neglect things which are being seen with the left side of the body. It has also been proved under various circumstances that left neglect has also led to complete unawareness of things which are in the left hemisphere of the body or at times, the denial of the body parts. It has been noticed that subjects with damage to the retrorolandic regions display more neglect of the left hemisphere than subjects with damage to the frontal regions. The inferior parietal lobules are also responsible for subjects displaying neglect. Lesions which are limited to the subcortical white matter, seldom make subjects neglect things. This research discerns the regions of the brain, when damaged, are responsible for hemispheric neglect in subjects. (Giuseppe Vallar, Daniela Perani, 1986, 609-22)

Further research in the same field has proved that the right hemisphere plays a pivotal role in the understanding of humour. A test was conducted on few subjects in the paper **Comprehension of humorous and nonhumorous materials by left and right brain-damaged patients** (Bihrlea, Brownell, Powelsona, Gardnerc, 1986). The left hemisphere damaged individuals had no issues in understanding humor. Right hemisphere damaged individuals, on the other hand had problems in understanding humor and lacked the understanding of coherence as well.

In the article **The Language of the Brain** (Bower, The Language of the Brain, 1987), the life story of two persons have been narrated. The first person, Sarah, was an incredible artist. Unfortunately she suffere a stroke to the right hemisphere of the brain and she lost control over the left eye, followed by loss of control in her left limbs. She could not draw anymore. When she tried to paint things, the maximum she could do was to do a few lines and colour. The left side of her canvas would always be blank, after the stroke. She also had visual orientation issues after the stroke, as well as left hemisphere neglect. She started to use sign language after the stroke and then became an expert in it. She had no problems in using sign language at all but she had major issues in orientation, when asked to do a task needing body and eye coordination. The second person, Gail, was deaf since birth and used sign language since birth. She suffered a stroke to the left hemisphere of the brain and she lost most of her ability of signing. She had the same problems a non signer would have if they suffered a stroke to the left brain. Incidentally Gail had no deterioration in visual tasks or in visual orientation. She had some probems in the right hemisphere of the body but that did not get in the way of her everyday chores. She unlike Sarah had issues with communication after the stroke. It has been hence, hypothesized that most of the language faculty is localised in the left hemisphere of the brain, while the right hemisphere of the brain takes care of the senses and their coordination. This can also be proved by the fact that damage to the right hemisphere results in disoriented vision and partial hemiplegia at times. Damage to the frontal lobes of the left hemisphere, on the other hand renders a subject , incapable to use proper grammar in speech or in sign language. Gail, a signer, lost her ability to use complex grammatical functions in sign language, while Sarah, a non signer before her stroke, could use all intricate grammatical functions of sign language, even after her stroke to the right hemisphere of the brain. (Bower, 1987, 40-41)

The article **Dysphagia In Acute Stroke** (Caroline Gordon, 1987) studied the incidence, duration and reason for dysphagia in stroke patients. Dysphagia is referred to a clinical condition in which a subject in unable to swallow food due loss of motor control from the parts concerned. A total of 91 subjects were tested on as random selections. 41 subjects were admitted with dysphagia and 37 subjects out of the 41 subjects had a lesion in any one of the hemispheres. Seven subjects had lesions in bothe the brain hemispheres. Nineteen of these subjects regained back the ability to swallow in fourteen days from the date of their strokes. The authors conclude by stating that stroke in any one hemisphere of the brain can cause more incidences of dysphagia then unilateral stroke to both the hemispheres. In unilateral stroke cases, as the author states and hypothises , due to cerebral oedema to the brain stem, one can lose control of the motor activities inside the mouth; but this does not explain all cases. The central cerebral artery is responsible for the supply of blood to many regions which are responsible for swallowing. Infarctions at such regions and ischemic strokes, can cause swallowing problems. There is also another scenario in which it has been noted that many apraxic subjects have displayed dysphagia. Regarding this, it has been hypothesized that brain regions responsible for swallowing might be near to the regions which cause apraxia in the brain. There is no hard and fast factor which can be pointed out for dysphagia in subjects. (Caroline Gordon, Richard Langton Hewer, Derick T. Wade, 1987)

A large part of communication in discourses also happen through unspoken communication and participants with damage to the right hemisphere of the brain suffer major consequences as a result of the damage to the right brain. The article *The Role of the right hemisphere in emotional communication* by Lee Xenakis, Dawn Blonder and Kenneth M. Heilman published in the *Brain: A Journal of Neurology,* 1990, mentions that 'Previous research has established that patients with right hemisphere damage (RHD) are impaired in the comprehension of emotional prosody and facial expression.' They also mention that this kind of impairment have possibly many explanations. 'It may reflect defective acoustic and visuospatial analysis, disruption of nonverbal communicative representations, or a disturbance in the comprehension of emotional meaning.' They asked RHD patients, left hemisphere damaged patients (LHD) and normal controls (persons without disorders to judge the emotional content of sentences describing nonverbal expressions, and sentences describing emotional situations. They found out that RHD participants performed normally in their ability to infer the emotion conveyed by sentences describing situations. But the RHD patients were particularly impaired in judging the emotional content of sentences depicting facial, prosodic, and gestural expressions, suggesting a disruption of nonverbal communicative representations when compared to the LHD and normal persons. (Lee Xenakis Blonder et al, 1990, 1115-27)

As mentioned in Springer and Deutsch, 1993, (Springer and Deutsch, 1993, pp 3), various functions are performed by each hemisphere of the brain. There is a certain division of labour in the two hemispheres of the brain. The left hemisphere of the brain controls the voluntary activities in the right side of the body and the right hemisphere of the brain controlls the voluntary activities in the left side of the body. This is called the contralateral control of the brain. Ipsilateral functions of the brain, referrs to the involuntary activities of the brain being controlled by the same hemisphere of the brain. There are certain functions which are controlled by only either of the hemispheres. This was first proved by Marx Dax and later by Paul Broca whose study was on patients with problems in language. It was also proved by Carl Wernicke, whose efforts helped us discern that a damage in Broadman's area 22, or the posterior portion of the superior temporal gyrus. Such functions are referred to as the localised functions of the brain. These are special functions which only one of the hemispheres perform. Later, Paul Broca stated that the left hemisphere was the more dominant hemisphere. There were no big or noticeable effects in the language of patients who had suffered any damage to the right hemisphere of the brain. (Springer and Deutsch, 1993, pp 4)

John Hughlings Jackson, as cited in the book by Springer and Deutsch, **Left Brain Right Brain** (Springer and Deutsch, 1993, pp 5), an English neurologist known for his work in epilepsy, floated the idea of a leading hemisphere, which later on came to be known as the idea of cerebral dominance. He states that the hemisphere of the brain, responsible for language or the left hemisphere is the dominant hemisphere. The right hemisphere is also responsible for language in some people. In these people the left hemisphere is localised with the functions of the right brain. But the idea remains supreme and states that the dominant hemisphere is the one which has the localised functions of controlling language. The dominant hemisphere, was also stated to be controlling the higher functions in a human being. He also realised that the right hemisphere of the brain was being given much less importance than it deserved. He further mentioned that the right hemisphere of the brain also contained some localised functions, which the left hemisphere did not do. A certain patient of his, with a tumor to the temporal lobe of the the right brain was unable to recognize people, items and places. His claim was based on very little data, and hence was left unattended till the 1930s.

T Weisenberg, 1935, as cited in the book, **Left Brain Right Brain** by Springer and Deutsch, was the first study to understand and research brain damage (T Weisenberg, 1935) on 200 patients with more than 40 different kind of brain damages. It involved monitoring each patient for 19 hours. The results found were significant. The patients with damage to the left brain were found to have difficulties in language related faculties. They either had difficulty in comprehension or difficulty in production, difficulty in articulation and so on. The patients with damage to the right brain had problems in orientation. These patients performed really bad in nonverbal tasks and had huge difficulties in solving visual puzzles or arranging geometric figures and so on. It was found that these patients frequently lost their way home. It was also found that these patients neglected things in their left hemisphere as if they were not their own. They even ignored things seen or felt with their left hemisphere. (Springer and Deutsch, 1993, pp 14)

Scientists then realized that the right hemisphere of the brain is also specialized with many functions like creativity, intuition, art, music, metaphorical understanding and so on. After studying both the hemispheres of the brain, scientists have come to the conclusion that both the hemispheres of the brain work together to perform various day to day activities. The left brain alone cannot complete all actions on its own. It needs the right hemisphere to complete various processes. Tim J Crow was one of the pioneers in the field of bi-hemispheric brain study. In one of his papers, **Right hemisphere language functions and schizophrenia: the forgotten hemisphere?** he studied the functions of the right hemisphere in language. According to Tim J Crow, the right hemisphere helps in some language functions. He was one of the first persons to disband the view that the left hemisphere is the only seat and control of language in the brain. His paper suggested that the right brain was necessary to understand humor, sarcasm, discourse comprehension, emotional prosody and so on. Schizophrenia was primarily thought to be a disorder of the left hemisphere because it adversely affected speech and language. It was in due time that schizophrenics were tested in the brain and damages to the right hemisphere were also found to create various manifestations of schizophrenia. (Rachel and Crow, 2005, pp 55, Springer and Deutsch, 1993, pp 13)

The paper **Right-Hemisphere Memory Superiority: Studies of a Split-Brain Patient**

(Janet Metcalfe, 1995) relates the functions of the two hemispheres and how the absence of a communicative mechanism between the both can create huge problems in an individual. The paper states that the left hemishere is responsible for doing the primary inferences of the raw stimuli data we get from the sense organs. After the left hemisphere has done the primary inferences, the data is analysed by the right hemisphere and only then the person concerned can understand the thematic context, pragmatic meaning and metaphorical references of the data. The present research has conducted six experiments on a subject who has undergone complete corpus callosum resection. The paper concludes that the right hemisphere of the brain contains and stores much more exact memory traces than the left brain as the right brain has to continusouly analyse the situations from the very beginning of any situation, till the very end. The left hemisphere of the brain does quick analysis of facts and hence is responsible for analogies, math, inferences, fantasies, conjectures and generalisations. The right hemisphere has a more veridical memory system which sustains the inferences, generalisations and conjectures of the left hemisphere but in turn also saves an accurate record of the past, alongside the data of the left hemisphere. (Janet Metcalfe, Margaret Funnell and Michael S. Gazzaniga, 1995, 157-64)

The article **An Exploration of Right-Hemisphere Contributions to the Pragmatic Impairments of Autism** (Sally Ozonoff, 1996) explores the possibilities of similarities between autistic subjects and right hemisphere damaged subjects. Through a battery of tests, which included contextual understanding, pragmatic reasoning and indirect request comprehension. The autistic subjects performed much like right hemisphere damage due to stroke and had much lesser responses to the provided stimuli. For a long time, it was believed that the right hemisphere was only responsible for non-linguistic abilities, spatial abilities and music but now it has been proven that the right hemisphere of the brain is also responsible for certain linguistic abilities like metaphorical understanding, contextual and pragmatic reasoning and understanding. Much of our understanding of the right hemisphere has come from right hemisphere damaged subjects who had some sort of stroke or unilateral damage due to external factors. The effects of such damage can include difficulty in understanding or gauging the context of a situation, problems in pitch while speaking including effects like a very small pitch range, the incorrect pronunciation of vowels which happen due to the loss of control over the muscles due to strokes or other kinds of damage to the right hemisphere and the inability to remain focused on the theme of a discourse. Autistic individuals have problems in understanding the social context of conversations or the pragmatic links in conversation making their situation somewhat like right hemisphere damaged subjects. This study tried to understand the similarities between a right hemisphere damaged individual and an autistic subject. There are certain similarities like the problems in understanding context in a discourse and pragmatic understanding but the levels of plasticity and pervasiveness in an autistic subject is much more than that in a right hemisphere damaged subject. This study also delves into the fact that some subjects displaying symptoms of a right hemisphere damaged subject had a damage in the prefrontal cortex of the brain and no conclusion could be reached. (Sally Ozonoff, Judith N. Miller 1996, 411-34)

Subjects with damage to the right hemisphere of the brain have problems in understanding emotional expressions as conveyed by facial expressions, para-linguistic cues, the intonation of voice, gestural communication and so on. The paper **Lateralization in Emotion and Emotional Disorders** states that subjects with damage to the posterior region in the right hemisphere of the brain have problems in recognizing facial expressions, the tone of someone's voice denoting a certain mood or expression, in naming emotional scenes or associating emotions to people, judging certain things based on experienced things or seen with the sense organs and so on. They also face problems in comprehending language as well as in appreciating humorous incidents. They also face problems in understanding coherence in speech and in understanding or sticking to the theme of an ongoing discourse. The paper also claims that due to the contralateral nature of the brain, voice heard by the left ear can be better analyzed in terms of tone, because it goes directly to the right hemisphere. This research has also paid minute details to facial expressions and has stated the fact that the left side of a human face displays more expressions because the right hemisphere of the brain controls it. The right hemisphere is also responsible for the creation of tones and intonations in one's voice which are further responsible for the expression of emotions. It has been further noticed that subjects with damage to the left hemisphere displayed sudden depression syndrome and catastrophic reactions to normal life scenarios, while subjects with damage to the right hemisphere of the brain were completely unaware of any sort of sadness in life. They displayed indifference to situations in life and were often seen to be happy and euphoric about situations in which normal adults would be sad. This research also claims that anxiety and depression are both caused by the right posterior region of the brain. Certain emotive functions can be attributed to the anterior and posterior region of the right hemisphere of the brain and this has been found through patient study and different machines. This research aimed at giving us a better understanding of the organization of the brain when it comes to emotive behaviour and understanding. It has helped in the understanding of the working of the brain regions sub serving in normal emotional processing. This research has also tried to categorize the different types of depression based on their region of origin and localization. This research has helped in providing important insight into the neurophysiological substrates of the human brain along with cognitive concomitants of clinical disorders like anxiety and depression. (Wendy Heller, Jack B. Nitschke and Gregory A. Miller, 1998, 26-32)

The paper **Beyond the right hemisphere: brain mechanisms mediating vocal emotional processing** (Chiarello, 1998) talks about the interworking of the two hemispheres of the brain in the interpretation of speech. It has been found out left hemisphere activations are sharp, to the point and precise. The left hemisphere of the brain does very quick calculations while in speech or while listening to another person and is responsible for helping a person decipher the actual contents of speech. The activations of the right hemisphere are much slower, and the right hemisphere never is inactive while in a speech, continuously trying to make sense of speech. The right hemisphere tries to identify the various meanings of the contents the left hemisphere analyses from speech. The right hemisphere of the brain is responsible for helping a person with understanding the context of a dialogue. The right hemispher of the brain specialises at analyzing the acoustic part of speech rather than the linguistic parts of speech. (Chiarello, Mark Jung Beeman and Christine, 1998, 2-8)

The paper **Relative hand skill predicts academic ability: global deficits at the point of hemispheric indecision** (T.J. Crow, 1998) tries to discern how delayed associations or deficits with hemispheric indecision have potential relevance to human pathology. The test was carried out on a sample of 12,770 children at the UK National cohort. The skills tested were relative hand skill as a factor which would predict verbal, non-verbal and mathematical ability. The children had to mark them in check sheets. The age was set to 11 years. Females performed better than males in the verbal task questions while both the groups performed equal in the non-verbal tasks. Some forms of reading disability may be associated with failure to allocate dominance unequivocally to one hemisphere. Dyslexia and language disabilities in males may be attributable to the lesser degree of lateralization in males. Handedness in genetic in origin and has its variable in the X and Y chromosomes of the mother and father. It has been noticed that the left hemisphere of most adults are the dominant hemisphere or has cerebral dominance over the brain. Right handed parents would have right handed children while left handed children would have left handed children. We also know that voluntary body functions are contralateral and that the left side of the body is governed by the right hemisphere of the brain while the right side of the body is governed by the left hemisphere of the brain. This paper, in this context relativizes such an occurring by stating that the cerebral dominance of the left hemisphere of the brain is responsible for the majority of right handedness in human beings. (T.J. Crow, L.R. Crow, D.J. Done, S. Leask, 1998, 1275-82)

In the book **Introduction to Aphasia, Handbook of Neurological Speech and Language Disorders** (Kirshner, 1998) the author mentions that the process of recognition of audio starts with the ears, or in other words, the auditory pathway starts with the ears. The eight cranial nerves convey the signal to the area 41 and 42 of Broadman's area, which are further responsible for analysing the signals. The Heschls gyri is located on the superior surface of the superior temporal gyrus, which in turn is buried inside the sylvian fissure. Similarly the visual cortex is responsible for the visual pathway. The primary visual area is called the striate cortex. The posterior areas of the left hemisphere are responsible for processing sensory information into language, and the right hemisphere, specifically the Exner's area. Speech also involves the Basal ganglia, which is also responsible for motor activity in the body. The thalamus of the brain acts like a relaying centre which sits above the diencephalon and since it contains motor relay units, it sends the sensory information to the Wernicke's area and Broadman's area 39, which in turn is believed to be responsible for associating information from various sensory streams. (Kirshner, Howard S, 1998)

The book '*Right Hemisphere Damage*' by Elisabetta Ládavas extensively speaks about the various possibilities of damage to the right hemisphere of the brain and how various kinds of damage can manifest themselves through various symptoms. The book consists of ten chapters, explaining all the knit bits about stroke relating it to right hemisphere damage. The fact that the left hemisphere is the dominant hemisphere in language and the right hemisphere is not, is no longer correct and they stress on this very fact. Genetic evolution has just paved way for the left hemisphere to be the hemisphere which controls much of the language functions. MRI scans from subjects have proved that the right hemisphere have similar functional activation during speech, specially in discourses, metaphorical references and in comprehending things to the left hemisphere. (Ládavas, 2000)

The paper **Functional Neuroanatomy of the Cognitive Process of Mapping during Discourse Comprehension** (David A. Robertson, 2000) delves into the mechanisms of the right hemisphere of the human brain while comprehending things, situations or discourse. This research paper uses an fMRI machine to understand the regions of the brain active during discourses and speech in general. It has been a long standing belief that the left hemisphere of the brain stands responsible for language, in a human being. Recent studies along with the present study has proven the fact that the comprehension of speech, specially in discourses, to understand the thematic content in the discources and the emotive, metaphorical aspects of speech are done by the right hempisphere of the brain. Subjects with damage to the right hemisphere of the brain face challenges in doing the things mentioned in the previous line. The right hemisphere of the brain is responsible for analysing and understanding prosody, pragmatic intent, sentence by sentence thematic reference and coherence, emotive content and the aptness of metaphors. (David A. Robertson, Morton Ann Gernsbacher, Seline J. Guidotti, Rachel R. W. Robertson, William Irwin, Bryan J. Mock and Mary E. Campana, 2000, 255-60)

The paper **Word acquisition reflects lateralization of hand skill** (Stuart J. Leask, 2001) by expands upon a hypothesis through a series of tests trying to understand if there is a relation between the handedness in human beings with the development of language. This paper states that human beings are biased towards being right handed or towards being left hemisphere dominated in the ratio 10:1 with right hemisphere dominated subjects. In the process of their research they have pointed out evidence to the fact that human beings have been right biased when it comes to writing something or painting, for the last 5000 odd years. The authors have also found out that cerebral dominance in a human brain also affects the hemisphere of the body which is responsible for writing and drawing. The authors refer to the research conducted with 12,770 children at the UK National cohort and mention that most female children have much more verbal ability and fluency than their male counterparts. (Stuart J. Leask, Timothy J. Crow, 2001, 513-16)

Participants with acalculia (Ardila A, 2002, pp. 179-231) have lesser activation in the right hemisphere than with patients who do not. Acalculia refers to the inability to comprehend math. In simpler terms, it is the difficulty or in extreme cases, inability to use mathematical functions in everyday life, no matter how simple they are. It can mean the difficulty or inability to add, subtract, divide or multiply. There is a perspective which also considers the visual context of the disease, which mentions that individuals are unable to verify the spatial locations of mathematical units. For example, if a person is asked about the mid-point of a number line, after being specified the start and end, he or she would be unable to comprehend and imagine the number line in a spatial representation or if they do understand the spatial representation in their mind, they would face extreme difficulty in pointing out the mid-point. It has been mentioned that all groups of patients had certain degrees of acalculia but the persons who faced the maximum problems were found in '*retrorolandic*' or RHD patients. They also had problems in calculation abilities and errors in spatial understanding and comprehension. (Ardila A, 2002, pp. 179-231)

The paper **Effects of Damage to Right-Hemisphere Brain Structures on Spontaneous Emotional and Social Judgments** (Andrea S. Heberlein, 2003) finds out the processes involved in the right hemisphere, specifically the right somatosensory cortices (RSS), which might be indirectly or directly responsible for socio-emotional judgement procedures in a human being. This research has found out that subjects with RSS cannot describe social situations or emotional situations, with the suitable words. On the other hand, the RSS damaged subjects could describe actions properly and without any problems in recalling suitable words. At any given moment, when the RSS damaged subjects were asked to describe a situation, which would require their judgement skills, or emotional feedback, they faced problems in recallign suitable words. The research has come to a conclusion stating that the right somatosensory cortices are not only responsible for emotional and social comprehension, but also for displaying them. It further states that no singular region of the brain works for the comprehension and production of social judgement and emotive behavior. It states that, " The extra striate visual cortices, amygdala, ventral striatum, orbitofrontal cortex, and right-hemisphere somatosensory cortices all act together as components of a distributed neural system" for the comprehension and production of social judgment and emotive behavior. (Andrea S. Heberlein, Ralph Adolphs, James W. Pennebaker and Daniel Tranel, 2003, 705-26)

Studies in the right hemisphere are important because they study the localized functions of the right hemisphere. Minor damages to portions of the left hemisphere can cause aphasia and speech loss or even problems in understanding speech. This led to the belief that the right hemisphere is the subordinate hemisphere and that the left hemisphere is the dominant hemisphere. The fact that damage to the right hemisphere of the brain affects human activities in rather subtle ways rather than the non-subtle ways the left hemisphere does was another reason for scientists realizing late that the right hemisphere the brain also contained specialized functions. It is now a known fact that the right hemisphere of the brain is specialized with many functions like creativity, intuition, art, music, metaphorical understanding and so on. After studying both the hemispheres of the brain, scientists have concluded that both the hemispheres of the brain work together to perform various day to day activities. The left brain alone cannot complete all actions on its own. It needs the right hemisphere to complete various processes. Tim J Crow was one of the pioneers in the field of bi-hemispheric brain study. In one of his papers, *Right hemisphere language functions and schizophrenia: the forgotten hemisphere?* he studied the functions of the right hemisphere in language. According to Tim J Crow, the right hemisphere helps in some language functions. He was one of the first persons to disband the view that the left hemisphere is the only seat and control of language in the brain. His paper suggested that the right brain was necessary to understand humor, sarcasm, discourse comprehension, emotional prosody and so on. Schizophrenia was primarily thought to be a disorder of the left hemisphere because it adversely affected speech and language. It was in due time that schizophrenics were tested in the brain and damages to the right hemisphere were also found to create manifestations of schizophrenia. (Rachel and Crow, 2005, 963-78)

The paper **Dissociation between physical and mental number line bisection in right hemisphere brain damage** (Fabrizio Doricchi, 2005) tries to discern the spatial understanding or the lack of it in right hemisphere damaged subjects in comparison with normal subjects without any brain damage. It has been stated that human beings organise the number line spatially in their mind. The organisation of the number line is somewhat like an imaginary straight horizontal line. The present study found out how comparative judgements of numerical values activate the horizontal subsegment of the sulcus, in a nilateral fashion. The precentral gyrus of the left hemisphere of the brain and the prefrontal cortex also responds to such tasks. In comparison with such a task, it has been noticed that physical line bisections involve the striate regions, extrastriate visual cortex, inferior and superior parietal lobe and it is highly lateralized to the right hemisphere. The authors found out that subjects with damage to regions of the right hemisphere like the superior and inferior parietal lobe are affected and they deviate from correct answers while being asked about the number line. For example, a subject with right hemisphere damage to the brain when asked about the mid point of a line which starts at 1 and ends at 10, would point out 7 as the mid point and not 5 as the mid point. (Fabrizio

Doricchi, Paola Guariglia, Marina Gasparini, Francesco Tomaiuolo, 2005, 1663-65)

The right hemisphere activation levels are high while a person is reading a story, listening to a conversation or even listening to a talk passively. The imaging machines have let us to an understanding that the left hemisphere is not enough to listen and understand discourses. Participants without any sort of brain damage had been tested at labs and it was found out that the right hemisphere had more lit up sections during making discourses and listening to talks than the left hemisphere. The temporal lobe activity has been lateralized in the right hemisphere highly and this proves that the right hemisphere is responsible for an understanding in discourses. On being asked "Can you open the door for me", a typical RHD patient would answer in 'yes' or 'no' because they have lost the ability to understand the pragmatic reference of the question being asked but a subject without any brain damage would easily understand the meaning such a question and open the door for the person asking the question. Participants with RHD do not have the ability to differentiate between the literal meaning of the question and the real meaning of the question asked, with reference to the situation because we know that they have lost the ability to use the right hemisphere in communication and they cannot recall the other meanings of the words being used in the question. According to Tim J Crow and Rachel L C. Mitchell, the right brain is necessary for humans to comprehend discourses. (Rachel and Crow, 2005, 963-78)

According to Elisabeth Ahlsen, in her book, *Introduction to Neurolinguistics*, 2006, right hemisphere syndrome and disorders related to it have been much discussed about and the problems in the changed span of attention and the lack of attention are now well known. RHD patients neglect the left side of the vision field. They do not have hemianopia but they still suffer from left side neglect due to the damage in the right hemisphere of the brain. They further have problems in remembering information at times and are disoriented with information, lacking organization. Eventually they even lose problem solving abilities in even the smallest of situations, for example, the author describes a case where the patient got perplexed when a sink in was overflowing and could not execute the solution. They also lose sense of relevance and pragmatics. They lose the tonal range they normally use and even if they feel emotions their speech are devoid of most of the smaller emotions. (Ahlsen, 2006, 103)

The paper **Beyond the right hemisphere: brain mechanisms mediating vocal emotional processing** (Annett Schirmera, 2006) tries to understand the role of the right hemisphere in the understanding of moods and emotions in everyday speech and how it helps in the perception of speech. It has been noticed that the right hemisphere is responsible for the perception of emotions and moods through speech. The right hemisphere of the brain gains this ability through social interaction and gradual development of such skills since birth. Such an ability of the right hemisphere is an acquired ability, although it is not fully acquired. Such an ability is an asset towards the development of the human race. It has been acquired by the human kind as an adaptation to social life and these abilities are anchored within uch more basic neural impulses. These kinds of abilities are are composite results of various subprocesses going on together in the brain. Some people understand vocal cues better than others. It has been noticed that acoustic cues like frequency and pitch, temporal movements and so on are analysed by different parts of the brain. This research tries to put forward a more analytical view of the right hemisphere of the brain, which is responsible for vocal emtional comprehension. (Annett Schirmera, Sonja A. Kotzb, 2006, 24-30)

In the book **Textbook of Neuroanatomy** (K. Kaul Garg, I. Bahl, 2006), the author mentions that the expressive speech area, or the Broca's area involves area 44 and 45 of the Broadman's area. This area is present in the left hemisphere of the brain for 98% of the right handed human beings in 70% of the left handed people. In remaining 30% of left handers it is present in the right hemisphere. This area is very close to the motor areas responsible for speech, namely, lips, facial muscles, tongue and so on. The Broca's area is also genetically responsible for producing strings of phonemes, helping in speech.

The paper **Theory of mind impairment after right- hemisphere damage** accessed on the 25th of May, 2016, conducts a theory of mind experiment with 25 participants who are tested for effects of right hemisphere damage in comparison with normal controls. Theory of mind is defined as the ability of an individual to be able to evalutate other people's knowledge in relation to the situation or as relative to other person's knowledge. This research has used the aTOMia battery which they have specifically created for this research. The aTOMia battery consists of eight separate sections. It tests skills in understanding 'false belief', 'second order false belief', 'knowledge gaps' by placing two stories, 'instructions' skills,'faux pas' incidents, 'surprise', 'empathy' and 'cartoon'. The aTOMia group referred to the RHD participants. The TOMer group referred to the control group. It has been noticed that the RHD subjects have scored from a low of 13% to a high of 100%. Some RHD participants even after sustaining damage,showed no manifestations on the outside and scored very high. The difference between the high scorers and the low scorers was that the low scorers displayed hemisphericasl neglect, problems in discourse understanding, problems in understanding metaphors and various kinds of diminished linguistic abilities. These results show, in a way, that RHD does not always mean hemispheric neglect and linguistic disorders relating to the right hemisphere. It has been noticed that subjects who scored very low on the aTOMia battery have problems with language, right hemisphere skills and so on. The paper also suggests that it is important to notice that the aTOMia battery is much more valid for aphasiologists and clinicians. 17 RHD subjects displayed aTOMia and 8 subjects were normal. The mean score of the normal controls was 94% with a standard deviation of 6.6%. The 12 RHD subjects who scored less, had scores in the range of 13% to approx 65% which was much lower than the normal controls but the 8 subjects who scored higher, had scores which were close to that of the normal controls. (Noga Balaban, Naama Friedmann, Margalit Ziv, 2016, retrieved on 25th May, 2016)

1.2.2. A QUICK RECAP

It has been noticed that subjects with damage to the right hemisphere neglect the left hemisphere. They do not eat food from the left side of their plate. They can not see what they have towards the left of them. They cannot perceive things in the left. This is called left hemisphere meglect. Damage to the left hemisphere also causes minor problems in the right hemisphere, regarding perception but the effects are not manifested in such dramatic fashion, like in cases of right hemipshere damage. (Vallar, Perani, 1986, pp 609-22)

Further research in the same field has proved that the right hemisphere plays a pivotal role in the understanding of humour. A test was conducted on few subjects in the paper **Comprehension of humorous and nonhumorous materials by left and right brain-damaged patients** (Bihrlea, Brownell, Powelsona, Gardnerc, 1986). The left hemisphere damaged individuals had no issues in understanding humor. Right hemisphere damaged individuals, on the other hand had problems in understanding humor and lacked the understanding of coherence as well.

Damage to the right hemisphere of the brain also causes problems in visual orientation, like left hemisphere neglect. In the paper, **Language of the Brain** (Bower, 1987, pp 40-41), a subject with damage to the right hemisphere of the brain, who was an artist previously, lost her ability. All she could do was draw empty strokes on the canvas. But after the stroke, she learnt sign language and could use is like a native signer. She also displayed left hemisphere neglect.

She could not perceive things on the left side of her body. Another patient, who was a native signer, suffered a stroke to the left hemisphere of the brain. After the stroke, she lost her ability to sign properly. She had problems in signing which can be equated to grammatical problems in normal speech for non-signers. The first subject could use intricate grammer in sign language after a stroke to the right hemisphere and the second subject with a stroke to the left hemisphere, who was a native signer, lost her ability to use complex grammatical functions in her signing. It has also been noted, in the same context, in the paper **An Exploration of Right-Hemisphere Contributions to the Pragmatic Impairments of Autism** (Ozonoff, Miller 1996, pp411-34) that subjects with damage to the right hemisphere have difficulties in understanding the theme of discourses or the ability to follow the thematic content in discourses. They tend to digress while speaking or answering to another person.

Ropper mentions that damage to the right hemisphere of the brain also causes slurred speech, in the paper **Severe dysarthria with right hemisphere stroke** (Ropper, 1987, pp 1061-63)**.** The more the area damaged, the more the level of slurring. Subjects with damage to the right hemisphere of the brain have problems in articulating vowels, as a result. They also have a very limited frequency range in their speech, according to Behrens, in the paper **Characterizing sentence intonation in a right hemisphere-damaged population** (Behrens, 1989)**.** They have much lesser range between their maximum and minimum pitch. It has also been noticed that they have a much lesser f0 or fundamental frequency level. Subjects with damage to the right hemisphere display problems in modulating their fundamental frequency. It has also been noticed in the paper **The Role of the right hemisphere in emotional communication** (Blonder, Bowers, Heilman, 1990, pp 1115-27) that damage to the right hemisphere can cause the inability to understand facial expressions, tones, metaphors, imageries and the comprehension of gestures, emotions without spoken communication and so on. Such subjects suffer major disruptions in non verbal communication.

When an fMRi machine was hooked up to the brain of subjects in the research for the paper **Complementary Right- and Left-Hemisphere Language Comprehension** (Chiarello, Beeman, Christine, 1998, pp 2-8), it was found that the left hemisphere lighted up in short bursts in quick successions. The right hemisphere stayed lit for the whole duration. The authors conclude by stating that the left hemisphere makes quick and to the point analysis while the right hemisphere looks at the whole situation holistically, hence stayed lit up all the time. To add to this fact, it has also been stated in the paper **Functional Neuroanatomy of the Cognitive**

Process of Mapping during Discourse Comprehension (Robertson, Gernsbacher, Guidotti, Robertson, Irwin, Mock, Campana, 2000, pp 255-60) that the right hemisphere is responsible for understanding the thematic references in a discourse. The paper also states that the right hemisphere helps an individual stick to the theme of a discourse and not digress from the theme. The comprehension of speech, specially in any discourse, is done by the right hemisphere. The emotive, metaphorical, imagerial and non-linguistic parts of communication are all analysed by the right hemisphere. But participants with acalculia have much lesser activation of the right hemisphere as mentioned in the paper **Acalculia and Dyscalculia** (Ardila A, Rosselli M., 2002, 1-5). Persons with acalculia also have problems in doing mathematics, no matter how simple they are.

The right somato sensory cortices are responsible for emotive and social comprehension, as stated in the paper **Right hemisphere language functions and schizophrenia: the forgotten hemisphere?** (Mitchell, Crowe 2005, pp 963-78). It further states that the right hemisphere is also responsible for displaying emotional and social behavior. The right hemisphere of the brain is the hemisphere of brain, giving a person his or her personality. The authors of the abovementioned paper were few of the first persons to disband the view that the left hemisphere was responsible for every higher function including the whole of language. They mentioned that the right hemisphere helps in understanding the thematic content in discources, helps in not digressing from discourses, helps in understanding humor, sarcasm, helps in the comprehension of discourses, helps in the understanding of emotional comprehension and prosody comprehension. Damage to the right hemisphere, hence can result in schizophrenia.

Damage to the right hemisphere of the brain can also end up in the affected subject losing visual orientation, as mentioned in the paper **Dissociation between physical and mental number line bisection in right hemisphere brain damage** (Doricchi, Guariglia, Gasparini, Tomaiuolo, 2005, pp 1663-65). The paper states that physically recognising objects and numbers require a few striate and extrastriate regions of the brain, as well as the inferior and superior parietal lobe, all of which are highly localised to the right hemisphere. A damage to the right hemisphere of the brain, henceforth, can cause the inability to recognise numbers in a visual space. A few subjects with right hemisphere damage, when asked to point out the mid point between 0 and 10 on a visually drawn number line, pointed 7 as the mid point, due to the fact that they suffered from left hemisphere neglect.

Subjects with damage to the right hemisphere of the brain can be affected with hemiplegia or hemiparesis, depending on the level of damage. As mentioned in the book, **Introduction to Neurolinguistics** (Ahlsen, 2006, pp 6), subjects with damage to the right hemisphere of the brain can be suffering from left hemisphere neglect, even if their left side of the body is still under their control. Depending on the level of damage, subjects lose ability to participate in discourses properly and the abiity to comprehend metaphors, imageries, sarcasm, humor and emotional prosody. The paper **Beyond the right hemisphere: brain mechanisms mediating vocal emotional processing** (Schirmera, Kotzb, 2006, pp 24-30) states that the right hemisphere of the brain is responsible for judging emotions in speech and moods in speech. This ability of the right brain is an asset to the process of evolution in the human race. Acoustic cues like, frequency of voice and range of voice and temporal movements are analysed by the right hemisphere of the brain. In the book **Communication Disorders: Studies on Aphasia, Acalculia and Dysarthria** (Narang, 2009) 12 subjects were tested. It was found out that RHD subjects had major problems in analysing or comprehending tones or pitch levels and even during the production of tones in speech, in comparison with normal controls.

The right hemisphere of the brain primarily controls the voluntary activities in the left side of the body. Apart from that it imparts personalities to human beings, making us unique and novel and different from each other. The right hemisphere of the brain is also responsible for helping us comprehend the theme of situations, in particular, of discourses. It helps in understanding what is being spoken about, so that we can speak relevant things. The right hemispher further helps with understanding metaphors and imageries. The right hemisphere is responsible for giving us the sense of perception and when it is damaged the subjects affected can lose the sence of perception. Left side of the body neglect is very common among subjects with right hemisphere damage. The right hemisphere helps use recognise tones in voices as well as other para-linguistic cues in voice which help us understand conversations better. The right hemisphere also gives us the ability to use the frequency modulations, we do, in normal conversations to express various para-linguistic messages along with normal speech. (Springer, Deutsch, 1993, Weisenberg, 1935, Rachel and Crow, 2005, Metcalfe, Funnell and Gazzaniga, 1995, Moor, 1982, Robinson, Kubos, Starr, Rao, Price, 1984, Vallar, Perani, 1986, Bihrlea, Brownell, Powelsona and Gardnerc, 1986, Ozonoff, Miller, 1996, Gordon, Hewer, Wade, 1987, Narang, 2009)

The paper **A contrastive analysis of English and Bangla phonemics** (Binoy Barman,

2009) provides a wonderful comparison of the English vowels and the Bengali vowels through the use of phonemics. The author states, "English has 36 phonemes while Bangla has 37. Of the 36 English phonemes, 12 are vowels and 24 are consonants. On the other hand, of 37 Bangla phonemes, 7 are vowels and 30 are consonants." The author further states that the languages Bangla and English have two phonemes, which are perfectly common, namely /e/ and /æ/. The author further states that the remaining 5 vowels in Bangla are also like the ones in English, if vowel durations are not considered. The author provides two tables stating the vowels in Bengali and English.

Table 1: English phonemes

Vowels	*Consonants*
ɪ iː ʊ uː ɒ ɔː ʌ ɑː ə ɜː e æ	p b t d θ ð k g f v s z ʃ ʒ tʃ dʒ n m ŋ r l w j h

Table 2: Bangla phonemes

Vowels	*Consonants*
ɑ i e o u ɔ æ	p pʰ b bʰ t tʰ d dʰ ʈ ʈʰ ɖ ɖʰ c cʰ ɟ ɟʰ k kʰ g gʰ s ʃ m n ŋ l r h w j

Fig 1.1: Vowels in English and Bangla (Binoy Barman, 2009)

Table 5: Bangla vowels

	Phoneme	*Bangla word*	*Meaning*
1.	/ɑ/	kan	ear
2.	/i/	mil	similarity
3.	/e/	pet	belly
4.	/o/	gol	round
5.	/u/	book	chest
6.	/ɔ/	bok	stork
7.	/æ/	bang	frog

Fig 1.2: Words with Bangla vowels (Binoy Barman, 2009)

The author has also included three term descriptions of phonemes in Bangla, which is displayed in the image below.

Table 8: Pure Vowels of Bangla

	Front	*Central*	*Back*
Close	i		u
Middle (Half-close/Half-open)	e		o ɔ
Open	æ	ɑ	

Fig 1.3: Vowels in Bangla (Binoy Barman, 2009)

Finally, the author provides an acoustic space diagram of the Bengali vowels, as displayed below.

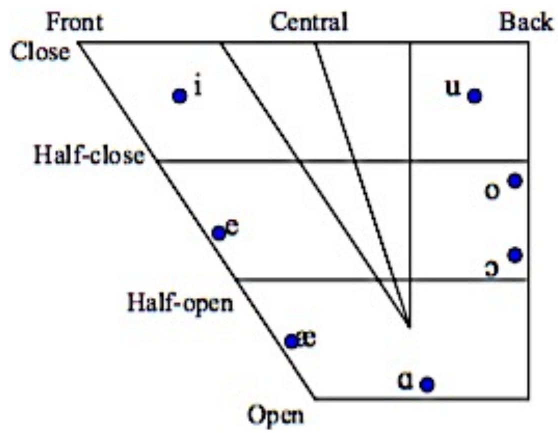


Fig 1.4: Acoustic space of vowels in Bangla (Binoy Barman, 2009)

We realize that the functions of the right hemisphere control such things which are not easily discernable in the human body, unlike the left hemisphere of the body which controls functions like speech, which is very overt and can be discerned easily. This very fact, led to the belief that the left hemisphere was the dominant hemisphere and that the right hemisphere of the brain just does nominal functions. John Hughlings Jackson was among the first few to realize that the right hemisphere of the brain deserved much more importance than it deserved at his time. The right hemisphere of the brain is responsible for the voluntary activities of the left hemisphere, to start with. It is responsible for visual orientation as well as a part of body balancing while walking and standing. It is also responsible for attention and perception. It if responsible for comprehension of speech along with the understanding of pragmatics and themes. It is also responsible for remembering names, places, settings, expressions, emotions and so on. In short, it is responsible for many subtle actions, which are not easily discernable in everyday life. Right hemisphere damaged subjects face a lot of problems in their day to day life, and it is important that researchers study the right hemisphere of the brain, along with the left hemisphere of the brain, so that we get to know more about the intricacies of the right brain and what functions it performs. (Springer and Deutsch, 1993, pp 013, Right Hemisphere Brain Damage, retrieved from http://www.asha.org/public/speech/disorders/RightBrainDamage.htm, on 29th June, 2016)

1.2.3. STROKE

The following section on stroke provides an overview of stroke and related cases where the right or the left hemisphere suffers injury or insult damage, showing their impact on the overall behaviour of the persons concerned.

A paper by Ropper AH, *Severe dysarthria with right hemisphere stroke*, mentions that stroke to the right hemisphere can cause highly slurred speech. It is also accompanied by variable degrees of hemiparesis depending on the degree of brain damage. The author has done a test involving dysarthric participants and has concluded that dysarthria can be caused due to a lesion in the right brain. Participants with dysarthria have difficulties in articulating vowels. They have a problem in using the active articulators of speech. Depending on the degree of damage of an individual and the right brain, the level of control in RHD participants depends and varies. The acoustic vowel space for such individuals also vary depending on the amount of brain damage caused. (Ropper, 1987, 1061-63)

The paper **Plasticity of Language-Related Brain Function During Recovery From Stroke** (Keith R. Thulborn, 1999) gives provides an insight into the plasticity of the brain and how after a stroke, the human brain tries to lateralise its functions through the unaffected areas. It has been noticed in fMRI scans that after a stroke in the left hemisphere, subjects have their right hemispheres glowing while doing language tasks. In general it would be the left hemisphere that would light up, because the left hemisphere of the brain is the hemisphere responsible for language skills but due to stroke, the human brain adopts and lateralizes the functions to the intact hemisphere. This research proves the 'organizational flexibility cortical systems' in the brain. (Keith R. Thulborn, Patricia A. Carpenter, Marcel A. Just, 1999, 749-54)

The book '*Right Hemisphere Damage*' by Elisabetta Ládavas extensively speaks about the various possibilities of damage to the right hemisphere of the brain and how various kinds of damage can manifest themselves through various symptoms. The book consists of ten chapters, explaining all the knit bits about right hemisphere damage. The fact that the left hemisphere is the dominant hemisphere in language and the right hemisphere is not is no longer correct and they stress on this very fact. MRI scans have proved that the right hemisphere have similar functional activation during speech, to the left hemisphere. (Ládavas, 2000)

Participants with acalculia (Ardila A, 2002, pp. 179-231) have lesser activation in the right hemisphere than with patients who do not. It has been mentioned that all groups of patients had certain degrees of acalculia but the persons who faced the maximum problems were found in '*retrorolandic*' or RHD patients. They also had problems in calculation abilities and errors in spatial understanding and comprehension. (Ardila A, 2002, pp. 179-231)

The article *Effects of Damage to Right-Hemisphere Brain Structures on Spontaneous Emotional and Social Judgments* published in the *Political Psychology* Journal in November 2003, it has been stated that the comprehension of emotion depends a lot on the well-functioning of the right hemisphere and right-hemisphere somatosensory cortex, a region known for its role in emotion recognition. The article states that seven participants with damage were shown a short movie. The movie moved in socially suggestive ways typically trying to elicit spontaneous social attributes from normal participants. It has been noticed that participants with RSS damage replied using lesser words than normal controls. (Heberlein et al, 2003, 705-726)

In the paper **Left out by a stroke**, (Bower, Left out by a Stroke, 2005), the author conducts two sets of MRI scan into the brains of 12 right hemisphere damaged subjects. The author hypothesized, with literature from the past, pointing out that damage to the right hemisphere renders an individual incapable of perceiving things with the left eye, hands, legs and so on; which is called left hemisphere neglect. When the experiment on 12 individual right hemisphere damaged subjects was conducted a pattern of brain activity was noticed. The two sets of scans were made longitudinally. The first MRI scan was done after one month of the stroke and the second MRI scan was done six months after the stroke. In the first set of MRI scans it was noticed that the subjects had much lesser right hemisphere activity and in real life, they had left hemisphere neglect. In the second set of scans, there was much higher rates of right hemisphere activity and the subjects had regained back attention in the left hemisphere except a few subjects. The author further states that it is believed that the right hemisphere is responsible for attention in a human being and that when the right hemisphere is damaged, a person loses the ability to concentrate on the left hemisphere. The author also adds, stating that, when there is damage in the left hemisphere, a subject can also display right hemisphere neglect to some extent but not to the degree to which it happens when the right hemisphere of the brain is damaged. (Bower, Left out by a Stroke, 2005, 278)

Strokes to the left hemisphere of the brain might cause problems in the language faculty of a human being and the same to the right hemisphere of a human being might disrupt orientation, theme understanding, discourse understanding and the overall understanding of metaphors and sarcasms and so on. Aphasia might follow any kind of stroke to the left hemisphere damaging either the Broca's area or the Wernicke's area, respectively in the frontal lobe and the temporal lobe. Stroke to any other place might cause no speech disorder but might cause apraxia or hemiplegia of the right hemisphere. (Ahlsen, 2006, p. 17)

The paper **Functional Status and Long Term Outcome of Stroke** (Thomson, 2008) researches, as the title suggests, the long term effects of stroke on an individual. The author has looked into the working of hospitals and trusts who deal with stroke patients and has concluded stating that previously stroke was not treated properly in comparison with now. In the past, stroke patients were not given proper care and most patients were discharged from hospitals after a short duration of time when they would seem to be normalised. Most hospitals would not scan the brain for changes in the clots or fibres due to which the stroke happened in the first place. The author further states that recently, many stroke foundations take much deeper care and track the clots causing the stroke. Patients are not released before their brain can function normally again. The author harps on the importance of being served the correct drug after a stroke. Some strokes require much more amounts of anti coagulants while some require much less. It is this experience which sets apart good stroke foundations from bad. (Thomson, Helen Rodgers, Richard, 2008, 337-38)

A case study of 12 patients was carried out by Vaishna Narang as described in her book (Narang, Communication Disorders: Studies on Aphasia, Acalculia and Dysarthria , 2009, p. 93) on 12 native Punjabi speakers who were affected by stroke. This study tested participants for the lexical level, sentence level and discourse level of communication. The study was conducted to understand the effect of stroke in LHD and RHD participants in comparison with normal controls in the lexical, sentence and discourse level. The results of the sentence level of study revealed that RHD subjects were most affected while either comprehending tones or pitch levels in a sentence or producing tones and pitch when compared with normal controls, in a sentence.

According to a journal article by Salonen in 1982 (Salonen et al, 1982, 526-537), an acute lack of blood to the brain and its parts result in lack of oxygen to the brain tissues; which in turn makes it difficult for the affected tissues of the brain to work, finally disabling them by asphyxiating them or killing them. Such an incident is called a Cerebral Vascular Haemorrhage or in more common terms a 'Stroke'. They happen when the blood supply to parts of the brain is stopped or disrupted. Strokes can be divided into two types by origin – Ischemic and Haemorrhagic. An Ischemic stroke is caused by blood clots. Blood clots decrease the blood flow to the parts being supplied by the blood vessel hosting the clot. It prevents oxygen from reaching the specific parts and this causes a stroke to occur. A lacunar stroke is a kind of ischemic stroke that happens when the blood vessels deep inside the brain get blocked. This kind of stroke mostly affects the pons, thalamus, basal ganglia and other portions of the brain which only small blood vessels can reach. The other type called the haemorrhagic type occurs when a blood vessel bursts resulting in bleeding on the brain or onto its surface. The haemorrhage can be caused due to high blood pressure or hypertension which can make the blood vessels less strong and then eventually burst. It can also be caused by aneurism in which a blood vessel expands like a balloon and then bursts. Age, Ethnicity, Genetics and stress can trigger stroke. A YouTube video '*What is stroke'* brilliantly explains a stroke in a visual manner. (What Is A Stroke?, 2013, p. https://www.youtube.com/watch?v=PwwuVZORiMc)

The Stroke Association of UK says 'The faster you act, the more of the person you save'. They preach the 'FAST' test which helps in immediate recognition of stroke by checking the most common manifestations of a stroke.

F – Face. Check if one side of the face is sagging proving damage to the contralateral side of the brain.

A – Arms. Check if both the arms can be lifted up by the person suspected with stroke. If the person is affected the person on being asked to pick up both hands would not be able to pick up both hands.

S – Speech. Check if the person has problems with speaking, if the person understands speech or if the person has problems in recalling words. Under extremes the person will just go mute.

T – Time. Time is of essence. Do not waste time. Call an ambulance.

An elaborate description of stroke and how a person can be saved with almost no disabilities is explained in the website of the Stroke Association. (Recognise the symptoms, 2014, pp. http://www.stroke.org.uk/about/recognise-symptoms)

1.2.4. LHD AND APHASIA

According to Ivar Reinvang, aphasia can be categorized as Broca's aphasia or expressive aphasia, Wernicke's aphasia, Anomic aphasia, Primary Progressive aphasia, deaf aphasia and global aphasia. (Reinvang, 1985, 5)

Damage to the left hemisphere of the brain causes left hemisphere disorder in persons. The damage can be by injury or insult. LHD can cause problems in language and communication if the language centers of the brain are affected. LHD can also cause paralysis without any adverse effect to the language of a person. According to the book, *Left Brain Right Brain* by Springer and Deutsch, aphasia is a symptom, which is discernible after any kind of damage that happens to the language centers of the brain. Aphasia is a language disorder and is an envelope term for a wide variety of disorders. Aphasia can be caused due to a stroke to the left or the right hemisphere or an accident that haemorrhages the brain, lesions, and tumours to the brain or other factors like pre-natal reasons. When Paul Broca came up with a term to describe the loss of speech in human beings for damage in the left hemisphere he coined 'aphemia' as the correct term. His terminology was replaced by 'aphasia', a term coined by Trousseau. Aphasia can be of various types depending on the region of damage in one's brain. Aphasia to the left hemisphere of the brain are most common causing either Broca's aphasia or Wernicke's aphasia and aphasia caused by damaged to the right hemisphere are less common. (Springer and Deutsch 1993, 42)

Expressive aphasia or Broca's aphasia refers to a kind of aphasia that happens when the frontal lobe of a person is damaged in the left hemisphere of the brain. This kind of aphasia, as the name suggests creates problems in an individual to speak out an express. The speech of an aphasic in this category is stopped due to damage in the left prefrontal cortex. The speech of such an individual is fragmented and the subject halts in between speeches. The person affected by the aphasia knows what they want to communicate but they have a huge problem in articulating their problems through speech or expressions. Aggramatism and paragrammatism are specific symptoms associated with Broca's aphasia. Broca's aphasia is mostly complimented by weakness in the right hemisphere of the body or hemiparesis. (Springer and Deutsch 1993, 151)

According to the book, *Left Brain Right Brain* by Springer and Deutsch, damage to the posterior left temporal cortex or Wernicke's area causes problems in speech comprehension. Participants with such an aphasia have problems in understanding what is being told to them. They have major problems in understanding communication, yet they have no problems in speaking correct sentences, no matter how absurd they sound. Their sentences are grammatically correct. (Springer and Deutsch 1993, 151)

Anomic aphasia refers to a condition of an individual who has problems in recalling words. Any person who is affected by anomic aphasia has extreme problems in remembering names and coming up with words for a sentence they are speaking. (Springer and Deutsch 1993, 154)

Primary Progressive aphasia refers to a condition where an individual gradually loses the ability to read, write, and speak or to comprehend. While the wide horizon of communication windows slowly lessens down for such participants they develop new ways to communicate with other human beings like gestural communication. (Springer and Deutsch 1993, 154)

Deaf people use sign language to speak. Sign language is a fully developed way of speaking for deaf signers. It has been noted that deaf people with aphasia have similar problems as normal participants with aphasia. (Springer and Deutsch 1993, 154)

Global aphasia refers to a condition when a person has a widespread brain damage and two or more symptoms and kinds of aphasias take place at once. Participants with global aphasia can have symptoms of both Broca's aphasia and Wernicke's aphasia with the effects of right hemisphere damage added to it. The subject at times might not be able to move a complete body hemisphere or be under hemiplegia. (Springer and Deutsch 1993, 155)

A certain study by Johnson and Welch proves that the right hemisphere might also develop some of the left hemisphere's abilities in language, after a substantial damage has occurred to the left hemisphere. The brain can shift its centers of a few language related activities to the right hemisphere. The study proves that aphasia patients have grown back their language faculty after some time and an M.R.I scan shows that the right hemisphere has grown some of the functions. Although, the functioning might not be as smooth as the original efficiency, the right hemisphere does work almost normally and recovers most of the abilities. (Cao et al, 1999, pp. 2331-40)

1.2.5. DYSARTHRIA

Dysarthria (Darley, 1969, 246-69) refers to a neuronal disorder which leads to the inability to articulate speech properly. It is caused due to damage of speech centers in the brain which causes the various processes of speech articulation in a human being. Damages to the upper motor neuron can cause spastic dysarthria whereas damage to the lower motor neuron causes flaccid dysarthria. It can also be cause due to damage in the basal ganglia. When the condition that led to dysarthria in a subject reaches the peak, a patient cannot speak at all. This is called anarthria or the inability to speak or communicate.

Ataxic dysarthria is a kind of dysarthria in which damage to the cerebellum or the peduncle of the cerebellum causes an individual to have slurred speech, hyper speech or scanned speech. (Darley, 1969, 246-69)

1.2.6. RHD

RHD or right hemisphere damage refers to damage to the right hemisphere of the brain. It can be caused by injury or insult and manifests in the overall behaviour of an individual. RHD causes problems in the understanding of themes at the level of discourse. It causes problem in the production of pitch levels in RHD affected persons. It also causes vowel to be spoken in lesser space than normal controls or unaffected persons. (Ahlsen, 2006, 105)

1.2.6.1. RHD, DISCOURSE AND PRAGMATICS

The paper **Comprehension of humorous and nonhumorous materials by left and right brain-damaged patients** (Amy M. Bihrlea, 1986) tries to understand the ability of the right hemisphere and the left hemisphere in humor understanding and comprehension through a combination of one humorous joke and one non humorous story. This test has revealed that right hemisphere damaged subjects have a much slower response, if any, to humorous content with problems in coherence as well. The left hemisphere damaged subjects have no problems with humorous incidents, with some exceptions. Most of the left himsphere damaged subjects have no problems in understanding the content coherently. The right hemisphere damaged subjects performed worse then the left hemipshere damaged group in both the humprous task and the non humorous task. This research has proved that there is a difference between disorders like aphasia and the disorders caused by damage or lesions to the right hemipsphere. (Amy M. Bihrlea, Hiram H. Brownell, John A. Powelsona, Howard Gardnerc, 1986, 399-411)

A large part of communication in discourses also happen through unspoken communication and participants with damage to the right hemisphere of the brain suffer major consequences because of the damage to the right brain. The article *The Role of the right hemisphere in emotional communication* by Lee Xenakis, Dawn Blonder and Kenneth M. Heilman published in the *Brain: A Journal of Neurology,* 1990, mentions that 'Previous research has established that patients with right hemisphere damage (RHD) are impaired in the comprehension of emotional prosody and facial expression.' They also mention that this kind of impairment have possibly many explanations. 'It may reflect defective acoustic and visuospatial analysis, disruption of nonverbal communicative representations, or a disturbance in the comprehension of emotional meaning.' They asked RHD patients, left hemisphere damaged patients (LHD) and normal controls (persons without disorders to judge the emotional content of sentences describing nonverbal expressions, and sentences describing emotional situations. They found out that RHD participants performed normally in their ability to infer the emotion conveyed by sentences describing situations. But the RHD patients were particularly impaired in judging the emotional content of sentences depicting facial, prosodic, and gestural expressions, suggesting a disruption of nonverbal communicative representations when compared to the LHD and normal persons. (Lee Xenakis Blonder et al, 1990, 1115 -27)

Participants have extreme difficulties in understanding the thematic context of a discourse. They also face problems in sticking to the thematic context of a discourse and frequently are seen digressing from discourses. In the article *Right Hemisphere Syndrome,* Myers and Mackisack, 1990 state that the impairments of perceptions and of attentions are the main underlying reasons for the deficits in patients with RHD manifested as linguistic, non-linguistic or extra-linguistic deficits. They further speak in detail about the inability to understand context in many cases they face. There is marked reduction in the understanding of context in patients who have a sizeable damage to the right hemisphere. They suddenly lose the context or theme being spoken on. There are also cases when the patients digress in process of natural speech and then cannot get back to what they were originally speaking. (Myers and Mackisack, 1990, 10)

The paper **Theory of Mind and Pragmatic Understanding Following Right Hemisphere Damage** (Micheal Siegal, 1996) researches on the similarities between three-year-old children and right hemisphere damaged subjects. The aim of the research is to understand the reason for the inability in children to be able to suspend the belief of truth in sentences spoken to them. Previous research has revealed that the right hemisphere of the brain is responsible in the understanding of the sense of context in a situation and this research pivots on the same knowledge, trying to understand the striking similarity between three-year-old children and right hemisphere damaged subjects. The total test subjects consisted of left hemisphere damaged subjects, right hemisphere damaged subjects and children, who were tested for their understanding of pragmatic contexts in situations. Right hemisphere damaged subjects have difficulty in understanding the context of a situation like three-year-old children. Three-year-old children face this problem because their brain is not developed enough and this research has also found out that four-year-old children can understand the context of situations unlike the three-year-old ones. Right hemisphere damages subjects have the same problem as the three-year-old children but it is because they have sustained damage to the same regions that are not yet developed in the children. Owing to this there is a marked similarity in their inability to understand the context of a situation. The research also mentions that the simplicity of the tasks might also have perplexed the adults in the process of the research and hence, the incorrect answers by some of the adults. (Micheal Siegal, Janet Carrington, Michael Radel, 1996, 40-50)

According to the book *Handbook of Neurolinguistics* by Brigitte Stemmer and Harry A. Whittaker, although LHD have problems in syntax and word recalling, it is more difficult for a listener to understand the total content of an RHD subject than and LHD subject. Narratives made by an RHD participants have confabulations, unnecessary details and lots of repetitions. (Stemmer and Whittaker, 1998, 245)

In the article *Right hemisphere damage impairs the ability to process emotional expressions of unusual faces* by M.K Mandal, HS Asthana and S Maitra, 1998, a certain case of malfunctioning of the brain due to RHD has been focused on. They took patients with RHD as well as left hemisphere damage and neutral test takers as controls for the experiment. The patients as well as the control were asked to match photographs of emotion expressions that were depicted in unusual (line drawings, strange, and schematic) and normal (usual) representations of faces with the target emotion expressions of normal face. Non-patient controls were significantly superior to right hemisphere damaged patients in matching photographs of emotion expressions that were depicted in line drawings of normal face and schematic face. (MK Mandal, 1998, 167 - 176)

The spatial characteristics in a discourse derive their attributes from the surroundings being described or the place being discussed in the discourse. For example when a person starts speaking about a particular incident with someone who has experienced the situation, they have a mental picture of the place in which the discourse parameters are set in. While the discourse continues they do not abruptly shift the spatial characteristics of the place on which their discourse is set in. The temporal characteristic of discourse is referred to as the sense of time while taking part in a discourse. When the participants of a discourse are conversing, they have a particular time frame involved in the discussion, the violation of which would make an odd statement. According to Egenhofer, the temporal characteristic of a discourse keeps the discourse to the point and precise. (Egenhofer, 1998, 32)

The article *'Communicative Intentions and Language: Evidence from Right-Hemisphere Damage and Autism'* tries to clarify the point that autistic children have some problem in understanding the communicative intent of the speaker they are speaking to or by the person they are being spoken to, hence they develop responses which we term as 'strange' and think of them as unsocial. In other words, RHD is responsible for the loss in understanding of themes in speech as well as puns, metaphors and the whole meaning of a discourse. To test this children with autism were tested and their right brain MRI shows that there is much lesser activation than the participants with no damage, hence the decrease in the level of communication and speech, making them intrinsically unsocial. (Sabbagh, 1999, 29 - 69)

A certain research paper in neurophysiology has found out that the right hemisphere of the brain helps with the recalling of the 'other meanings' of a word when situation arises. (Seger, 2000, 1-3) This refers to the metaphorical sense of a word. When we say to someone, "Don't eat like a hippo", we do not mean to say that he or she is a hippo but we actually try to mock them from eating too much. A person without the faculty to understand the difference between metaphorical usage and general usage would mistake this sentence as himself or herself being called a hippo; or in a case when they are overhearing that the person being spoken to, to be a hippo.

The paper **Functional Neuroanatomy of the Cognitive Process of Mapping during Discourse Comprehension** (David A. Robertson, 2000) delves into the mechanisms of the right hemisphere of the human brain while comprehending things, situations or discourse. This research paper uses an fMRI machine to understand the regions of the brain active during discourses and speech in general. It has been a long standing belief that the left hemisphere of the brain stands responsible for language, in a human being. Recent studies along with the present study has proven the fact that the comprehension of speech, specially in discourses, to understand the thematic content in the discources and the emotive, metaphorical aspects of speech are done by the right hempisphere of the brain. Subjects with damage to the right hemisphere of the brain face challenges in doing the things mentioned in the previous line. The right hemisphere of the brain is responsible for analysing and understanding prosody, pragmatic intent, sentence by sentence thematic reference and coherence, emotive content and thw aptness of metaphors. (David A. Robertson, Morton Ann Gernsbacher, Seline J. Guidotti, Rachel R. W. Robertson, William Irwin, Bryan J. Mock and Mary E. Campana, 2000, 255-60)

The right hemisphere activation levels are high while a person is reading a story, listening to a conversation or even listening to a talk passively. The imaging machines have let us to an understanding that the left hemisphere is not enough to listen and understand discourses. Participants without any sort of brain damage had been tested at labs and it was found out that the right hemisphere had more lit up sections during making discourses and listening to talks than the left hemisphere. The temporal lobe activity has been lateralized in the right hemisphere highly and this proves that the right hemisphere is responsible for an understanding in discourses. On being asked "Can you open the door for me", a typical RHD patient would answer in 'yes' or 'no' because they have lost the ability to understand the pragmatic reference of the question being asked but a subject without any brain damage would easily understand the meaning such a question and open the door for the person asking the question. Participants with RHD do not have the ability to differentiate between the literal meaning of the question and the real meaning of the question asked, with reference to the situation because we know that they have lost the ability to use the right hemisphere in communication and they cannot recall the other meanings of the words being used in the question. According to Tim J Crow and Rachel L C. Mitchell, the right brain is necessary for humans to comprehend discourses. (Rachel and Crow, 2005, 963-78)

The right hemisphere helps a person understand the meaning of the discourses being made and as a result helping in inserting the persons into discourses. This as a whole makes a person able to live in a society. The authors of '*Right hemisphere language functions and schizophrenia: the forgotten hemisphere?'* mention that the right hemisphere of the brain has almost no or less control over direct linguistic processes like syntax, morphology and phonology. The right hemisphere however is '*the primary mediator of a set of paralinguistic* *or pragmatic phenomena that accompany the words of an utterance and that can modify or influence its meaning.'* The right hemisphere henceforth helps in integrating the sense of reality into speech comprehension. It helps us understand how a certain speech we are hearing relates to present conditions. It gives us a sense of pragmatics. (Rachel and Crow, 2005, 963-78).

Discourse understanding and comprehension decreases as a result of damage to the right hemisphere of the brain. Participants with damage to the right hemisphere of the brain have been seen to analyze discourses in different ways. Participants have been seen to have digressive tendencies in discourses and lesser span of attention has also been seen. Participants with damage to the right hemisphere of the brain suffer symptoms like lack of attention, inability to comprehend discourses properly, inability to understand humor and sarcasm, inability to organize things properly, inability to reason out situations, inability to understand metaphors in speech and the inability to remember new memories at times. These participants also suffer from a disorder called neglect, in which a subject totally neglects the left side of the field of vision and the left hemisphere of their body. Participants remain disoriented even in known locations and have extremely weak sense of pragmatics. (Ahlsen, 2006, 98)

Damage to the right hemisphere of the brain can cause attention deficits in the behavious of the individual affected. This can create further problems in listening skills and comprehension. According to the article *Perseveration in Right Hemisphere Brain Damaged Individuals* by Jayanti Ray, Shyamala Chengappa, 2008, it has been mentioned that damage to right hemisphere of the brain results in a cluster of cognitive-linguistic impairments which include attention deficits, neglect, discourse deficits, pragmatic disorders, poor inference abilities, and semantic processing deficits. It has been noticed that RHD is sometimes accompanied by behavioural deficits which complicates other symptom of RHD. Perseveration is one such after effect of RHD. It is when a stimulus has stopped to exist but the reaction of the stimulus keeps on happening in an individual; or when the reaction also happens when a similar stimulus replaces the original stimuli. It happens in conditions like traumatic brain injury, dementia, amnesia, etc. (Ray and Chengappa, 2008, p. Vol 21 Number 1)

1.2.6.2. RHD AND SENTENCES

The paper *Characterizing sentence intonation in a right hemisphere-damaged population* by Behrens SJ, characterized the sentence intonation of RHD patients. The study focused on a greater number of acoustic parameters and the recordings were elicited under natural circumstances. Eight RHD speakers and seven non-neurological control participants produced declarative and imperative sentences as well as yes-no and wh-questions. The slope of F0 change, linearity of pitch contour, and variance of F0 points were calculated for each utterance. The same was calculated for the preterminal and the terminal contour separately. The contours in RHD were less linear and flatter in F0 decline than normal controls for the declarative sentences. The response to yes or no questions from brain damaged patients differed a lot from the response from normal controls. Patients displayed a smaller F0 dispersion around a mean F0. *'Preterminal range values were more restricted for patients' utterances of yes-no questions, while terminal properties between groups differed for three of the four sentence types examined.'* Hence it can be discerned that patients with damage to the right brain have some problem in modulating their fundamental frequency. (Behrens, 1989, 181-200)

As seen in a large number of studies, the pitch levels in the sentences of participants affected with RHD have been seen to be lesser. Participants speak within a limited range and do not cover the full range of frequency normal controls can. It has been noticed that RHD participants have a lesser variation for pitch in sentence intonation for declarative, interrogative and imperative sentences. Every human being has a fundamental frequency of their own but their pitch in actual speech depends on a lot of factors. Pitch patterns in a sentence can be drastically different depending on if the sentence being spoken is a statement or a question or an order. We shall compare the pitch variations in the intonations for declarative statements in RHD participants in comparison with normal controls. Various other factors like mood of the speaker, the topic of discourse, the physical environment the speaker is in, the physical disorders of a person including brain damage and many other factors can change the pitch range in speech for a human being. (Behrens, 1989, Eriksson, 1994, Myers, 1998, Obler, 1998, Ahlsen, 2006)

It has been found out that the f0 for an English conversation for persons of the age 24- 49 is around 101 for male with a standard deviation of 3.4 and 182 for female with a standard deviation of 2.7, whereas, the f0 for reading in English for males is 128 with a standard deviation of 4.35 and 213 for females with a standard deviation of 4.5. An article by Eriksson provides similar information and wonderful insight into the frequency ranges of speech in and during various activities. (Eriksson, 1994, 1)

The pitch in sentences are measured by looking into the pitch range of vowels. This requires the f0 for vowels to be found out at each levels of vowels. It has been seen that RHD participants have lesser variation in f0 range than normal controls. In the article *Right Hemisphere Language Comprehension: Perspectives From Cognitive Neuroscience by* Mark Jung Beeman, C. C. (1997).. Mahwah, New Jersey: Psychology Press, it is mentioned that the Right Hemisphere is not directly responsible for language but without the well-functioning of the Right Hemisphere it is impossible to speak the way we do. The Right Hemisphere is responsible for helping speakers with the f0 of speech as well as the ability to hold on to conversations and their pragmatic essences. (Mark Jung Beeman, 1997)

According to the article by Penelope S Myers, *Analysis of Right Hemisphere Communication Deficits: Implications for speech pathology,* damages to the parietal region of the right hemisphere makes a subject lose tonal range in speech. Sentences of such individuals either verbal or non-verbal do not contain the emotion originally supposed to be there. The author also suggests that the 'witticisms' of such participants are also conveyed in a 'flat tone'. (Myers, Analysis of Right Hemisphere Communication Deficits: Implications for speech pathology, 1998, 1)

According to the book, *Language and the Brain* by Loraine K Obler and K Gjerlow, participants with RHD have lower f0 variation in their speech in normal discourse. RHD participants generally speak without much variations in their speech. A nomal control on the other hand has good variation in speech. A person listening to an RHD subject would have problems in understanding the mood and emotions of a person through the intonations in the sentences. Generally we know if a person is sad, angry, happy, disgusted by the intonation and pitch variations in a sentence but the same in an RHD subject is difficult to discern because of the damage caused to the right hemisphere of the brain. (Loraine K Obler, 1998, 20)

According to the book *Right hemisphere damage: Disorders of communication and cognition* by Penelope S Myers (Myers, Right hemisphere damage — Disorders of communication and cognition, 1999), participants with RHD have problems in understanding the intonation in sentences they hear. They also face problems in using proper intonations in their sentences. Participants have difficulty in understanding the pitch in speech they listen to and judge the sentences based only on the content of the sentences. Generally, we judge a sentence and comprehend it according to Grice's Maxims (Grice, 1975) but we also comprehend a sentence according to the intonation patterns used.

According to Elisabeth Ahlsen, in her book, *Introduction to Neurolinguistics*, 2006, right hemisphere syndrome and disorders related to it have been much discussed about and the problems in the changed span of attention and the lack of attention are now well known. RHD patients neglect the left side of the vision field. They do not have hemianopia but they still suffer from left side neglect due to the damage in the right hemisphere of the brain. They further have problems in remembering information at times and are disoriented with information, lacking organization. Eventually they even lose problem solving abilities in even the smallest of situations, for example, the author describes a case where the patient got perplexed when a sink in was overflowing and could not execute the solution. They also lose sense of relevance and pragmatics. They lose the tonal range they normally use and even if they feel emotions their speech is devoid of most of the smaller emotions. (Ahlsen, 2006, 103)

A case study of 12 patients was carried out by Vaishna Narang as described in her book (Narang, Communication Disorders: Studies on Aphasia, Acalculia and Dysarthria , 2009, p. 93)on 12 native Punjabi speakers who were affected by stroke. This study tested participants for the lexical level, sentence level and discourse level of communication. The study was conducted to understand the effect of stroke in LHD and RHD participants in comparison with normal controls in the lexical, sentence and discourse level. The results of the sentence level of study revealed that RHD subjects were most affected while either comprehending tones or pitch levels in a sentence or producing tones and pitch when compared with normal controls, in a sentence.

The present study examines ten sentences in indicative or declarative mood, articulated by RHD participants in comparison with age and gender matched normal controls. The sentences articulated by RHD participants would be compared with the age and gender matched controls based on pitch levels and variation in the intonation levels in the sentence recordings. They will be analysed using softwares and tools, discussed in the next chapter on 'Research Methodology'.

1.2.6.3. RHD AND SPEECH PATTERNS

As seen in a large number of studies, the acoustic space of RHD participants suffer a decrease in the overall articulation area inside the mouth. RHD participants have a smaller acoustic space for vowels and they generally use lesser area to articulate vowels than normal controls. (Darley, 1969, Ladefoged, 1975, Ropper, 1987, Myers and Mackisack, 1990)

Formants are referred to as the frequencies which resonate the loudest with the fundamental frequencies of the vocal tract. The laryngeal cavity, the oral cavity and the nasal cavity are the places where the resonances take place and produce the formants. They appear as dark vertical bands in a spectrogram. It has also been mentioned that a formant is stronger when it appears darker on a spectrogram. Formants of a human voice can be electronically recorded and reproduced as numbers to make a rough representation of the physiological limits of a person, called an acoustic space. (Peter Ladefoged, 1975)

The vowels spoken in RHD participants are articulated with minimal movement of the active articulators and it is difficult to discern the vowels apart from each other. The vowels are articulated so close to each other that it is difficult to tell them apart. (Darley, 1969, 246-269)

A paper by Ropper AH, *Severe dysarthria with right hemisphere stroke*, mentions that stroke to the right hemisphere can cause highly slurred speech. It is also accompanied by variable degrees of hemiparesis depending on the degree of brain damage. The author has done a test involving dysarthric participants and has come to the conclusion that dysarthria can be caused due to a lesion in the right brain. (Ropper, 1987, 1061-63)

Participants with dysarthria have difficulties in articulating vowels. They have a problem in using the active articulators of speech. Depending on the degree of damage of an individual and the right brain, the level of control in RHD participants depends and varies. The acoustic vowel space for such individuals also vary depending on the amount of brain damage caused. (Ropper, 1987, 1061-63)

It has been noted that participants with damage to the right hemisphere of the brain have a much lesser range of active articulation during speech. This is due to the factor that the brain centers which control the muscular activity are damaged and control is partial. This leads to increased efforts on the part of RHD participants to pronounce. As a result, RHD participants have much lesser acoustic space in their speech. (Myers and Mackisack, 1990, 10)

According to the website http://www.phonetics.ucla.edu/course/chapter9/cardinal/cardinal.html, vowel space refers to the approximate region in which each vowel is produced inside the mouth through a graphical representation using formant values of each vowels, duly recorded. The chart for cardinal vowels of speech was first created by Daniel Jones. He mentions that physiologically speaking, each cardinal vowel represents the peripheral vowels in the graphical representation of vowels for the vowel space chart. (Jones, 2015, p. http://www.phonetics.ucla.edu/course/chapter9/cardinal/cardinal.html)

1.2.7. PROSODY AND EMOTION

The article '*Seeing Emotion with Your Ears: Emotional Prosody Implicitly Guides Visual Attention to Faces'* by Simon Rigoulot and Marc D. Pell speaks about the way facial cues are closely knit with emotional prosody (Vivian Raithel, 2004, 1). They found out that emotional cues in the voice are automatically scanned while listening to a person and a look at the face assures what they are hearing. This ensures the conversation is relevant at all times. They found out the ability of human beings to differentiate between various emotions through speech and the ability to detect the common emotions in everyone's speech. (Simon Rigoulot, 2012, 1-2)

There is a certain part of speech called the emotional prosody which is responsible for letting the hearers of speech discern the mood in which the speaker is speaking. It is very important for any person to understand the emotional undertones of speech because to answer back to the question, it is important we understand the mood of the person. If we do not understand the mood of the person, we might end up saying something irrelevant and in the process initiating an unsocial conversation. It has been found out that the right hemisphere is responsible for tones in language but under more careful observation it has been found out that the right hemisphere is also responsible for helping us understand the emotional prosody of speech. RHD patients have a typical problem of not being able to discern the mood of the speaker they are listening to. There are many cases of RHD when the patient with RHD has replied back to the speaker with an answer which is inappropriate for the situation causing the initiation of an unwanted communication. It has also been found out that the damage to the Right hemisphere of the brain can also cause the inability to display emotional prosody. There are cases of RHD in which emotional prosody cannot be found. (Vivian Raithel, 2004, 1)

1.2.8. RELATED STUDIES IN JNU

Important work in acoustic phonetics have been done in JNU. The paper '*F1 and F2 Correlation with F0: A Study of Vowels of Hindi, Punjabi, Korean and Thai'* by Vaishna Narang, Deepshikha Mishra and Ritu Yadav deals in the empirical study of vowels of four languages. They have examined the formants of the vowels as well as the fundamental frequency using f0, f1 and f2 of the vowels in Hindi, Punjabi, Korean and Thai. (Vaishna Narang D. M., 2012)

Another work by Narang, *'Acoustic Space, Duration and Formant Patterns in vowels of Bangkok Thai'* visits the fundamental theories of 'DT hypothesis' and 'Quantal theory' through the use of acoustic space in vowels of Bangkok Thai. (Vaishna Narang D. M., 2010)

Agniva Pal (2016) unpublished M.Phil thesis on **Language and Speech of the RHD**, presents the study 18 right hemisphere damaged participants in comparison with their age and gender matched normal controls. It studies the deviations at the level of discourse, frequency at the level of sentences and vowels as used in words at the level of speech. At the level of discourse it studied the duration of discourse, the fluency in discourse, comprehension and digressions in speech. It included some personal and subjective views from the researcher regarding the facial expressions and emotional quotients. At the level of sentences, it studied the fundamental frequency as a measure for pitch levels in declarative sentences for continuous speech. It studied the pitch range through the study of maximum and minimum frequency in continuous speech. At the level of vowels as in words. The acoustic space of vowels in cases of RHD and Controls was studied in detail using all peripheral vowels in the Bengali language. It is interesting to note that in some cases the acoustic space of vowels was reduced to as small as 9%, 13%, 23%, 43% to 70% and 90%. In the cases with more than 70% acoustic space, the deviations were not audible without tools and instruments. It is also important to notice that no major difference was found between the RHD group and the control group in terms of vowel duration.

1.3. THE PRESENT STUDY: SCOPE AND OBJECTIVES

1.3.1. INTRODUCTION AND BROAD CATEGORISATION

The present study falls under the broad area of neurolinguistics. It is an empirical study which involves the collection of primary data from right hemisphere damaged subjects (to be referred to as RHD subjects) along with age and gender matched normal controls preferably from the same family as the RHD subjects. It is a quantitative study but not a longitudinal study. It is a cross sectional study. The present study would look into pitch variations and deviations, as in deviations or variations in the fundamental frequency; at the level of sentences and vowels, as in words. At the level of sentences, pitch levels for three kinds of sentences, namely declarative, imperative and interrogative sentences for RHD participants would be studied, as well as the range in the f0 levels, in comparison with age and gender matched controls. At the level of vowels, as in words, the pitch as well as formants of vowels would be used to find out the acoustic space of the vowels, using target words to extract the vowels. Further, vowel duration would be looked into. The present research will also look into the pitch variations at the level of discourse for RHD participants in comparison with age and gender matched controls. Other variables considered would be the length of discourse, fluency in discourse, the digressions and comprehension ability, as well as spatial and temporal displacements.

1.3.2. RESEARCH QUESTIONS

2. How does RHD affect the use of pitch in verbal communication and fluency?
3. How does RHD affect the use of pitch at the level of segments (primarily vowels), at the level of words and sentences?
4. How does RHD affect pitch at the level of discourse in connected speech?

1.3.3. OBJECTIVES OF THE STUDY

The present research will look into the deviations in pitch, as in fundamental frequency at the level of sentences and at the level of vowels, as in words. At the level of sentences, the pitch variations, as in f0 variations in declarative, imperative and interrogative sentences would be looked into

At the level of vowels as in words, the acoustic space of vowels would be studied, in which the acoustic space of RHD participants would be compared with age and gender matched normal controls, as well as the whole control group. The variables used would be the first formant and the second formant of the respective vowels. Next, the duration of vowels would be studied.

At the level of discourse, pitch variations in the whole discourse would be looked into. Variables to be discerned are range of pitch, fluency in speech, comprehension ability, digressions, thematic cohesion and spatial and temporal displacements.

1.3.4. SPECIFIC OBJECTIVES

1. At the level of vowels, as in words, the recordings would include all the vowels of the Bangla language, so that the formant 1 and formant 2 can be used to find out the acoustic spaces of vowels and the vowel durations.
2. Three types of sentences would be recorded in the present study, namely, declarative, imperative and interrogatives. At least two samples of each kind would be recorded thrice.

3. At the level of discourse, the pitch range (maximum f0 - minimum f0), mean and Standard Deviation would be found out, to check the effect of RHD.
4. The present research would document the exact places of lesion in the RHD participants, along with the exact prognosis given by the specialist. The place of lesions would be correlated with the problems being faced by participants.

1.4. TENTATIVE CHAPTERISATION

This section will give an overview of the whole as presented in this dissertation.

The first chapter shall introduce the topic of research to the readers. It will chronologically explain the evolution of brain studies and how the preliminary procedures of brain study have led us to the advancement in brain studies today. It shall discuss the important definitions, contexts and scenarios needed to be known before the present research can be pursued. It shall speak about stroke. This chapter shall also explain aphasia and the various kinds of it and how RHD changes language and speech in RHD individuals. This chapter shall speak about the general objectives of the study as well as the scope of the study followed by the general research questions.

The second chapter on Research methodology would explain the methodological choices in the whole research and would cover the various kinds of research approaches. It would further explain the choice of language, parameters, subject and tools. It would also explain the inclusion and exclusion.

The third chapter would showcase individual Case Studies, discussing the RHD participants and comparing them with age and gender matched normal controls. At first this chapter would provide a list of all the RHD participants and age and gender matched normal controls for a reader to understand the controls used for each RHD participant. The section prior to the case studies would provide the details for all controls so that when the research would moves into the case studies, the RHD participants can be readily compared with control data which have already been prepared. The section on case studies would be discussing each case study individually including sections on their primary information, history, condition at present followed by sections on discourse (in a tabulated form), sentences, acoustic space for vowels and visual orientation. Each RHD participant would be compared to individual controls, i.e., age and gender matched controls and then be compared to the average of the whole male/female control group depending on the gender of the RHD participant.

The fourth chapter on Analysis and Discussions would sum up the case studies and discuss the general trends in the present research, after they have been compared with age and gender matched normal controls in the third chapter. The fourth chapter would also discuss the group comparisons between RHD participants and age and gender matched normal controls. It would conclude by moving into the general discussions regarding the research findings. This chapter would address the research question formulated in the first chapter.

2. RESEARCH METHODOLOGY

2.1. INTRODUCTION

The previous chapter named 'Introduction and Literature Review' gives a chronological account of how scientists slowly grasped the working of the human brain, from very basic stages of understanding it to advanced stages. It primarily began with Marx Dax back in the 1800s followed by Broca, Wernicke, John J Gumpers and so on.

Scientists realised that the two hemispheres of the brain have some common functions as well as some specialised functions. Detailed experimentation with aphasia patients revealed that the left brain was responsible for the faculty of language in human beings. Further research in this field proved that the right hemisphere of the brain, the non-dominant hemisphere in the brain, was responsible for non-linguistic functions. The concept of cerebral dominance paved a path towards the understanding of the fact that each brain hemisphere along with having specific functions also have different functions and that one hemisphere is more dominant than the other. The previous chapter explained how scientific experimentation and research of the human brain led to the understanding that damage to the left hemisphere causes problems and anomalies in language while damage in the right hemisphere causes difficulties in the non-linguistic features of language. Damage to either hemispheres can cause hemiplegia and hemiparesis as well. To sum up, the previous chapter revisited relevant literature pertaining to the research, as well as portrayed the chronological journey of the understanding of the human brain by scientists over the centuries.

2.1.1. GENERAL RESEARCH METHODOLOGIES

Research approaches are not airtight containers and there is no discreet boundaries governing the limits of each research approach. The following research methodologies and approaches are a few general research methodologies, used widely all over the world by researchers.

2.1.1.1. INDUCTIVE AND DEDUCTIVE RESEARCH APPROACHES

As cited in the book *Sociological Inquiry Principles: Qualitative and Quantitative Methods* by Amy Blackstone, 2012 (Blackstone, 2012), a deductive research aims at testing theory, which already exists and an inductive approach generates new theory from data. An inductive research approach refers to the kind of research that starts researching without any prior bias or theory in mind. This kind of research aims at discerning certain trend in the data received by comparing them to a control group. The findings of this kind of research are theorized only after the data has been collected. On the other hand a deductive approach to research tries to prove an already existing hypothesis by collecting data from the masses.

A research methodology involving deductive reasoning would usually begin with a hypothesis. Deductive research methods usually put more effort into causality and are more commonly associated with quantitative research but as mentioned before, there are no set rules, and qualitative studies might follow a deductive research approach, as well. Researches involving deductive approaches usually have a top down approach and begins by selecting pre-existing theories on pre-selected topics of interest. The researcher then narrows down the research scope into more specific hypothesis, which can be tested and observations are collected to substantiate and support the hypothesis. After this the researcher can finally gain the ability to test the hypothesis mentioned before with specific data which wither confirm its truth or deny it. (Blackstone, 2012)

Researches involving inductive reasoning are generally qualitative in nature and use a set of research questions to define the scope and aims of the study. An inductive research aims at exploring new phenomenon and tries to look at previously done researches, from a different perspective. Researches involving the inductive approach usually follow a bottom up approach. An inductive research detects patterns and regularities within specific observations and measures, which might be from primary or secondary data. New theories are generated out of observations made. (Blackstone, 2012)

According to the book *The Discovery of Grounded Theory: Strategies for Qualitative Research* by Glaser, Barney G & Strauss, Anselm L. (Glaser and Strauss, 1967), one specific approach to inductive research, called the grounded theory where the researcher is required to begin a research with absolutely no preconceived notions. This kind of research aims at developing new theories based on data. Such kinds of data analysis, once completed require the researcher to examine already existing theories, to effectively place the new theory in the actual discipline. Grounded theory research approach is generally used in such researches, where the phenomenon being researched has not been researched on before.

2.1.1.2. EMPIRICAL AND RATIONAL RESEARCH APPROACHES

According to the paper *Rationalism vs. Empiricism* by Peter Markie, 2004 (Markie, 2004), an empirical research method assumes the researcher to believe that every knowledge we gain about the world is through sense experiences. On the contrary, a researcher using a rational approach is assumed to believe that a substantial amount of knowledge can be gained outside the realm of sense experiences and that already existing concepts and knowledge exceeds the stretch of sense experiences.

According to the paper *Rationalism vs. Empiricism* by Peter Markie, 2004 (Markie, 2004), the existence of the human mind, God, the sixth sense, knowledge of one's existence are all such things which cannot be proved empirically or be substantiated with information. Rationalism believes in priori knowledge or the existence of knowledge independent of experience. Rationalists assume that such knowledge is part of our nature and some claim that it is divine in nature. A rational research works on already existing knowledge and builds on the theories which exist, further substantiating the already existing information and knowledge with observations made newly.

According to the paper *Rationalism vs. Empiricism* by Peter Markie, 2004 (Markie, 2004), an empirical research is based on experimentation and observation. This kind of research is mostly used to test a hypothesis unlike a rational approach where the hypothesis are substantiated with observations, which prove it. An empirical research begins by setting the scope of a research which limits the data; followed by the collection and organisation of data. This is followed by analysis of data, which leads to predominant trends and patterns, which in turn are the observations, made from the data. Furthermore, empirical researches combine extensive research with detailed case study, which is in turn a mixture of quantitative and qualitative approaches to research.

The paper *Empirical vs Rational method for developing new Drugs* by Peter Gund, 1999 (Gund, 1999) talks about the rational and empirical method into making new drugs. In this paper, the author states that a drug can be made based on the formulae laid out by ancient texts or shamans but until and unless it has been empirically tested, a researcher cannot comment on its availability, effectiveness, delivery methods to site and so on. Even if we have prior knowledge about the composition of the drug, it is impossible to know how it is going to behave in a dynamic everyday condition.

The book Research Methodology by Alexander M. Novikov and Dmitry A. Novikov, 2013 (Novikov and Novikov, 2013), suggests that empirical research methods may be divided into two approaches. One approach starts with an investigation, followed by monitoring and an experiment and so on leading to the final findings. Another method called the methods-operations approach starts with an observation, followed by measurements or inquiries and testing leading to findings.

2.1.1.3. QUALITATIVE AND QUANTITATIVE RESEARCH APPROACHES

According to the book *Qualitative-quantitative research methodology: Exploring the interactive continuum,* by Newman, 1998, a qualitative research approach is used by researchers who want to study variables which are not in numerical form. It further suggests that the researcher involved shall be engaging themselves in very intricate subjective details of each variable involved. The researcher needs to engage in studies, which includes the involvement of the variables ranging way beyond mass data collection. Each variable in a qualitative research can change the overall finding of the research unlike in a quantitative research where each variable being studied only adds to the common findings and the mass findings. The methodological approach in a qualitative research is always guided and moulded by the concrete knowledge bases and theories at hand. For example, studying human behaviour requires a qualitative research methodology because human behaviour cannot be quantified. (Newman, 1998).

According to the book *Qualitative-quantitative research methodology: Exploring the interactive continuum,* by Newman, 1998, a quantitative research approach is used by researchers who are studying data which can be delineated in terms of numbers. Such data can be further used to create statistical information regarding data collected and the results can be quantified through graphs, charts and so on. Various tools are also used to collect data so that the data collected can be statistically analysed and discerned. Researchers can find out patterns and trends from collected data in quantitative researches. For example studying the average cost of cell phones used by people in a country requires large scale data collection and can be quantified. (Newman, 1998)

According to the book *Research Design* edited by David de Vaus, 2001 (Vaus, 2001), suggests that if the primary goals of a study are to provide a description of a problem or situation, data collection is done and then analysed. The researcher then looks for the patterns in variation without quantifying the data. Two examples of qualitative research are observational method and historical analysis. The author further suggests that if a study aims at measuring the magnitudes in variation using variables which are quantifiable, it is a quantitative research. Such research studies the phenomenon quantitatively and tries to quantify the data collected.

The book *An introduction to the research methodology in humanities* by Mohamadreza Hafeznia, 1996 (Hafeznia, 1996, pp. 55), compares the qualitative and quantitative methods of research. It states that qualitative methods should be involved in researches which are aspiring to research variables, which have not been worked on before, or have very less prior research on, whereas quantitative research should be involved in researches which aspire to work on variables which have been researched on before but need to be tested under different environments or circumstances. Such researches can collect social information about the variables through qualitative means. Qualitative methods can be used to gain new insights or to create new hypothesis and they are good at exploring causal relationships in places where the researcher cannot ascertain the reason for such relationships.

2.1.1.4. CROSS SECTIONAL VS LONGITUDINAL APPROACH

According to the paper *Cross-Sectional Versus Longitudinal Survey Research: Concepts, Findings, and Guidelines* by Rindfleisch, Malter, Ganesan and Moorman, 2008 (Aric Rindfleisch, 2008), a longitudinal research approach is an observational research approach, used to study changes in variables over time. Researchers conduct several observations of the same variable over a time-period to check the changes in the variable. Such research can last many years. Longitudinal studies also aim at establishing the chain of events, which lead to the change in variables over time. An example of such a study has been mentioned in the paper *Cross Sectional versus Longitudinal Data: An Empirical comparison of mean differences in academic growth* by Thomas L. Hilton and Cathleen Patrick, 1969 (Hilton and Patrick, 1969). A Growth Study was conducted at Educational Testing Service in which, the annual scores of fifth graders were recorded. Their annual scores were taken again when they were in seventh, ninth and the eleventh grades respectively. This study aimed at understanding the overall progress in a student's academic growth over the years.

A cross-sectional study, according to the paper *Cross-Sectional Versus Longitudinal Survey Research: Concepts, Findings, and Guidelines* by Rindfleisch, Malter, Ganesan and Moorman, 2008 (Aric Rindfleisch, 2008), is an observational research approach, which studies different variables at only one given point of time. Such studies do not record the changes in one variable over time but multiple variables together, at any point of time. A cross- sectional study has nothing to do with the past of the variables being recorded as well as the future of the variables. Such researches are only concerned with the present of the variables, at the time they are being recorded or observed. The paper *Cross Sectional versus Longitudinal Data: An Empirical comparison of mean differences in academic growth* by Thomas L. Hilton and Cathleen Patrick, 1969 (Hilton and Patrick, 1969) talks about a study conducted in 1966, which studied the annual results of third, sixth, ninth and twelfth grade students. The annual results of different grades of students for one certain year were collected and compared.

2.1.1.5. SHIFT IN RESEARCH PARADIGMS

We have looked at general research methodologies in the previous sections. In this section, we shall explore the shift in research methods from the behavioural to cognitive approaches, from the empirical to rationalistic and from the inductive to deductive. Linguistics as a discipline also changed from the behaviourism to cognitivism and as the new millennium progressed more and more researchers questioned the existence of the consciousness and the mind (Massey, 2017).

In the paper *Figural after-effects in the third dimension of visual space* by Köhler, Wolfgang, and David A. Emery, 1947 (Köhler, 1947, pp. 159-201), it has been suggested that behaviourists use the term stimulus very loosely. Behaviourists state that a response happens as a reaction to a stimulus. The authors, on the other hand state that it is a set of learned responses, which actually act as the response. The brain processes every time it must respond to a certain stimulus and reacts to the stimulus in a similar way, or in a way, which makes the response more favourable. Such responses can be compared to a well-structured field. The authors also suggest that the brain remembers every encounter it has with stimuli presented to it and that it uses prior experiences to react to new ones, something behaviourism cannot prove or substantiate with empiricism. It is only rationalism, which can prove, that there is some underlying mechanism, which is learning the stimulus and remembering a pattern, which again can be compared to a well-structured field. The authors further add that, something psychological must have been going on inside the brain or some mechanism. This exactly has been the focus of cognitivism since its birth.

Tolman, Edward C., and Egon Brunswik in their paper *The organism and the causal texture of the environment*, 1935 (Tolman, 1935, pp. 43) took a different perspective regarding what has been mentioned in the previous paragraph and then arrived at a similar conclusion. The authors suggest that something inside organisms creates a link between what is being perceived and what is being performed. Tolman and Brunswik suggest that rats create a mental representation or cognitive map of environments they are left in. Henceforth, in theory, rats can respond to environments or events or stimuli not by direct motor responses. Instead they respond according to a cognitive model after assessing the significance of the stimuli. They called it molar behaviorism. Watson, as cited in the paper *Behaviorism* by Jay Moore in the journal *The Psychological Record* , 2011 (Moore, 2011, p. 449) suggested that behavior are muscular responsescaused by stimuli, with which the brain has already been associated with. Tolman and Brunswick, on the other hand argue that every stimuli is associated with a response category. For example, if a human learns that an electrode can electrocute him or her, Watson's theory suggests that the person would have learnt a specific conditioned reflex. On the other hand, a molar behaviorist would claim that the person would have learnt a global response for avoidance. To prove which one was correct Delos D Wickens conducted an experiment and spoke about the same in the paper *The transference of conditioned excitation and conditioned inhibition from one muscle group to the antagonistic muscle group* published in *The Journal of Experimental Psychology* 1938 (Wickens, 1938 pp 101). The author exposed participants to a situation in which subjects were exposed to electrodes. On touching the electrodes, an electric shock was given to the participants on which they withdrew their hands. The molecular behaviourism model suggests that the participants would learn a specific reflex to such a situation, which is retracting the hand but the molar behaviourist model suggests that the person would avoid the whole thing altogether. Or in other words, if asked to touch the electrode again, the molecular behaviourism model suggests that the person would touch it again and retract the hand when shock is given, because a response needs a stimulus to happen. But the molar behaviourism model wins the case, hands down. The participants on being asked to touch the electrode again, did not touch it, altogether avoiding it. This proves the fact that participants are expecting results from situations they have encountered before and making situational maps of the same. The participants learned expectancies rather than stimuli response associations. Inductive methods and empirical methods were failing to provide insight into what was making the brain give such responses, as recorded in the above-mentioned experiment.

The most important factor, which pushed behaviourism into cognitivism, was Chomsky's *A Review of B.F. Skinner's Verbal Behaviour*, 1959 (Chomsky, 1959, pp 26-58). BF Skinner in his book *Verbal Behavior*, 1957 (Skinner, 1957) takes a very stimulus response approach to everyday actions and reactions by every living beings. Chomsky not only criticizes the book by Skinner but also provides a more cridible alternative to it. Chomsky states that no behavioral theory can deal with creativity in language. The rules used by one to speak, cannot be learned. Words can be inserted in certain syntactic orders, depending on the language and be spoken. Chomsky states that languages have two levels of existence – deep and surface. Chomsky gives an example of two sentences. 1. John is easy to please and 2. John is eager to please. The word order and surface structures of both the sentences are same and grammatically John is the subject for both the sentences. But, the sentences do not mean the same at a deeper level of existence. Chomsky explains further that John is the logical object of the first sentence while being the subject of the second sentence. Chomsky explains that every speaker would have to understand this deep meaning, he has been speaking about or else, speakers would come up with the following versions of the above-mentioned sentences- 1. To please John is easy and 2. To please John is eager, which is not okay. Chomsky argued that behaviourists had limited themselves with only the surface structures of languages, hence not noticing the deep structures human beings are so prone to using while speaking every day. Chomsky further states that this is exactly why the behavioural scientists cannot answer what lies beyond behaviour because empirical methods cannot substantiate such questions. Chomsky also gives us examples of ambiguous sentences like 'Visiting relatives can be a nuisance'; 'They are cooking apples'; or 'The chicken is ready to eat' and states that the human mind is able to process such sentences, depending on the situation at hand, even when there are two or more meanings for the identical stimuli. We listen to a sentence first, then analyse it grammatically, which happens automatically. The change from behaviourism to cognitivism has brought in new vistas to be experimented with, in the realm of linguistics and opened up new theories, which through the rational, deductive and qualitative approaches lead to the slow uncovering of the human mind.

2.1.1.6. WORKING WITH HUMAN PARTICIPANTS

For every empirical research, primary data is required from the field from participants or informers who would be the sources of information. Any research involving human participants requires the researcher to follow a set of ethical norms which are mandatory for the well-being of the participants and smooth running of the research. There are many documents, national or international which lay down rules and regulations for research with human participants; like

Belmont Report 1978, Helsinki Declaration 2000, CIOMS 2002, UNESCO 2005 and ICMR guidelines specifically for India. The major purpose of such rules and regulations are to mainly protect the rights of the human participants as well as dignity and cultural identity. The book *Research Methods in Clinical Linguistics and Phonetics: A Practical Guide* edited by Nicole Muller and Martin J. Ball, 2013 (Müller and Ball, 2013), writes down a set of rules and regulations regarding the ethical concerns of working with human participants. Following is a list of ethical issues and concerns, which have to be maintained by every researcher, working with human participants. It does not matter if a research does not use invasive procedures, ethical clearance for every research involving human participants is mandatory. Following is an abridged list of ethical concerns to be considered:

1. **Beneficence**: The best interests of participants have to be kept in mind.
2. **Non-maleficence**: the participant has to be kept away from any harm and risk to him or her has to be avoided at all costs.
3. **Autonomy**: Subject has a right to decide whether to take part in a research or not. The subject might also opt out of the research midway.
4. **Disclosure**: the participant has a right to know everything about the research and where data collected from them will be used.
5. **Justice**: if there are invasive procedures involved in a research, the researcher has to ensure that the participants who are being tested have to be treated in case of any sort of sickness. The researcher also has to take care of all the expenses a participant has to undergo because of the research, if any.
6. **Confidentiality**: The names of the participant cannot be used along with the information received from them. Participants can only be named as codes in a research. Researchers are not allowed to use their names.
7. **Competence**: the researcher has to accept responsibility for the quality of work
8. **Integrity**: avoiding conflicts of interest and to keep a transparency in all sorts of communication
9. **Compliance**: the research proceedings cannot change after the research procedures have been sanctioned
10. **Respect**: protecting individual autonomy and accepting differences

The present chapter explains the methodological procedures and approaches followed in the present study. It begins with a brief description of the various general research methodologies, which have evolved over a period, for research in general and applied linguistics and applied-clinical linguistic studies. Sections 2.1.1 to 2.1.3 provide brief introductions to various research methodologies while section 2.1.4 discusses ethical concerns in working with human participants in an empirical research.

Section 2.1 discusses the various research procedures and methodologies, which are, used in general linguistics while section 2.2 discusses the methodologies and procedures, which can be used in applied linguistics, clinical linguistics and neurolinguistics. Section 2.3 discusses the various methodologies, which can be used for the present research, in brief.

Section 3 introduces the present research. Section 3.1 lists down the scopes and objectives of the present study while section 3.2 lists the research questions. Section 3.3 discusses the procedural steps at the level of discourse, at the level of sentences and at the level of words, as in vowels. Section 3.4 discusses the ethical clearance of the present research.

Section 4 gives a detailed description of data elicitation. Section 4.1 explains how the participant selection followed by the inclusion and exclusion criteria. Section 4.2 discusses the language selection, followed by tools and equipment used in the present study. Section 4.2.1.1 to 4.2.1.3 discuss the various linguistic tools being used in the present study like the discourse stories, the sentences being used at the level of sentences for data elicitation and the flash cards being used to elicit words, as in vowels from the participants. Section 4.3 details the recording procedure and sample selection process. It narrates the entire process of the research data collection beginning at random sampling under the supervision of Dr. Goutam Ganguly, followed by GCS and MMSE and then the recording at three levels, namely discourse, sentences and vowels, as in words.

Section 5 describes the details of the analytical procedures used in the present research. It enlists the softwares and how they have been used to find out the means, standard deviations and so on at the three levels of recordings.

The present research looks into the deviations in pitch, as in fundamental frequency at the level of sentences and at the level of vowels, as in words. At the level of sentences, the pitch variations, as in f0 variations in declarative, imperative and interrogative sentences have been looked into. At the level of vowels as in words, the acoustic space of vowels have been studied, in which the acoustic space of RHD participants have been compared to age and gender matched normal controls, as well as the whole control group values. The variables used are the first formant and the second formant of the 7 Bangla vowels. Next, the duration of vowels have been studied. At the level of discourse, pitch variations in the whole discourse have been looked into. Variables looked into are range of pitch, fluency in speech, comprehension ability, digressions, thematic cohesion and spatial and temporal displacements.

2.2. RESEARCH METHODS

Different kinds of research require different tools and methodologies. For example, a research in general linguistics might require tools to collect lexical information from a group of people whereas a phonetic research might require the researcher to collect audio from the persons speaking the language being researched on. A syntactic research might use questionnaire or stimuli tests to conclude the syntactic structure of a language or the grammatical rules and a psycholinguistic research might use introspection and voice or video recording as methodologies to study the participants in a research study (Max Planck, 11). It is also necessary for every researcher involving human participants in their research to get an ethical clearance from competent authorities, namely the Ethical review board for their respective institutions. The researcher has to follow a set of norms and regulations laid out by various institutions like ICMR, for India. These rules have been made in such a way that they protect the participants being involved in any research (their rights, cultural traditions, autonomy, consent and so on). Further information regarding the same can be found in section 1.1.4. Following are the research methodologies, which can be used for the main branches of linguistics in section 2.1, followed by applied neuro and clinical linguistics in section 2.2. Section 2.3 concentrates on the methodologies and tools, which are suitable for the present research. Main section 3 deals in the present research aims scopes and objectives as well as data elicitation and analysis procedures, which include the methodological details and procedures.

2.2.1. GENERAL LINGUISTICS, PHONETICS, SYNTAX, SOCIO AND FIELD LINGUISTICS

Linguistics is the scientific study of language and to study various sections in linguistics, various kinds of research methodologies are needed. Research in general linguistics require either primary data or secondary data. If primary data is required, researchers can look for data through the collection of audio from some source persons, collect results of questionnaires, use surveys and use voting and so on. If secondary data is required, a researcher may approach libraries or look for data in previously completed projects and research. General data collection, which involves audio or video, requires cameras and microphones, which would be able to record and save data. For annotating data various softwares like ELAN (ELAN, 2017) can be used and for saving data, it is suggested that they be saved in portable hard discs as well as on the cloud.

Max Planck Institute has a number of Questionnaires in their own website, which can be used by any researcher for research data collection in general linguistics. Some tests included in it are "The Lingua Descriptive Study Questionnaire", "Adverbial Quantification", "Syntax of Exclamative Constructions" and so on. This website also describes five stimulus tests. Stimulus tests need stimuli to be presented to a person, basing on which questions can be asked. The person being shown the stimuli is then expected to speak back in the target language (the researcher shows items which can only be named or spoken about in one target language, according to the languages used by the participants). (Max Planck, 11)

Databases can be used to deal with a lexicon in given language and softwares like FieldWorks Language Explorers (FLex) by SIL (SIL, 2017) work as data holders. Lexemes can be easily filled into linearized or interlinearised forms according to the need of the researcher. One can create a dictionary using FLex. Other tools like The Linguist's toolbox by SIL or its later reincarnation Toolbox by SIL, can also be used for data consolidation in the field. One can create an encyclopedia using lexemes, along with other entries relating to that lexeme and add pictures to it.

ELAN (ELAN, 2017) is one software, which can be used to annotate field recordings, either to detect syntactic structures later on or to even annotate running sound files or even video. Elan also supports the full use of IPA and hence translations of texts can also be done inside it. Elan supports FLex files as well and hence databases can be imported from FLex to Elan. One might use a handy microphone to collect audio data from the field while documenting a language and later on use ELAN to transcribe the lines recorded along with IPA transcriptions of the same in a different tier.

Toney by SIL can be used to classify spoken forms into phonetic categories and to sort linguistic forms into clusters according to the criteria set by the researcher. For example, allophonic representations of the phoneme [z] can be all grouped together in a set of given sound files, using Toney. There is another method of saving mass data using KURA by SIL, which helps in saving categorized data collected during a fieldwork. (SIL, 2017)

One might use Praat (Praat: Home, 2015) to find out formants, pitch, intensity and other acoustic data from sound files while working with phonological data. Praat can also be used to segment sounds, de-noise sound files and to monitor sound spectrograms for further analysis. Other tools like palatography and electropalatography can help understand the active and passive articulators and the exact regions of articulation.

Linguistic fieldwork also requires the researcher to make the participants feel comfortable. It is absolutely a necessity that the participants feel normal and stable for the researcher to record unbiased opinions, recordings or videos. For example, suppose a person is shy of being recorded in a research where the researcher is recording sound files to find out peripheral vowels. If the participant is not speaking the way he or she speaks normally, it would entail some prejudice in the data for that research. It can skew the entire data of the research. (Max Planck, 11) Under circumstances when the participant being researched on, is a tribal or from an extremely backward region, they must be made to feel comfortable. A working rapport with the participant and the researcher can ease up the process of data collection largely.

2.2.2. APPLIED, CLINICAL, COGNITIVE AND NEURO LINGUISTICS

According to the website *Definition of Applied Linguistics* accessed on the 11th of Feb, 2017, interdisciplinary field like applied linguistics cover a wide variety of language related issued and problems. Applied linguistics aims at understanding how different variables pertaining to language tend to mould or change one's life. Applied linguistics uses a variety of methodologies, tools and procedures from various disciplines. It used methods and procedures from humanities as well as from natural and social sciences. (Definition of Applied Linguistics, 2017)

Language assessment tests aim at understanding the linguistic competence and performance of an individual in a target language. Tests like the ETS TOEFL (TOEFL, 2017) assess the ability of an individual in the English language. TOEFL aims at understanding the efficacy of an individual in reading, listening, speaking and writing in English. Such tests can be used for immigration purposes, for jobs in foreign countries, for education purposes or to diagnose the total ability of a person in a certain language. Unbiased literacy tests can test the abilities of an individual in a target language and let the researcher know how much of a fluent user the participant is or not.

According to the paper *Theory and Praxis of Discourse Analysis* on the website *Master of Advanced Studies in Linguistics* accessed on the 12th of Feb, 2017, discourse analysis is a branch of linguistics, which tries to identity, and break down discourses in either texts or audios. However, linguists generally prefer discourse analysis to be done in a 'natural' setting where the participant is normal and not under stress of performance. Discourse analysis involves recording participants under normal conditions and for naturally occurring conversations. The text can later be analysed for micro and macro themes in the discussion, the contexts and their relation to the discussion, how much of problems are being discussed, the pragmatics of uttered sentences and so on. There are other factors like fluency, digressions, the ability to comprehend and the ability to adhere to the theme of a discourse, which can also be looked into. (Theory and Praxis of Discourse Analysis, 2017)

Language pedagogy deals in various methodologies possible of teaching languages. Throughout the course of history there have been various methodologies followed while teaching languages to individuals. The most famous among them are the grammar translation method, where a language is taught through the prescriptive rules that come along with it. A person is taught the grammatical rules of a language and along with it, bits and parts of vocabulary. The person has to use the grammatical rules to build meaningful grammatical sentences. This takes time and is a long process. The second method that is much more widely accepted is the situational method which needs the learner to be placed in a situation which needs him or her to use the target language under pressure. He or she can be supplied words and phrases along with short translations of them and they have to use the language they do not know because the situation needs it to be that way. For example, students aspiring to learn German learn the language much faster if they are taught under the supervision of a German teacher who denies to speak in a language the students know, instead speaking in German and then handing over a dictionary to the students, who can use the dictionary to learn the phrases and then use it. Learning the grammar of the language comes later on in this approach. The direct method is used in some places, where learners are made to repeat phrases after the teacher and then they are told the meaning. This creates a reinforcement in the minds of the learners and they learn the phrases repeated aloud. (Language pedagogy, 2017)

Second language acquisition studies use methodologies, which can diagnose the progress of a learner in his or her second language. Such studies are longitudinal studies and require the participants to be under close observation. (Second Language Acquisition, 2017)

The Webster Merriam dictionary defines cognition as the ability of a person to think, understand, learn and remember (Cognition, 2017) Cognitive Linguistics delve into the efficacy of participants in the abovementioned functions and how their impairment can lead to a disruption in the normalcy of it. Memory tests look into the ability of a person in his or her semantic memory, episodic memory, procedural and priming memory, perceptual learning memory and the working or the short-term memory. Some memory tests are 'California Verbal Learning Test', 'Cambridge Prospective Memory test' and the 'Memory Assessment Scales', 'Kolkata Cognitive Screening Battery'. (Cognitive Sciences, 2017)

The website *Rapid Automatized Naming Tests: What You Need to Know* accessed on the 11th of Feb, 2017 states that rapid automatized naming or RAN is the ability to quickly name a series of familiar objects. RAN tests aim at an individual's speed and accuracy in naming familiar objects and the results of such a test can predict the efficacy of a person in further reading exercises, or in general. (Rapid Automatized Naming Tests: What You Need to Know, 2017)

In the webpage, *Perceptual learning* in the website *Encyclopedia Britannica* accessed on the 11th of February 2017, it has been stated that Perceptual learning refers the ability of an individual to respond to a stimuli with the use of sensory systems, while the response is being improved over time with experience. Such kind of learning can change the way individuals react to situations and to specific stimuli. Individuals can find better and more effective ways of reacting or responding to a subject over time. Longitudinal researches can be conducted to understand how an individual reacts to certain stimuli over time. (Perceptual learning, 2017)

Clinical and neurolinguistic studies require many clinical procedures. These kinds of studies generally involve participants with some sort of clinical disorders or damages. Such studies can collect data from participants in a wide variety of ways, using methods like neuroimaging results, audio or video recordings, acoustic phonetics as a parameter to determine acoustic space or pitch graphs, cognitive tests to understand the levels of damage in one's brain or regions and then correlating the data with that of neuroimaging results and so on. (Müller and Ball, 2013)

Aphasia is an envelope term for all sort of speech disorders resulting from insult or injury to language centres in the brain like the Broca's area or the Wernicke's area. There are different kinds of aphasia which can result in damage to various language centres like Broca's aphasia or Wernicke's aphasia or global aphasia. Boston Diagnostic Aphasia Examination and the Western Aphasia Battery are two common ways to diagnose aphasia. (Aphasia, 2017)

The webpage *Schizophrenia Screening Test* on the website *Psych Central* accessed on the 11th of February, 2017, states that schizophrenia can be tested through a series of questions or by close monitoring of an individual. There is no direct or short cut way of diagnosing schizophrenia in an individual because it is a group of very complex mental disorders. Schizophrenia can be caused by a multitude of factors and it can manifest as delusions, hallucinations, disorganised speech and behaviour, coma like daze or any sort of bizarre or hyperactive behaviour. There are rudimentary tests though, like the 'Schizophrenia Screening Test' (Schizophrenia Screening Test, 2017)

The Webpage for The DSM V or *Diagnostic and Statistical Manual of Mental Disorders* in the website *DSM Library*, accessed on the 11th of February, 2017 states that the DSM, in its fifth revised edition, is relied on by clinicians, researchers and doctors for its ability to diagnose most disorders pertaining to mental insult, injury or other reasons. It does not take a prescriptive approach to the diagnostics of a disorder and takes a multi axial approach. (Diagnostic and Statistical Manual of Mental Disorders , Fifth Edition, 2017)

- **Axis I**: All psychological diagnostic categories except mental retardation and personality disorder
- **Axis II**: Personality disorders and mental retardation
- **Axis III**: General medical condition; acute medical conditions and physical disorders
- **Axis IV**: Psychosocial and environmental factors contributing to the disorder
- **Axis V**: Global Assessment of Functioning or Child Global Assessment of Functioning

Neurolinguistics as the term suggests can be studied with tools from both the disciplines. Tools like the fMRI can be used to check the oxidation levels in the brain through the use of magnetic resonance, while linguistic tools audio recording can record the utterances of a person. Suppose a person has suffered damage to a certain region of the brain. An fMRI machine can be used to check the exact regions of damage along with the amount of change the person has suffered in speech terms. Other tools like PET, WADE also serve similar purposes.

The Mini Mental State Examination or MMSE is a very common way to test problems of memory loss and other related mental abilities. It lets a researcher understand if an individual is suffering from dementia or not. Prior medical records of a person can further substantiate the results of an MMSE exam. There are various questions in an MMSE exam, the full marks being 30. A score of 27 or more is expected from undamaged individuals with no dementia. There is a Hindi version of the MMSE exam available in India called the Hindi Mental State

Examination (Ganguli et all, 1993). (The MMSE test, 2017). A copy of the MMSE has been displayed in the Appendix.

The Glasgow Coma scale is a test, which can be administered only by clinical persons on patients and participants to understand the extent of coma. GCS can actually help a researcher understand how terminally ill a participant is. The scores are distributed as such: Eye (4), Verbal (5), and Motor (6). The maximum score is 15. A score of under 11 is considered critical. A score under 8 is considered fatal. A score under 15 needs urgent attention and care. (Glasgow Coma Scale/Score (GCS), 2017) The NIMHANS neurophysiological battery serves a similar purpose. (Rao SL, Subhakrishnan DK, Gopulkumar K, 2004). A copy of the GCS has been displayed in the Appendix.

2.2.3. METHODOLOGIES WHICH CAN BE USED FROR THE PRESENT STUDY

The present study is a neurolinguistic study, which uses tools and methodologies from general linguistics as well as neurolinguistics. Flash cards and images have been used to elicit data from the participants in the field. The participants have been asked to name a few objects from images while in other cases, they were asked to read out full sentences written down on flash cards. The present research also uses audio recordings to find out the pitch variations in Bangla speaking cases of Right Hemisphere Damage through the use of Praat, to analyze the formants, the pitch and other acoustic data in the recordings.

Recordings have been conducted at three levels, namely, at the level of discourse, at the level of sentences and at the level of vowels, as in words. At the level of discourse, the participants were required to listen to two short stories and then answer questions pertaining to the story, as well as narrate the story back to the researcher. At the level of sentences, the participants were required to read out sentences written in Bangla, from flash cards being displayed to them, while being recorded. At the level of words, as in vowels, the participants would have to read out the name of pictures or things in pictures being shown out to them.

2.3. THE PRESENT RESEARCH

The present study falls under the broad area of neurolinguistics. It is an empirical study which involves the collection of primary data from right hemisphere damaged participants (to be referred to as RHD subjects) along with age and gender matched normal controls preferably from the same family as the RHD subjects. It is a quantitative study but not a longitudinal study. It is a cross sectional study.

2.3.1. SPECIFIC OBJECTIVES AND SCOPE OF THE STUDY

The present research primarily studies pitch and pitch variations at the level of discourse, sentences and vowels in words. We have also studied fluency at the level of discourse. Along with these main parameters we have also observed other parameters like thematic digressions, questions answered at the level of discourse and vowel durations at the level of vowels in words.

The present research looks into the deviations in pitch, as in fundamental frequency at the level of sentences and at the level of vowels, as in words. At the level of sentences, the pitch variations, as in f0 variations in declarative, imperative and interrogative sentences have been looked into.

At the level of vowels as in words, the acoustic space of vowels have been studied, in which the acoustic space of RHD participants have been compared to age and gender matched normal controls, as well as the whole control group values. The variables used are the first formant and the second formant of the 7 Bangla vowels. Next, the duration of vowels have been studied.

At the level of discourse, pitch variations in the whole discourse have been looked into. Parameters looked into are range of pitch, fluency in speech, comprehension ability, digressions, thematic cohesion and spatial and temporal displacements.

We documented the places of lesion in the RHD participants, along with the exact prognosis given by the specialist. The place of lesions might help correlate the areas of brain damage for the participants enlisted in the present research later on.

The following are the specific aims of the present study:

1. At the level of vowels, as in words, the recordings include all the vowels of the Bangla language, so that the formant 1 and formant 2 can be used to find out the acoustic spaces of vowels and the vowel durations. There are 7 vowels in Bangla.
2. Three types of sentences have been recorded in the present study, namely, declarative, imperative and interrogatives. 3 samples of each kinds of sentence has been recorded thrice.
3. At the level of discourse, the pitch range (maximum f0 - minimum f0), mean and Standard Deviation have been found out, to check the effect of RHD on discourse.

2.3.2. RESEARCH QUESTIONS

1. How does RHD affect the use of pitch in verbal communication and fluency?
2. How does RHD affect the use of pitch at the level of segments (primarily vowels), at the level of words and sentences?
3. How does RHD affect pitch at the level of discourse in connected speech?

2.3.3. PROCEDURAL STEPS FOR THE THREE COMPONENTS OF THE STUDY

2.3.3.2. DISCOURSE

The discourse section for the present study required the RHD participants as well as the normal controls to listen to a story narrated by the researcher and then answer a few questions pertaining to the narrated passage. The participants were also required to narrate the story back to the researcher, which was recorded by the researcher for further being analyzed. This required two very short stories which have been translated into Bangla, along with the pertaining questions. Further details about the same can be found in section **4.3.**

2.3.3.3. SENTENCES

The sentence section of the present research requires the researcher to show 9 flash cards to the RHD participants as well as normal controls for 3 declarative sentences, 3 interrogative sentences and 3 imperative sentences. The flash cards had the sentences written down in large Bangla fonts. The participants just had to read out the sentences on the flash cards while they will be recorded. Further details of the same can be found in section **4.3.**

2.3.3.4. VOWEL SOUNDS AND ACOUSTIC SPACES

The vowel and acoustic spaces part of the present research requires the researcher to display pictures to the RHD participants as well as normal controls for eliciting words. The participants named the pictures, which were shown to them and their voices were recorded for the present research. Sometimes the participants were asked questions pertaining to the pictures shown to them, to elicit the correct word. Further details on the same can be found in section **4.3.**

2.3.4. ETHICAL CLEARANCE

Any research involving human participants, being done by JNU students requires and ethical clearance from the JNU Institutional Ethics Review Board (IERB). A detailed description of the research proceedings and the involvement details of the participants have to be stated to the JNU IERB while presenting one's research proposal to be granted an ethical clearance. The ethical clearance for the present research has been granted by IERB, JNU.

Every human participant has the right to know, if he or she has to be subjected to research proceedings. If a participant has been selected for a certain research, the participant has the right to know about the subject matter of the research and what all information is required from him or her for the whole research proceedings. The participant also has the right to know how the information taken from them will be used in the course of the whole research. For working with human participants, other than being granted an ethical clearance from JNU IERB, a researcher also needs a PIS ICF form. When a participant agrees to provide information for a certain research, he or she has to sign a form with detailed information about the research (including information like a brief introduction, research objectives, nature of involvement of the subjects and how the information will be used). The PIS ICF form, which has been sanctioned by the JNU IERB, for the present research has been displayed in the appendix for the present research. (separate PIS ICF forms have been used for the RHD participants and the control group).

2.4. ELICITATION PROCEDURES

2.4.1. PARTICIPANT SELECTION

Preferably, monolingual Bangla speaking participants who have damage to the right hemisphere of the brain, have been selected. Controls chosen are generally members of the same family with age and gender matching. In case no one from the same family was found deem for the research according to the parameters mentioned above, control participants were chosen from the same socio- economic background.

Monolingual participants are rare to come across, but in particular this research needs monolinguals or in case they are not found in plenty, participants speaking the Bangla as the first language, without any or less influence from their second language, would be selected. This would only be possible in the lower middle class or lower class families.

There are no enrolment criteria but only participants willing to sign the PIS ICF after listening to the research details would be recorded and allowed to participate.

The research recordings began with a random sampling target of around 80 (a sum of both RHD group and controls together) but the final number of select samples has changed due to factors like – participants leaving the recordings mid-way, problems in recording and loss of data; although the number of samples lost are not huge.

The present research also uses the test results of previously done neuro-imaging tests done by the participants to categorize the participants in the study. Data analysis has been done in Microsoft Excel. Further details on the present research can be found in section 3.

2.4.2. INCLUSION AND EXCLUSION CRITERIA

Primarily, the research data elicitation began with random sampling. The inclusion criteria had been set after a few random samplings. The Mini Mental State Exam ensured the current state of the participants, both RHD and healthy participants, and a score of 27-28 would ensure, that they are not suffering from any other sort of disorders which might sabotage the data. The Glasgow Coma Scale with score of at least 11 would also ensure similar levels of severity of all participants and that no participant is under coma, which might sabotage the data.

The exclusion criteria would make sure that participants in the ICU would not be selected, or participants with extreme disabilities. The other criteria have been determined after the random sampling phase.

Inclusion Criteria	Exclusion Criteria
RHD	LHD, Global
One month post trauma	Severe cases in ICU
18 years and above	Children and participants above 82 years
Bangla speakers monolinguals	Good proficiency in second language
Volunteering for ICF	No consent
MMSE score of 24-30	MMSE scores under 24
GCS score at 11	Participants with dementia

2.4.2.2. RHD PARTICIPANT CASE STUDY AND CONTROLS

To acquire a steady flow of participants, Bangur Institute of Neurosciences, Kolkata was approached. Dr, Goutam Ganguly, from the above-mentioned institute has acted as a co-supervisor to the present research. The participant selection procedure according to the inclusion and exclusion criteria have all taken place under his supervision. Participants have been documented in details. A specific format for documenting participants has been created and used. Such forms for all participants have been filled up with details of the subject like the place of lesion or lesions, the time post incidence, the present condition, the symptoms and so on. In the primary information section, name, age and gender of the subjects have also be documented, although this is purely for documenting the data and related purposes. The names of the participants have not been used in the present research; instead codes have been used.

The prognosis of the imaging results of the participants have been documented for categorizing the participants.

Controls for the present research have been selected, ideally from the same family, matching the participants in gender and age. In case, no age and gender matched controls were available from the same family, participants from the same socio-economic background have been used.

2.4.2.3. CODING THE PARTICIPANTS

Only voice recording from participants were required. MRI and CT scans were used in identifying the inclusion criteria for the participants. Everything received from the participants have been kept confidential. We also could not display the signed informed consent forms of the participants due to the fact that the abovementioned forms have their names and hence displaying them would result in not being able to protect their confidentiality. Participants have been coded according to the following table:

Serial number	Name initials	Age	Gender	R / C
00	AB	50	M	R
01	AC	55	F	C

The above table explains the process of coding the names for the participants in the present study. The unique serial number for every participant is an 8-digit code. The first two digits are allotted according to alphabetical order of the participants. The initials of the name have engaged the next two digits. The next two digits have been used by the age followed by a single digit for gender. The last digit is either R (signifying RHD) or C (signifying controls). For example, 00AB50MR, 01AC55FC as stated in the table above.

2.4.2.4. PARTICIPANT PRIMARY INFORMATION FORM

An easy form had been created and it has been used to document the primary details of every participant recorded in the present research. The following is the form that has been used. This form shall not be furnished in the published works and in later publications. This form has served only as a means of storing data with the proper paraphernalia.

PARTICIPANT PRIMARY INFORMATION

Name	Name of the participant
Age	the age of the participant

Gender	Male/ Female
Primary Patient testing at	Name of the first place the participant was treated at
Patient Recorded at	Place where the participant was recorded
Region of damage	The name of the region damaged after stroke
Scan Type	CT Scan/ MRI Scan
Time Post Incidence	Time in months or days (whichever necessary) after the stroke

HISTORY OF SUBJECT

Approximate date of the stroke

The place of the damage (with exact words from the scans)

The participant's profession and economic/ financial status

CONDITION OF SUBJECT

- MMSE scores of the subject
- GCS scores of the subject

2.4.3. LANGUAGE SELECTION, TOOLS AND EQUIPMENTS

The language selected for the present research is Bangla and preferably, monolingual Bangla speaking participants who have damage to the right hemisphere of the brain, would be selected. It is important to notice here that monolingualism in India is very scarce. Participants who generally depend on Bangla as their mother tongue (or use Bangla for most of the times) an have a working knowledge of another language (for work or for other purposes) and use it scarcely, have been initiated into the research mostly. It is also important to note that, the participants selected have very less or no influence from their second language on the first language.

Any kind of research requires certain tools and instruments. Tools and instruments include all sorts of paper questionnaires, reading lists, test batteries and so on. They also include all sorts of technological help and software, hardware used for recording and analysing and so on. The following sections discuss the various kinds of tools and instruments used in the present research.

2.4.3.2. RESEARCH TOOLS AND PROCEDURES FOR LINGUISTIC RESEARCH

A reading list was required for the present research. The reading list had to contain two short stories for discourse recordings; 3 types of sentences with 3 samples each and words containing all peripheral vowels in the Bangla language. A list of words and sentences were carefully selected for the recording process. The words selected would help find out all the vowels. Three kinds of sentences would ensure uniformity in the pitch ranges. The two short stories required for discourse recordings, a list of 7 words and 9 sentences have been attached below.

2.4.3.2.1. DISCOURSE

A list of two very short stories with 5 questions have been prepared to test discourse abilities of the RHD participants. First a story would be narrated to the participants and then questions would be asked to them. The participants would be marked on the basis of their ability to answer the questions correctly. It is important to notice that primarily only one story would be told to them followed by 5 questions. If they can complete this task, only then the second story would be told to them followed by the 5 next questions. The second story would be a bit more complex than the first story.

The Hart and the Hunter

The Hart was once drinking from a pool and admiring the noble figure he made there.

"Ah," said he, "where can you see such noble horns as these, with such antlers! I wish I had legs more worthy to bear such a noble crown; it is a pity they are so slim and slight."

At that moment a Hunter approached and sent an arrow whistling after him.

Away bounded the Hart, and soon, by the aid of his nimble legs, was nearly out of sight of the Hunter; but not noticing where he was going, he passed under some trees with branches growing low down in which his antlers were caught, so that the Hunter had time to come up.

"Alas! Alas!" cried the Hart: "We often despise what is most useful to us"

1. What animals were mentioned?
2. What was the deer doing?
3. Why did the deer run?
4. Why was he caught?
5. What was the deer insulting, in the beginning?

একটা হরিণ ছিল। সে তার শিংটা খুব ভালোবাসতো। একদিন পিপাসা পাওয়া তে হরিণটা নদীর ধার এ গেলো। তারপর নদীর ধার এ গেলো জল খেতে । তখন নিজের প্রতিচ্ছবি টা দেখতে পেলো । নিজের শিং দেখে খুব খুশি হলো হরিণটা আর খুব প্রশংসা করলো হরিণটা । তারপর আর একটু এগোনোতে হরিণ টা নিজের শরীর টা দেখতে পেলো আর নিজের পাতলা পা গুলো ও দেখতে পেলো । হরিণটা নিজের পা গুলো দেখে খুব দুঃখ পেলো আর খুব নিন্দা করলো নিজের পা এর । পা গুলো এতো পাতলা যে মানায় না হরিণটার সুন্দর শিং তার সাথে । এসব হতে হতে হঠাৎ একটা শিকারী পেছন থেকে একটা তীর মারলো হরিণটার দিকেই তবে তীর টা সামনে দিয়ে বেরিয়ে গেলো । হরিণটা ভয় পেয়ে দৌড়াতে শুরু করলো আর শিকারী টা তারা করলো হরিণটা কে । দৌড়াতে দৌড়াতে হরিণটা জঙ্গল এর মধ্যে ঢুকেই গেলো আর তারপর একটা লতা পাতা ঝোপ এর মধ্যে হরিণটার শিংটা আটকে গেলো । হরিণ টা আর ছাড়াতে পারলো না শিং টা কে। শিকারী টা ধরে নিলো হরিণ টা কে । হরিণ টা বুঝতে পারলো যে যার প্রশংসা করছিলো সেই ধরা পরিয়ে দিলো হরিণ টা কে র যার নিন্দা করছিলো সে এ হরিণটাকে দৌড়াতে সাহায্য করছিলো।

1. কোন পশু কে নিয়ে এই গল্প টা?
2. হরিণ টা কি করছিলো?
3. হরিণ টা পালালো কেন?
4. হরিণ টা কেন আটকে গেলো?
5. হরিণ টা কার নিন্দা করেছিল?

The Frogs Desiring a King

A few frogs lived happily in a marshy swamp that was perfect but then they started to look for a king who would rule them. They prayed to God to give them a king. God sent them a big block of wood and it fell right into the marsh. At first, they were afraid of its size but then they slowly got used to it and realized it was not moving. They finally, climbed to the top of it and conquered their king. They prayed to God again, this time asking for a live king who would actually rule over them. Now this made Jove angry, so he sent among them a big Stork that soon set to work gobbling them all up.

Then the Frogs repented when too late.

1. What animals were mentioned?
2. Where did the frogs live?
3. What did the frogs want the first time?
4. What did the frogs want the second time?
5. Why did the frogs die?

অনেক ব্যাঙ থাকতো একটা ডোবা তে | তাদের খুশির অভাব ছিল না আর তারা নিজেরা সারাদিন মজা করতো | হঠাৎ একদিন তাদের মনে হলো তাদের একটা রাজা দরকার | এই জন্য তারা ভগবান কে প্রার্থনা করলো আর চাইলো যে তাদের একটা রাজা পাঠানো হোক যে তাদের ওপর রাজত্ব করবে | ভগবান কি না কি ভাবছিলো আর অন্যমনস্ক হয়ে একটা বিশাল বোরো গাছের দল ডোবা টা তে ফেলে দিলো | ব্যাঙ গুলো প্রথম এ ভয় পেলেও পড়ে বুঝলো যে ইটা নড়ছেনা আর জীবিত নয় | কয়েকটা সাহসী ব্যাঙ ডাল টার ওপর এও উঠলো | তারা বুঝতে পারলো যে রাজা কোনো কাজ এর না| আবার ভগবান কে প্রার্থনা করলো রাজার জন্য, তবে এবার এমন রাজার যে সত্যি এ রাজত্ব করবে আর তাদের দমিয়ে রাখবে | এই শুনে ভগবান এর খুব মাথা গরম হলো যে তারা খুশি না | ভগবান তাদের ডোবা তে একটা সার্স পাখি পাঠিয়ে দিলো | পাখি টা পৌঁছাতে পৌঁছাতেই ব্যাঙ গুলো কে খেতে লাগলো | ব্যাঙ গুলো বুঝলো আর ভেবে লাভ নেই, যা ভুল হওয়ার হয়ে গেছে |

1. কেন পশু কে নিয়ে গল্প টা?
2. ব্যাঙ গুলো কোথায় থাকতো?
3. ব্যাঙ গুলো কি চেয়েছিলো?
4. দ্বিতীয় বার কি চাইলো ব্যাঙ গুলো?
5. ব্যাঙ গুলো সব মারা গেলো কেন?

2.4.3.2.2. SENTENCE

The present research would work with three kinds of sentences, namely declaratives, imperatives and interrogatives. The present research would record three sentences each from the aforementioned 3 kinds of sentences, equalling in a total of 9 sentences from every participant. Following is the list of sentences, which has been used.

DECLARATIVE

Sentences		**Meaning**
1.	ɑmi bʰɑlo ɑcʰi	I am in good health.
2.	ɑmɑr bari ʃɔhore	I live in the city.
3.	ɑmi bʰɑt̪ kʰɑi	I eat rice.

IMPERATIVE

Sentences		**Meaning**
1.	ed̪ike eʃo	Come here.
2.	d̪ɔrɟɑ tɑ kʰolo	Open the door.
3.	ɑmɑke ɟɔl d̪ao	Give me water to drink.

INTERROGATIVES

Sentences		Meaning
1.	t̪omɑr nɑm ki?	What is your name?
2.	t̪omɑr bɑri kot̪ʰɑe?	Where do you live?
3.	t̪umi kot̪ʰɑ t̪ʰeke ɑscʰo?	Where are you coming from?

1. *আমি ভালো আছি*
2. *আমার বাড়ি শহরে*
3. *আমি ভাত খাই*
4. *এদিকে এস*
5. *দরজা টা খোলো*
6. *আমাকে জল দাও*
7. *তোমার নাম কি***?**
8. *তোমার বাড়ি কোথায়***?**
9. *তুমি কথা থেকে আসছো***?**

2.4.3.2.3. WORDS

The present research has recorded 7 words each from all the participants in order to procure the vowel sounds in the words. The words were chosen with stop consonants on either side of vowels. The list of words are as follows:

Vowel	Word	Meaning
/i/	/tip/	Ornamental or religious mark on the forehead
/e/	/pet/	Stomach
/æ/	/æk/	Numerical one in Bangla
/ɑ/	/kɑtɑ/	To cut
/ɔ/	/tɔk/	tangy
/o/	/kopi/	cabbage
/u/	/kukur/	dog

The following pictures were used (displayed to the participants) to elicit words from the participants.





/tip/ /pet/ /tæk/ /æk/ /kɑta/



/tɔk/ /kopi/ /kukur/

1. টিপ্
2. পেট
3. এক
4. কাঁটা
5. টক
6. কপি
7. কুকুর

Linguistic research requires recording equipment and softwares. Linguistic research requires the ability to transcribe spoken speech for further analysis using various softwares like Praat, Goldwave and Elan. Praat for Mac and Windows (Boersma, 2001) has been used for analyzing the formants and pitches of the recordings. Praat is a free software for analyzing and doing phonetics on personal computers. (Praat: Home, 2015) Goldwave is a free distributable software for very good quality sound recording along with advanced editing options. Noise reduction, if done in samples, have been done using this software. (Goldwave Home, 2015) Microsoft Excel was primarily used to save the primary data after being processed from Praat. Microsoft Excel, a program based on spreadsheets helps in creating the charts necessary to compare two groups of data. (Excel: Create Order, 2015) The main research has been written with the help of Microsoft Word. Microsoft Word is an efficient document handling program. (Word: Write On, 2015) Primary recording has been conducted with a ZOOM H1 field recorder. It is a handy microphone with functions like low cut and PCM lossless recording formats. The format values and the pitch values are being stored in an Excel document on the computer. The files will also be saved to the Microsoft Cloud for safekeeping.

2.4.3.3. RESEARCH TOOLS AND PROCEDURES FOR NEUROLINGUISTIC RESEARCH

Research in the area of Neurolinguistics primarily requires an ethical clearance from JNU IERB. The researcher has to get ethical clearance from JNU IERB and only then can he or she involve human participants in the research. For the present research, ethical clearance has been received from IERB, JNU, the scan of which has been attached below.

A set of two short stories, 9 sentences (3 each of declarative, imperative and interrogative) and 7 words for vowels are needed in all for the recording phase, for the participants. A Zoom H1 field recorder has been used at the field for recording data.

Recording patients with brain damage requires extra attention. As a precaution this research has made sure a family member of the RHD participants would always accompany the participants while they were being recorded.

Neurolinguistic research also requires researchers to work with human participants who might or might not be in their best mental or physical state. It is required on the part of the researcher that the researcher shows extreme patience while dealing with the participants. There might be situations where the RHD participants might suffer an emotional breakdown, burden or feel fatigued or might feel unwell generally. Under such circumstances, the participants would be given time to recover and feel better. It would be in the best interests of both the research and the researched that the RHD participant be interviewed on another date, in another sitting. The pictures used while eliciting data would be selected in such a way, that the participants do not feel threatened or unwell or scared in any way. In general, any sort of discomfort would not be caused to the participants. If any discomfort is noticed, the recordings would be best avoided for that particular sitting.

2.4.3.4. RECORDING PROCEDURE AND SAMPLE SELECTION

As mentioned earlier, Dr. Gautam Ganguly as worked as the co-guide for the present research. He is a neurologist at the Bangur Institute of Neurosciences, Kolkata. He has helped in selecting the proper participants, who fit the inclusion and exclusion criteria.

The first one week at the field was dedicated to random sampling which gave us a better idea into the influx of participants for the present research. Dr. Ganguly would primarily talk to the participants fitting the inclusion exclusion criteria, about the research and conduct the GCS test on them. If the participants would perfectly fit the inclusion and exclusion criteria, and would agree to participate in the present research, the PIS ICF form would be filled up and completed. After permission was granted by the participants, the next step would involve the MMSE test, which can be administered by a non-clinical person legally. In the course of the present research, the MMSE tests were conducted by the researcher. If the participants displayed scores of around 25-30 they were then recorded for discourse, sentences and vowels, as in words. The above-mentioned steps took take place under the supervision of Dr. Ganguly. The next steps involved the researcher to go to the residences of the participants for good sound samples and recordings with less ambient noise, as well as the comfort of the participants.

The recording procedures began by making the participants feel comfortable. The participants were first spoken to about the whole research. Once the participants were ready to record the actual recording procedures were started.

The discourse recordings included the narration of two short stories to the participants and then asking them 6 relevant questions, based completely on the narrated story. If participants could answer all the questions from the first story properly, only then they were narrated the next story and asked the following set of 6 questions. Audio recorded from the discourse recordings do not include the narrator telling the story but only the responses from the participants.

The sentence recording process required the participants to read out what was written on flash cards for three different types of sentences. Big flash cards with the Bangla text was shown to them and then, they would read out what was written on the cards. In case, the participants would have no knowledge of the written script they would be asked to repeat after the narrator. This research required participants, to not mimic the intonation patterns of the narrator, and hence the participants were requested to repeat the sentences after the narrator narrated them, in a way they would tell it normally.

The word recordings involved showing flash cards to the participants who then identified the name of the things shown, which were in turn the target words.

The control recordings involved the exact same procedures. But since, the controls were normal individuals in comparison with the RHD group, their recordings could be completed in one session.

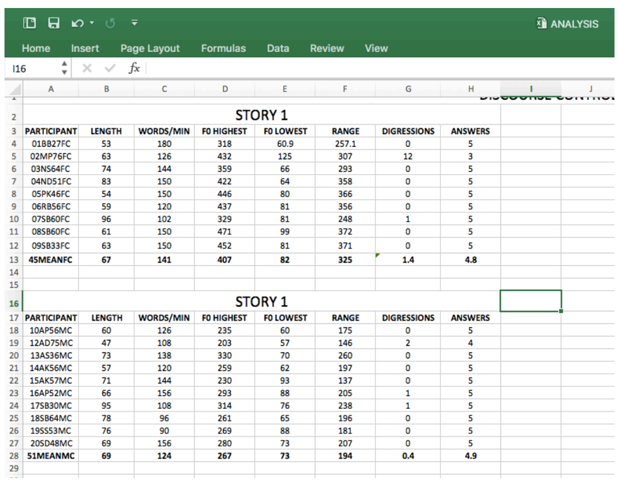
2.5. ANALYTICAL PROCEDURES

A plethora of analytical procedures have been used in the present research. This section enumerates all processes used to extract data from the recordings, in order to be used in statistical methods. This section has been divided into three subsections, one for the level of discourse, one for the level of sentences and one for the level of vowels. Each section describes how the data have been extracted from the recordings made from the participants, along with images, wherever necessary.

2.5.1. DISCOURSE

The following process explains the total details of how information was recorded and then extracted from the recordings, at the level of discourse, from the participants. One story was read out to the participants and then 5 pre-determined questions were asked. The correct and incorrect answers were written down. The participant was then asked to narrate back the story, which was completely recorded, along with help from the narrator, in case the participant forgot or made a digression. Same process was repeated with the second story. The recordings were then saved onto a hard disc, to be analyzed, in the steps as follows. The recordings were imported to Praat, after which they were all selected one by one and edited with 'view and edit', from the right side of the Praat window. In the 'view and edit' mode the recordings were cut to the portions in which, only the participant's portions of speech were present. It is important to note that gaps in speech were not cut down. Only portions of speech by the narrator were cut out from the discourse, either at the beginning or at the end of the story. Pitch is denoted by the blue dotted line. Pitch should not be calculated where the participant displays emotions or falsetto speech. We should choose a portion where the blue pitch line looks consistent and the crests and troughs look consistent (no unnatural peaks). The selection has to made manually because these recordings were made in natural environments, which might have had ambient noises. It is necessary to listen to the audio and make a manual selection because that would help us rule out that possibility that a non-human sound is not being studied. Pitch or f0 was found out by hitting get pitch from the Pitch drop down menu. A new dialogue box, with the value would open every time such a command was placed. The values were then pasted to an Excel sheet, accordingly, keeping into account the codes of the participants. The same procedure was then repeated again, only this time, it being to find out the lowest pitch values. These values were also copied and pasted from Praat to Excel. The total duration of the stories was found out by looking at the bar below the spectrograms, which house the time periods.

These values were then pasted to an Excel sheet. The total number of words spoken by participants, were manually calculated by listening to the recording and then counting the number of words spoken by them. The values were then pasted to an Excel sheet. The total number of digressions were also found out by listening to the recordings. The total number of digressions were then pasted to an Excel sheet. The total number of answers, made by the participants to the discourse questions were already noted down at the time of the actual recordings. These values were pasted to the same Excel sheet. Now that all the values, pertaining to discourse recordings, were pasted to an excel sheet, the statistical analysis began. All the values were compared among the participants in bar graph form. Bar graphs were made for all the five parameters mentioned above and the comparisons were made.



STORY 1

PARTICIPANT	LENGTH	WORDS/MIN	F0 HIGHEST	F0 LOWEST	RANGE	DIGRESSIONS	ANSWERS
01BB27FC	53	180	318	60.9	257.1	0	5
02MP76FC	63	126	432	125	307	12	3
03NS64FC	74	144	359	66	293	0	5
04ND51FC	83	150	422	64	358	0	5
05PK46FC	54	150	446	80	366	0	5
06RB56FC	59	120	437	81	356	0	5
07SB60FC	96	102	329	81	248	1	5
08SB60FC	61	150	471	99	372	0	5
09SB33FC	63	150	452	81	371	0	5
45MEANFC	**67**	**141**	**407**	**82**	**325**	**1.4**	**4.8**

STORY 1

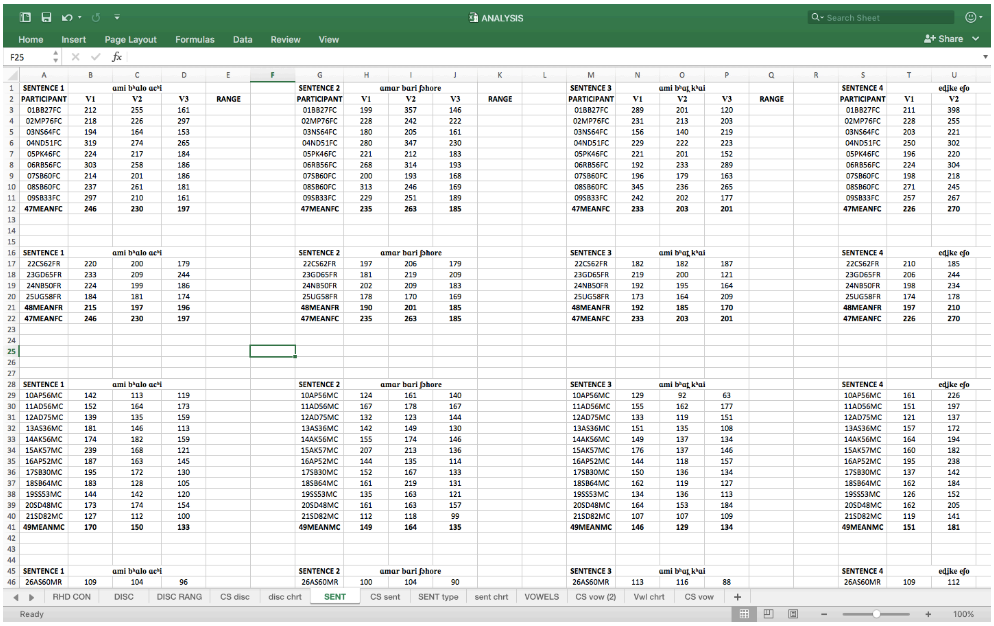
PARTICIPANT	LENGTH	WORDS/MIN	F0 HIGHEST	F0 LOWEST	RANGE	DIGRESSIONS	ANSWERS
10AP56MC	60	126	235	60	175	0	5
12AD75MC	47	108	203	57	146	2	4
13AS36MC	73	138	330	70	260	0	5
14AK56MC	57	120	259	62	197	0	5
15AK57MC	71	144	230	93	137	0	5
16AP52MC	66	156	293	88	205	1	5
17SB30MC	95	108	314	76	238	1	5
18SB64MC	78	96	261	65	196	0	5
19SS53MC	76	90	269	88	181	0	5
20SD48MC	69	156	280	73	207	0	5
51MEANMC	**69**	**124**	**267**	**73**	**194**	**0.4**	**4.9**

Fig 2.1: The length (duration), fluency (words per minute), highest f0, lowest f0, pitch range (highest f0- lowest f0), number of digressions and number of answers; all pasted in an excel sheet.

2.5.2. SENTENCE

1. The following process explains the total details of how information was recorded and then extracted from the recordings, at the level of sentences, from the participants. The participants were given a list of 9 sentences and asked to read out aloud. They were also told to read them out, as naturally as possible. This process was repeated for all the participants. These sentences were recorded and saved. The sentences were then imported to Praat. Each sentence was opened and divided into three parts manually, according to the vowels in a sentence. The f0 or pitch of the vowels were then found out. The values for them were then pasted onto an Excel sheet. This process was repeated for all the participants. This gave us the tripartite values for all sentences, recorded from all the participants. Data was consolidated in an Excel sheet,

for further statistical analysis. For comparing the controls to the mean of the whole group, they were placed in one x-y scatter graph with joint lines.

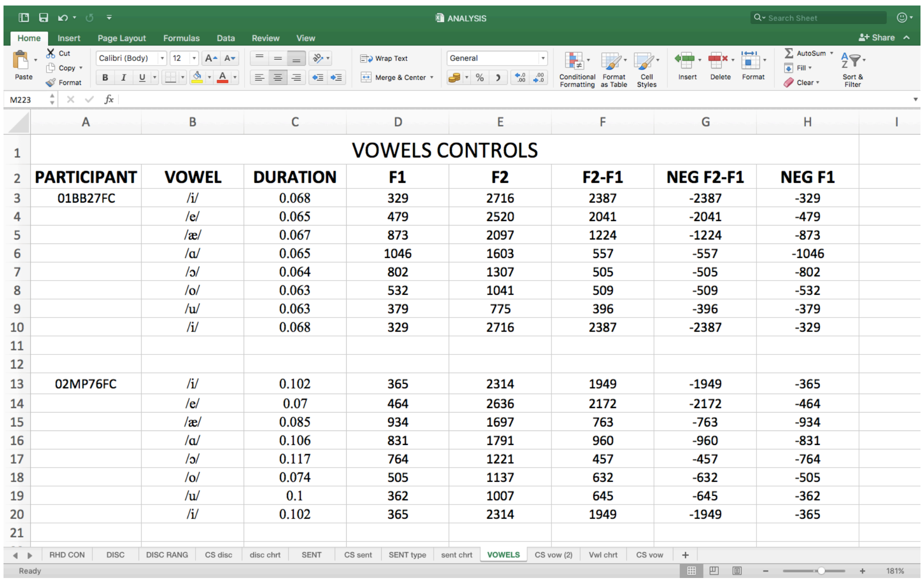


	A	B	C	D	E	G	H	I	J	K	M	N	O	P	Q	S	T	U
1	SENTENCE 1		ami bʰalo acʰi			SENTENCE 2		amar bari ʃɔhore			SENTENCE 3		ami bʰaʈ kʰai			SENTENCE 4		edʝke eʃo
2	PARTICIPANT	V1	V2	V3	RANGE	PARTICIPANT	V1	V2	V3	RANGE	PARTICIPANT	V1	V2	V3	RANGE	PARTICIPANT	V1	V2
3	01BB27FC	212	255	161		01BB27FC	199	357	146		01BB27FC	289	201	120		01BB27FC	211	398
4	02MP76FC	218	226	297		02MP76FC	228	242	222		02MP76FC	231	213	203		02MP76FC	228	255
5	03NS64FC	194	164	153		03NS64FC	180	205	161		03NS64FC	156	140	219		03NS64FC	203	221
6	04ND51FC	319	274	265		04ND51FC	280	347	230		04ND51FC	229	222	223		04ND51FC	250	302
7	05PK46FC	224	217	184		05PK46FC	221	212	183		05PK46FC	221	201	152		05PK46FC	196	220
8	06RB56FC	303	258	186		06RB56FC	268	314	193		06RB56FC	192	233	289		06RB56FC	224	304
9	07SB60FC	214	201	186		07SB60FC	200	193	168		07SB60FC	196	179	163		07SB60FC	198	218
10	08SB60FC	237	261	181		08SB60FC	313	246	169		08SB60FC	345	236	265		08SB60FC	271	245
11	09SB33FC	297	210	161		09SB33FC	229	251	189		09SB33FC	242	202	177		09SB33FC	257	267
12	**47MEANFC**	**246**	**230**	**197**		**47MEANFC**	**235**	**263**	**185**		**47MEANFC**	**233**	**203**	**201**		**47MEANFC**	**226**	**270**
16	SENTENCE 1		ami bʰalo acʰi			SENTENCE 2		amar bari ʃɔhore			SENTENCE 3		ami bʰaʈ kʰai			SENTENCE 4		edʝke eʃo
17	22CS62FR	220	200	179		22CS62FR	197	206	179		22CS62FR	182	182	187		22CS62FR	210	185
18	23GD65FR	233	209	244		23GD65FR	181	219	209		23GD65FR	219	200	121		23GD65FR	206	244
19	24NB50FR	224	199	186		24NB50FR	202	209	183		24NB50FR	192	195	164		24NB50FR	198	234
20	25UG58FR	184	181	174		25UG58FR	178	170	169		25UG58FR	173	164	209		25UG58FR	174	178
21	**48MEANFR**	**215**	**197**	**196**		**48MEANFR**	**190**	**201**	**185**		**48MEANFR**	**192**	**185**	**170**		**48MEANFR**	**197**	**210**
22	**47MEANFC**	**246**	**230**	**197**		**47MEANFC**	**235**	**263**	**185**		**47MEANFC**	**233**	**203**	**201**		**47MEANFC**	**226**	**270**
28	SENTENCE 1		ami bʰalo acʰi			SENTENCE 2		amar bari ʃɔhore			SENTENCE 3		ami bʰaʈ kʰai			SENTENCE 4		edʝke eʃo
29	10AP56MC	142	113	119		10AP56MC	124	161	140		10AP56MC	129	92	63		10AP56MC	161	226
30	11AD56MC	152	164	173		11AD56MC	167	178	167		11AD56MC	155	162	177		11AD56MC	151	197
31	12AD75MC	139	135	159		12AD75MC	132	123	144		12AD75MC	133	119	151		12AD75MC	121	137
32	13AS36MC	181	146	113		13AS36MC	142	149	130		13AS36MC	151	135	108		13AS36MC	157	172
33	14AK56MC	174	182	159		14AK56MC	155	174	146		14AK56MC	149	137	134		14AK56MC	164	194
34	15AK57MC	239	168	121		15AK57MC	207	213	136		15AK57MC	176	137	146		15AK57MC	160	182
35	16AP52MC	187	163	145		16AP52MC	144	135	114		16AP52MC	144	118	157		16AP52MC	195	238
36	17SB30MC	195	172	130		17SB30MC	152	167	133		17SB30MC	150	136	134		17SB30MC	137	142
37	18SB64MC	183	128	105		18SB64MC	161	219	131		18SB64MC	162	119	127		18SB64MC	162	184
38	19SS53MC	144	142	120		19SS53MC	135	163	121		19SS53MC	134	136	113		19SS53MC	126	152
39	20SD48MC	173	174	154		20SD48MC	161	163	157		20SD48MC	164	153	184		20SD48MC	162	205
40	21SD82MC	127	112	100		21SD82MC	112	118	99		21SD82MC	107	107	109		21SD82MC	119	141
41	**49MEANMC**	**170**	**150**	**133**		**49MEANMC**	**149**	**164**	**135**		**49MEANMC**	**146**	**129**	**134**		**49MEANMC**	**151**	**181**
45	SENTENCE 1		ami bʰalo acʰi			SENTENCE 2		amar bari ʃɔhore			SENTENCE 3		ami bʰaʈ kʰai			SENTENCE 4		edʝke eʃo
46	26AS60MR	109	104	96		26AS60MR	100	104	90		26AS60MR	113	116	88		26AS60MR	109	112

Fig 2.2: An image showing the consolidation of sentence data in an Excel sheet

2.5.3. VOWELS

The following process explains the total details of how information was recorded and then extracted from the recordings, at the level of vowels (from words), from the participants. 7 pre-determined pictures were shown to all the participants and specific questions were asked to the participants, regarding the pictures to get the right word being looked for, from them. These words were recorded and saved to be analyzed. These sound files were then imported to Praat, and edited on. Each vowel was opened and then the consonants were cut away from the recordings, leaving only the vowels. The first and the second formant of the vowels were then found out, from the formant drop down menu and pasted to an Excel sheet. The duration of the vowels were also pasted to an Excel sheet (just like discourse durations were pasted to an Excel sheet). Next, we found out the values of f2-f1 and converted them into negative. We also converted the f1 values into negative. This is because an x-y scatter chart in the 3rd quadrant mimics the acoustic space in vowels. We then plot negative f1 on the Y axis against f2-f1 on the X axis to get an acoustic space chart. The area of the irregular polygons, as in acoustic space charts have been found out with the help of a website named Math Open Reference (Reference, 2017). The coordinates, as in the f1 values and the f2-f1 values had to be pasted manually to this website. This website gave us the area of the irregular polygons. The areas of the irregular polygons were pasted in a fresh Excel sheet and then, bar graphs were made, to compare their areas.



VOWELS CONTROLS

PARTICIPANT	VOWEL	DURATION	F1	F2	F2-F1	NEG F2-F1	NEG F1
01BB27FC	/i/	0.068	329	2716	2387	-2387	-329
	/e/	0.065	479	2520	2041	-2041	-479
	/æ/	0.067	873	2097	1224	-1224	-873
	/ɑ/	0.065	1046	1603	557	-557	-1046
	/ɔ/	0.064	802	1307	505	-505	-802
	/o/	0.063	532	1041	509	-509	-532
	/u/	0.063	379	775	396	-396	-379
	/i/	0.068	329	2716	2387	-2387	-329
02MP76FC	/i/	0.102	365	2314	1949	-1949	-365
	/e/	0.07	464	2636	2172	-2172	-464
	/æ/	0.085	934	1697	763	-763	-934
	/ɑ/	0.106	831	1791	960	-960	-831
	/ɔ/	0.117	764	1221	457	-457	-764
	/o/	0.074	505	1137	632	-632	-505
	/u/	0.1	362	1007	645	-645	-362
	/i/	0.102	365	2314	1949	-1949	-365

Fig 2.3: An Excel sheet consolidating formant 1 and formant 2 (f1 and f2), and duration of vowels in an Excel sheet.

3. CASE STUDIES

3.1. INTRODUCTION

The previous chapter on Research Methodology, begins with various kinds of general research methodologies in section 2.1.1 and makes summarized comparisons between them, like inductive vs. deductive methods, empirical vs. rational methods, qualitative vs. quantitative methods and cross sectional vs. longitudinal methods. This is followed by section 2.2 which shines some light onto specialized research methods which can be used for the present research. Methodologies in this section include the ones used in general linguistics, socio-linguistics, syntax, phonetics and field linguistics. It is followed by methods used in clinical, applied, cognitive and neuro-linguistic studies. Section 2.2.3 amalgamates the previously mentioned methodologies and chooses the best possible options for the present research.

The present research began with primary objectives, discussed in section 1.5 of the first chapter and 2.3 of the second chapter. It discusses the scopes and objectives of the present research. The subsequent subsections introduce the topic of the present research as well as broadly categorizes it. Next, the major questions regarding the empirical data, have been listen down as the research questions, followed by general objectives and specific objectives of the present research. The following flowchart displays the research methodology employed in the present research, already discussed in the previous chapter.

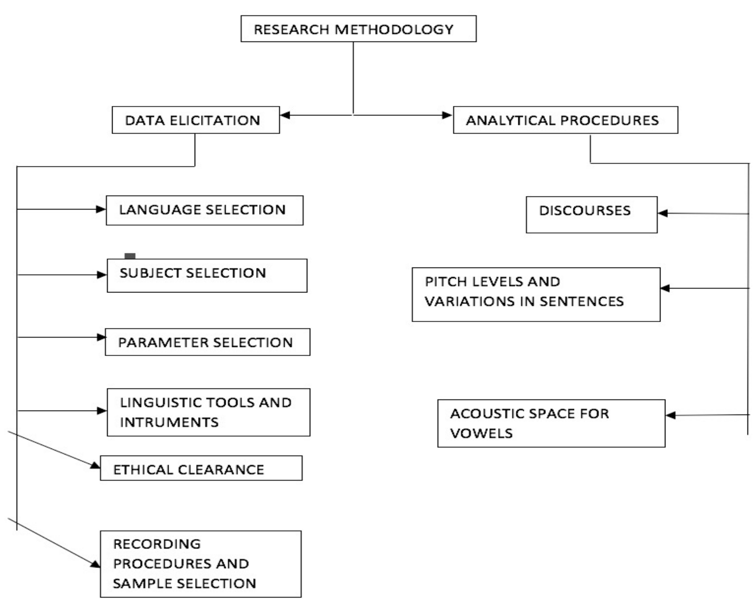


Fig 3.1: A flowchart depicting the research methodology employed in the present research.

The previous chapter lists down the procedural steps taken at the three tiers of communication chosen for the present research, namely, at the level of discourse, sentences and words, that is, in vowels. At the level of discourse the present research has looked into the length, fluency, range of pitch, digressions and number of answers made to the pre-determined questions in the discourse. At the level of sentences, 9 sentences have been studied; 3 declarative, 3 imperative and 3 interrogative sentences. The following flowchart summarizes all the parameters being studied at the three levels of communication.

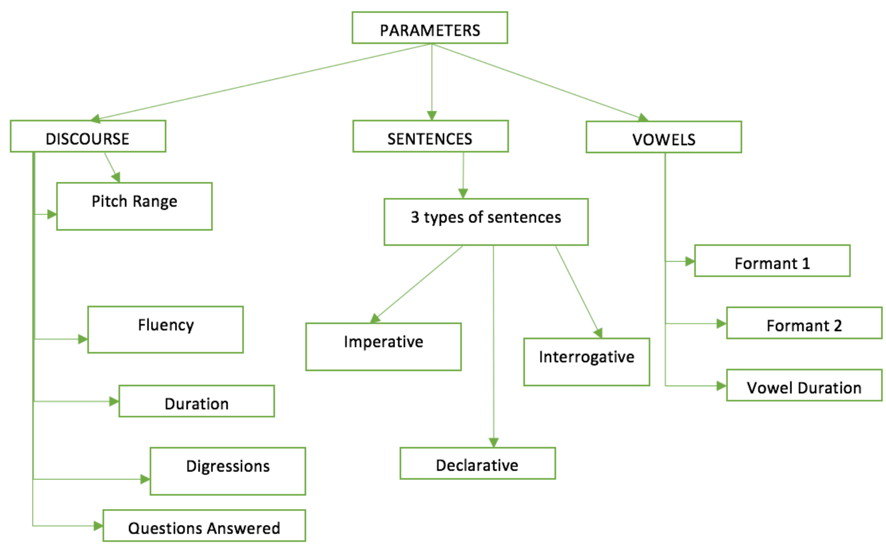


Fig 3.2: A flowchart depicting all the parameters being researched in the present study.

3.2. PARTICIPANT SELECTION

This topic was explained and touched upon in the previous chapter under section **2.4.1**, but since the present chapter discusses all the case studies, it is important that we take a look at the inclusion and exclusion criteria and then take a look at all the 44 participants.

Inclusion Criteria	Exclusion Criteria
RHD	LHD, Global
One month post trauma	Severe cases in ICU
18 years and above	Children and participants above 82 years
Bangla speakers monolinguals	Good proficiency in second language

Volunteering for ICF	No consent
MMSE score of 24-28	MMSE scores under 24
GCS score at 11	Participants with dementia

The present research includes only right hemisphere brain damaged individuals or RHD participants, with a time gap of at least one month post incidence. All the participants recorded are more than 18 years of age and are preferably Bengali monolinguals. In case they are not Bengali monolinguals, they are individuals who have very less influence of a second language on Bangla. Only participants who have agreed to read and sign the ICF forms have been included in the study. The co-supervisor for this study, Dr. Gautam Ganguly, helped with participant selection by only allowing me to interview participants who have a score of 24-30 on MMSE and at least 11 on the GCS.

The present study avoided participants with global brain damage or left hemisphere of the brain damage or participants with multiple stroke reports. No participants were interviewed in hospitals, hence no participants who were in the ICU. No individuals below the age of 18 were interviewed or above the age of 82 (set through random sampling). Participants with extreme dementia (chosen by the co-supervisor) or with MMSE scores below 24 were not recorded.

We finally have a list of 44 participants. We have a total of 23 RHD participants along with 21 age and gender matched controls. We have 4 female RHD participants and 19 male RHD participants, along with 9 female control participants and 12 male control participants. All the 44 participants have been discussed in the present chapter. They have been studied according to the 3 major parameters discussed in the previous section; namely discourse, pitch contours in sentences and acoustic space in vowels. Every case study provides detailed information about the participants recorded, along with subjective remarks made by the accompanying doctor.

The following tables help us take a quick look into the participants, both RHD (in the order of their appearance later on, in the chapter) and controls. The tables also display their codified names along with the age and gender matched controls they have been paired to. It is worth remembering here that the coding works in the following way:

a. First two digits are the alphabetical order

b. The third and fourth digits denote the name initials

c. The fifth and sixth digits denote the age

d. The seventh digit denotes gender

e. The eighth digit denotes control or RHD

FEMALE RHD PARTICIPANTS		
No	PARTICIPANT RHD	PARTICIPANT CONTROL
	22CS62FR	07SB60FC
	23GD65FR	03NS64FC
	24NB50FR	04ND51FC
	25UG58FR	06RB56FC

Table 3.1: All the female RHD participants and their age and gender matched control.

MALE RHD PARTICIPANTS		
No	PARTICIPANT RHD	PARTICIPANT CONTROL
1	26AS60MR	15AK57MC
2	27BD57MR	15AK57MC
3	28DM35MR	13AS36MC
4	29DS55MR	10AP56MC
5	30HD50MR	16AP52MC
6	31KM80MR	21SD82MC
7	32KD72MR	12AD75MC
8	33NB42MR	20SD48MC
9	34SR36MR	13AS36MC
10	35SA58MR	15AK57MC
11	36SB47MR	20SD48MC
12	37SH31MR	17SB30MC
13	38SB74MR	12AD75MC
14	39SR34MR	13AS36MC
15	40SB82MR	21SD82MC
16	41SK55MR	10AP56MC
17	42SR44MR	20SD48MC
18	43SK55MR	14AK56MC
19	44ZS64MR	18SB64MC

Table 3.2: All the female RHD participants and their age and gender matched control

FEMALE CONTROL PARTICIPANTS	
1	01BB27FC
2	02MP76FC
3	03NS64FC
4	04ND51FC
5	05PK46FC
6	06RB56FC
7	07SB60FC
8	08SB60FC
9	09SB33FC

FEMALE CONTROL PARTICIPANTS	
1	01BB27FC
2	02MP76FC
3	03NS64FC
4	04ND51FC
5	05PK46FC
6	06RB56FC
7	07SB60FC
8	08SB60FC
9	09SB33FC

Table 3.3 and 3.4: All the female and male control participants.

3.3. ORGANISATION OF CASE STUDIES

The present research includes 23 RHD case studies and 21 age and gender matched normal controls. A total of 19 male and 4 female RHD participants have been recorded. A total of 12 males and 9 females have recorded as controls. Controls have been selected primarily from the family of the RHD participants. In case controls could not be recorded from the same families, they have been recorded from age and gender matched participants belonging to the same economic and social backgrounds.

Let us take a look at the organization of the case studies in the form of a flowchart, below.

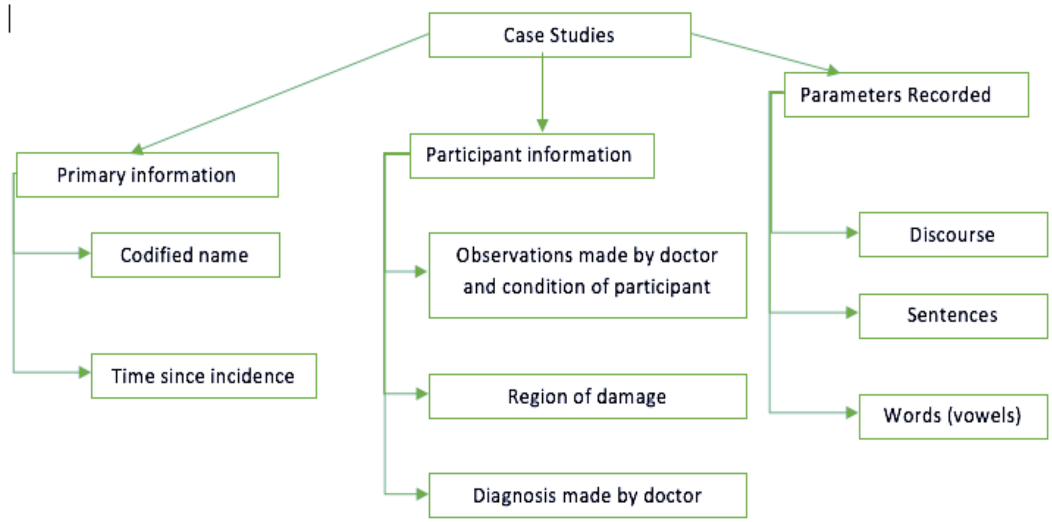


Fig 3.3: A flowchart depicting the organization of individual case studies

We have now taken a look at the flowchart depicting organization of case studies. The next section will depict a template, using the flowchart above, which would be used throughout, for all the case studies in the subsequent sections to follow. All the necessary descriptions will be provided below.

CASE STUDY

PRIMARY INFO

Codified Name: This will be the eight-digit codified name that has been assigned to all RHD and control participants

Time since incidence: This section will contain information about how long back the participant had a stroke or insult or injury to the brain.

Participant information

Condition of participant: This section will explain the condition of the participant as explained by the doctor, at the time of the recordings, in details. It will include details like the diagnosis of the stroke, description of whether the subject is bed ridden, speech slurred or not, problems with eating, hammer test for jerk reactions on both elbows and knees, prick test for testing neural impulses, test of the ability to use muscles of the hand when suspended by the doctor in midair (test for stroke) and details of physiotherapy

Observations made by doctor: This section will mention any special terms or conditions mentioned by the doctor.

Diagnosis made by doctor: This section will mention and explain any terms used by the doctor at the time of case studies pertaining to the diagnosis of the participant, if any.

Region of damage: This section will mention the exact location of the lesion, in the brain and note down the exact language used on the imaging reports.

Comprehensive study of participant at the 3 levels of communication

A. **Discourse:** Under this heading we will discuss the 5 parameters being studied under discourse. It is worth noticing that we have used Praat for all the following sections, explained below.

1. **Pitch range**: This section shall find out the highest and lowest pitch recorded in the discourse level recordings, for all participants. Subtracting the lowest pitch from the highest pitch would give us the pitch range of the participant. It would be denoted by bar graphs along with the mean of the whole group, which would also give us an insight into the standard deviation of the participants.

A sample chart has been displayed below. This chart shows the variations in pitch range at the level of discourse, for male control participants, in the present study. Graphs like the one below, would be discussed in details, following the graph.

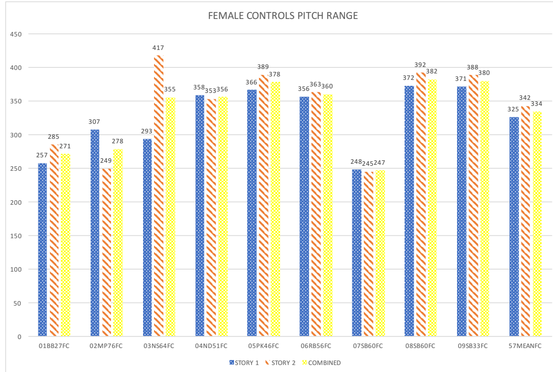


Fig 3.4: Female Controls pitch range

2. **Fluency**: Every participant has a speed of word flow, at which they speak. This section looks into the number of words a participant speaks in a minute or fluency. It has been calculated, manually, for all the participants by listening to the recordings and then counting the number of words. It is worth mentioning that this section has not counted filler words or expressions made while recording. These will be presented in bar graph forms.

3. **Duration:** This section looks into the amount of time, each participant has taken to narrate back the story, they were told, by the narrator. Every story was listened to and then the total time taken was calculated. The total amount of time taken does not include any speech made by the narrator. It only included speech made by the participants. The narrator's voice has been included at places where the participants needed help, only. These will be presented in bar graph forms. The descriptions would also compare the duration with the fluency figures.

4. **Digressions:** This section includes all the types of displacements and lapses made by the participants while narrating back the stories. The records were played back and listened to and noted down. The stories narrated by the RHD participants have been noted down (after being translated to English) and the digressions have been marked in bold in the text. The participants were led back to the main story by being helped by the narrator. Bar graphs would mark the number of digressions and lapses in the stories.

5. **Questions answered:** There were 2 stories, which were narrated to the participants. Each story was accompanied by 5 questions which were very easy to answer. The questions required the participants to pay attention to the narrator, while he narrated the story. The answer to these questions were not recorded in the discourse recordings, but were written down by the narrator. The answers by the RHD participant and the individual control participant would be produced here.

B. **Sentences:** Under this heading, we will look into the 3 kinds of sentences (with 3 each) recorded and the various parameters associated with them. Three kinds of sentences recorded were declaratives, imperatives and interrogatives. The following process, already enumerated in the previous chapter, section **2.3.3.2**, has been mentioned below, and has been used in the present research to study the sentences recorded. The sentences were imported to Praat where they were divided into three parts. Each part of the sentences contained one or many vowels. The pitch or fundamental frequency (f0) of these vowels, for one part among the three parts, were averaged to find out the f0 level for one part of the sentence. The values of the three parts, for all the sentences, were then imported to MS Excel, where they were compared. Bar graphs compare the individual sentences to the mean of the whole group, the individual control they are paired to and the control group. A sample sentence chart has been provided below. Every sentence graph, like the one below, would be discussed in details, following the graph.

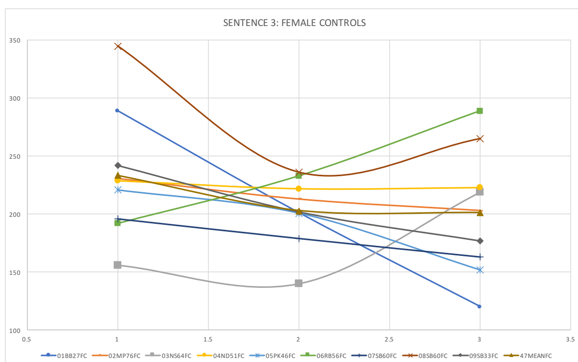


Fig 3.5: Sample sentence scatter graph

C. **Vowels:** The vowels were primarily recorded as words, from where the vowels were dissected out, to be studied. The following process, as mentioned in the previous chapter**,** has been mentioned below, and has been used to study the vowels, in the present research. The 7 words recorded from the participants were imported to Praat. The words were dissected and the consonants were removed, leaving behind, only the vowels. The vowels were further perfected and then the formant values were found out. The first and the second formants of all the vowels for all the participants were imported to MS Excel, where they were compared. Acoustic space in vowels were made using the first formant (f1) in the Y axis and the difference between the second formant (f2) and the first formant (f1) or f2-f1 in the X axis. The resultant was plotted on a x-y scatter chart where it formed an irregular polygon, roughly mimicking the acoustic space for the vowels we recorded. The area of the acoustic space charts have been calculated with an online tool. (Irregular polygon area calculator, 2015) A sample acoustic space chart has been displayed below. Such graphs would be discussed in detail.

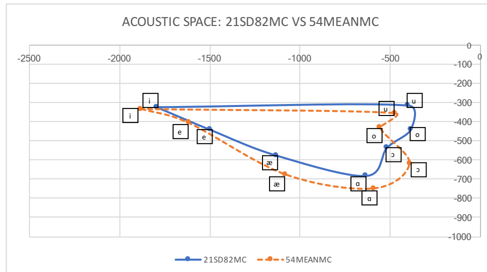


Fig 3.6: An acoustic space chart comparing individual control 21SD82MC with the mean of the whole male control group, 54MEANMC.

It is also important to mention here, that the first case study would be discussed in complete details with the graphs occupying half a page or so followed by their descriptions. The rest of the case studies would have the images together, followed by the description of them after all the images have been displayed.

3.4. CONTROLS

Every RHD participant has been matched to an age and gender matched control, in order to be compared and judged for patterns at the three levels of communication properly. This section houses the data for the individual controls and how they compare to the mean of the control group. This is important and not redundant because even non-patient participants might display signs of RHD, upon ageing or other factors which might or might not have been taken care of. Hence, it is important that we take a look at the controls in the present study before we move on to the RHD participants.

3.4.1. CONTROLS: DISCOURSE

In this section, we shall look into patterns in the five selected parameters in discourse, namely duration, fluency or words per minute, range in pitch, number of answers made to discourse questions and the number of digressions caught in the recordings.

It is important to notice that this section has been further divided into five subsections, going by the 5 parameters, which have previously selected. Each section contains two bar graphs, one for males and one for females. Each individual bar graph would contain the value for story 1, then for story 2 and then finally a combined bar for the mean of both the stories.

3.4.1.1. PITCH RANGE IN DISCOURSE

The following bar graphs display the pitch range, for normal controls, in comparison with the mean of the whole control group. Pitch has been measured throughout the discourse proceedings and then the difference between the highest point in pitch and the lowest point in pitch, has given us the pitch range for discourse.

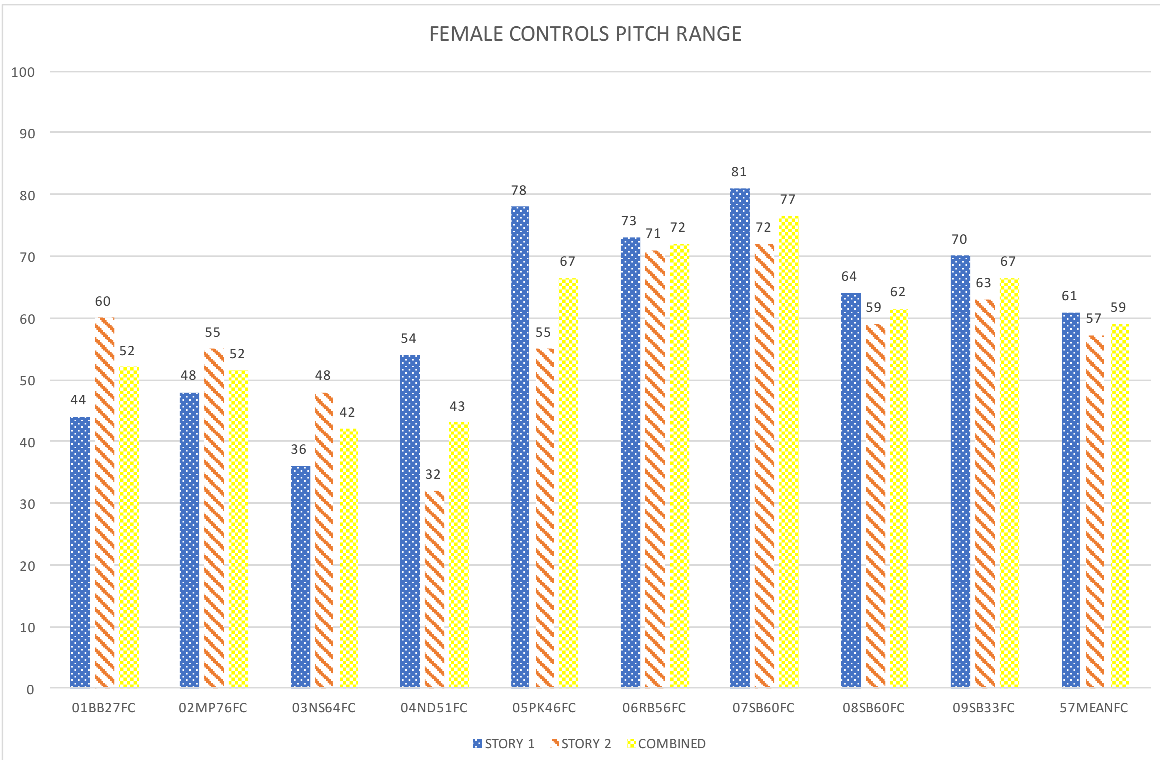


Fig 3.7 above displays the pitch ranges in the discourse recordings of the female controls, in comparison with the mean of the whole female control group (57MEANFC). We can observe the following from the figure displayed previously that all the controls have a fairly consistent pitch range in both the stories, except 01BB27FC, 03NS64FC, 04ND51FC and 05PK46FC. 01BB27FC has pitch ranges of 44 Hz and 60 Hz in the two stories, 04ND51FC has pitch ranges of 54 Hz and 32 Hz, in the two stories, 05PK46FChas pitch ranges of 78 Hz and 55 Hz in the two stories. 07SB60FC has the highest pitch range in story 1 at 81 Hz, compared to the mean pitch range 57MEANFC at 61 Hz. 07SB60FC also has the highest pitch range for story 2 at 72 Hz, compared to the mean pitch range 57MEANFC at 57 Hz. 03NS64FC has the lowest pitch range for story 1 at 36 Hz and 04ND51FC has the lowest pitch range in story 2 at 32 Hz, which are lower than the ranges of 57MEANFC at 61 Hz for story 1 and 57 Hz for story 2. This might just be a sign of the fact that they were disinterested in narrating back the story

and thought of it as not needed, after their family member with RHD was recorded. It might also because of an undiagnosed damage to the brain or it might just be the way they speak. Low pitch range in normal controls might not have their roots in RHD.

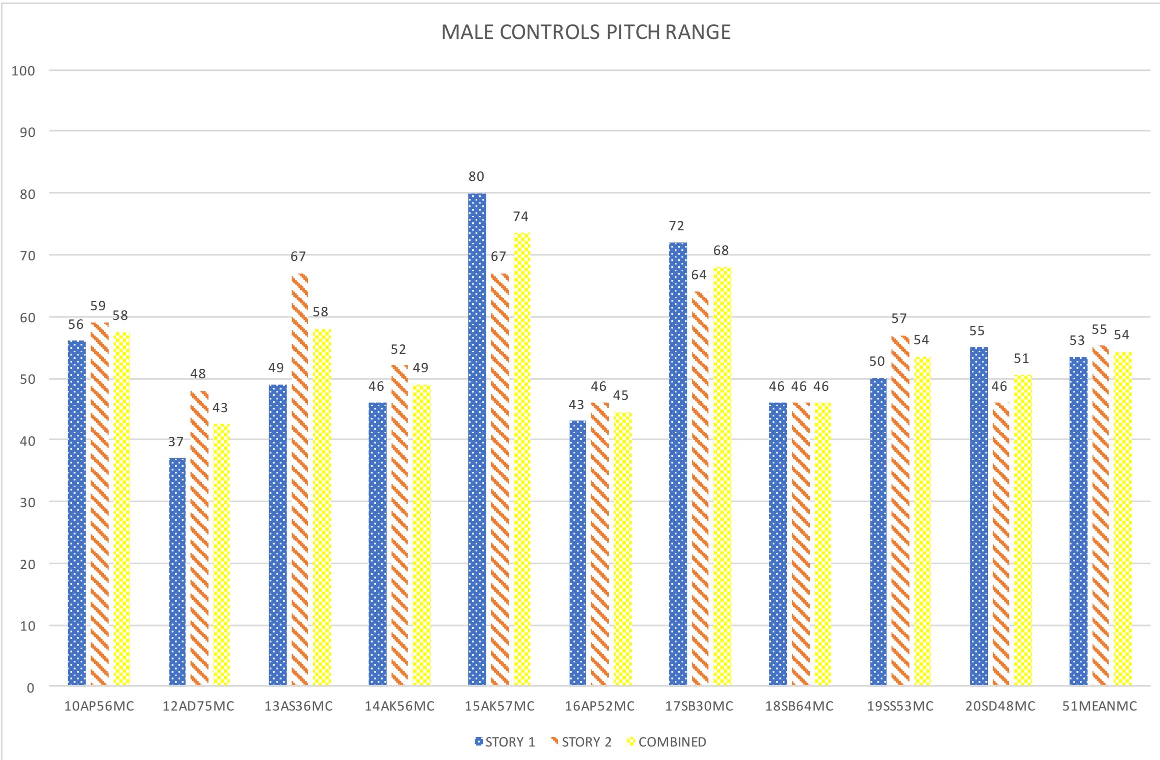


Fig 3.8 above displays the pitch ranges in the discourse recordings of the male controls, in comparison with the mean of the whole male control group (51MEAMC). We can observe the following from the figure displayed previously that all the male controls have fairly consistent pitch ranges in their stories, except for 13AS36MC with pitch ranges of 49 Hz and 67 Hz, in the two stories and 15AK57MC, who has pitch ranges of 80 Hz and 67 Hz in the two stories. 15AK57MC has the highest pitch range in story 1 at 80 Hz, compared to the mean pitch range 51MEANMC at 53 Hz. 13AS36MC and 15AK57MC have the highest pitch range for story 2 at 67 Hz, compared to the mean pitch range 51MEANMC at 55 Hz. 12AD75MC has the lowest pitch range for story 1 at 37 Hz which is lower than the range of 51MEANMC at 53 Hz for story 1. 16AP52MC, 18SB64MC, 20SD48MC have the lowest pitch range for story 2 at 46 Hz which is lower than the range of 51MEANMC at 55 Hz for story 2. 15AK57MC has the highest average pitch range, combining both the stories at 74 Hz. The lowest average pitch range has been displayed by 12AD75MC, at 43 Hz. In comparison, the pitch range for the mean 51MEANMC is at 54 Hz.

3.4.1.2. FLUENCY IN DISCOURSE

The following bar graphs display the level of fluency in discourse or the number of words spoken in the course of the discourse, calculated as words per minute; for normal controls, in comparison with the mean of the whole control group. Fluency has been calculated by counting the number of words spoken by each participant in a minute. It is important to notice that useless, tag words or fillers have been not counted, except for when they are in actual sentences. A bar to the end, in both the bar graphs following also contains the fluency of the original reader, to whom the participants listened to (in this case, me). It gives us an idea about the actual word fluency, displayed by the reader, as well as also gives us an insight into how much the participants spoke back after listening to the reader.

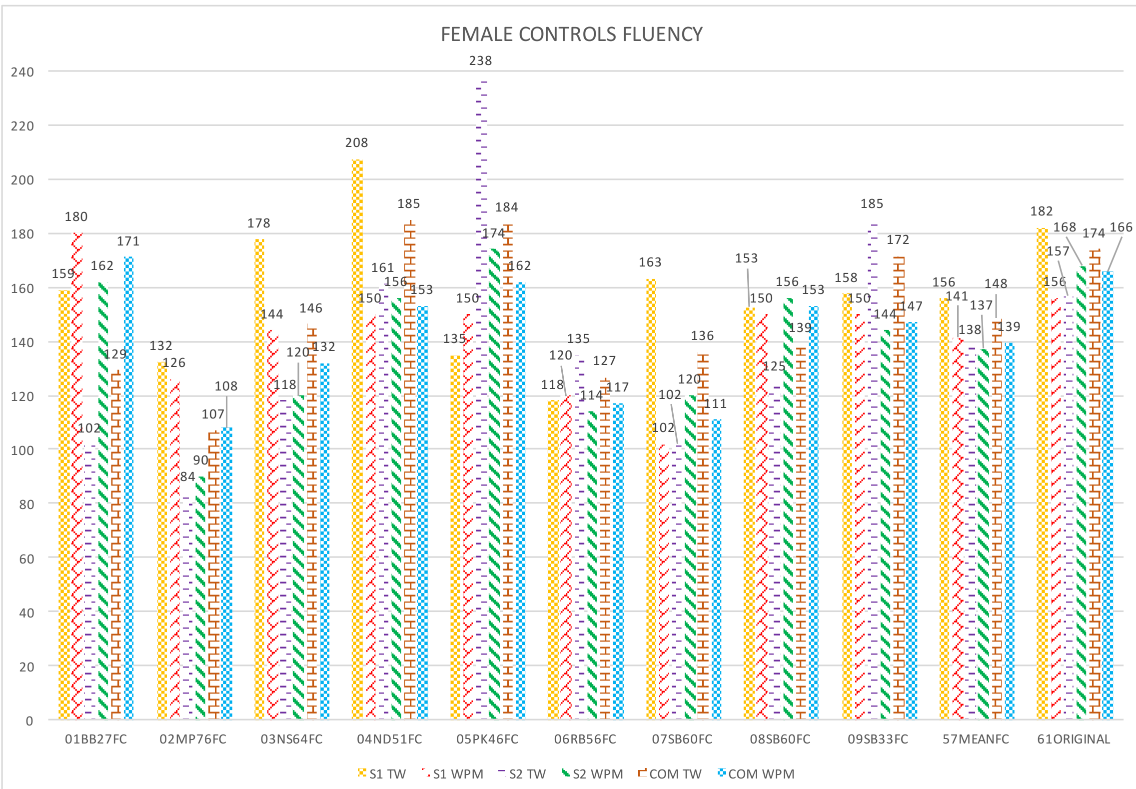


Fig 3.9 above displays the fluency or words per minute in the discourse recordings for the female controls, in comparison with the mean of the whole female control group (57MEAFC) and with that of the original reader 61ORIGINAL. We can observe the following from the figure displayed previously that The original narrator 61ORIGINAL spoke 182 words in story 1 and has a fluency rate of 156 wpm in story 1. He spoke 157 words in story 2 and has a fluency rate of 168 in story 2. He spoke 174 words in the combined mean and has a combined fluency rate of 166 wpm. The mean of the control group 57MEANFC spoke

156 words in story 1 and has a fluency rate of 141 wpm in story 1 in comparison with 61ORIGINAL, who has 182 words and 156 wpm. 57MEANFC has 138 words in story 2 and has a fluency rate of 137 in story 2 in comparison with 61ORIGINAL, who has 157 words and 168 wpm. 57MEANFC has 148 words in the combined mean and has a combined fluency rate of 139 wpm in comparison with 61ORIGINAL, who has 174 words and 166 wpm. 01BB27FC spoke 159 words in story 1 and a fluency rate of 180 words in comparison with 57MEANFC with 156 words and 141 wpm and 61ORIGINAL, who has 182 words and 156 wpm. 01BB27FC spoke 102 words in story 2 and a fluency rate of 162 words in comparison with 57MEANFC with 138 words and 137 wpm and 61ORIGINAL, who has 157 words and 168 wpm. 01BB27FC has 129 words in the combined mean of two stories and has a fluency rate of 171 words, in comparison with 57MEANFC with 148 words and 139 wpm and 61ORIGINAL, who has 174 words and 166 wpm. 02MP76FC spoke 132 words in story 1 and a fluency rate of 126 words in comparison with 57MEANFC with 156 words and 141 wpm and 61ORIGINAL, who has 182 words and 156 wpm. 02MP76FC spoke 84 words in story 2 and a fluency rate of 90 words in comparison with 57MEANFC with 138 words and 137 wpm and 61ORIGINAL, who has 157 words and 168 wpm. 02MP76FC has 107 words in the combined mean of two stories and has a fluency rate of 108 words, in comparison with 57MEANFC with 148 words and 139 wpm and 61ORIGINAL, who has 174 words and 166 wpm. 03NS64FC spoke 178 words in story 1 and a fluency rate of 144 words in comparison with 57MEANFC with 156 words and 141 wpm and 61ORIGINAL, who has 182 words and 156 wpm. 03NS64FC spoke 118 words in story 2 and a fluency rate of 120 words in comparison with 57MEANFC with 138 words and 137 wpm and 61ORIGINAL, who has 157 words and 168 wpm. 03NS64FC has 146 words in the combined mean of two stories and has a fluency rate of 132 words, in comparison with 57MEANFC with 148 words and 139 wpm and 61ORIGINAL, who has 174 words and 166 wpm. 04ND51FC spoke 208 words in story 1 and a fluency rate of 150 words in comparison with 57MEANFC with 156 words and 141 wpm and 61ORIGINAL, who has 182 words and 156 wpm. 04ND51FC spoke 161 words in story 2 and a fluency rate of 156 words in comparison with 57MEANFC with 138 words and 137 wpm and 61ORIGINAL, who has 157 words and 168 wpm. 04ND51FC has 185 words in the combined mean of two stories and has a fluency rate of 153 words, in comparison with 57MEANFC with 148 words and 139 wpm and 61ORIGINAL, who has 174 words and 166 wpm. 05PK46FC spoke 135 words in story 1 and a fluency rate of 150 words in comparison with 57MEANFC with 156 words and 141 wpm and

61ORIGINAL, who has 182 words and 156 wpm. 05PK46FC spoke 238 words in story 2 and a fluency rate of 174 words in comparison with 57MEANFC with 138 words and 137 wpm and 61ORIGINAL, who has 157 words and 168 wpm. 05PK46FC has 184 words in the combined mean of two stories and has a fluency rate of 162 words, in comparison with 57MEANFC with 148 words and 139 wpm and 61ORIGINAL, who has 174 words and 166 wpm. 06RB56FC spoke 118 words in story 1 and a fluency rate of 120 words in comparison with 57MEANFC with 156 words and 141 wpm and 61ORIGINAL, who has 182 words and 156 wpm. 06RB56FC spoke 135 words in story 2 and a fluency rate of 114 words in comparison with 57MEANFC with 138 words and 137 wpm and 61ORIGINAL, who has 157 words and 168 wpm. 06RB56FC has 127 words in the combined mean of two stories and has a fluency rate of 117 words, in comparison with 57MEANFC with 148 words and 139 wpm and 61ORIGINAL, who has 174 words and 166 wpm. 07SB60FC spoke 163 words in story 1 and a fluency rate of 102 words in comparison with 57MEANFC with 156 words and 141 wpm and 61ORIGINAL, who has 182 words and 156 wpm. 07SB60FC spoke 102 words in story 2 and a fluency rate of 120 words in comparison with 57MEANFC with 138 words and 137 wpm and 61ORIGINAL, who has 157 words and 168 wpm. 07SB60FC has 136 words in the combined mean of two stories and has a fluency rate of 111 words, in comparison with 57MEANFC with 148 words and 139 wpm and 61ORIGINAL, who has 174 words and 166 wpm. 08SB60FC spoke 153 words in story 1 and a fluency rate of 150 words in comparison with 57MEANFC with 156 words and 141 wpm and 61ORIGINAL, who has 182 words and 156 wpm. 08SB60FC spoke 125 words in story 2 and a fluency rate of 156 words in comparison with 57MEANFC with 138 words and 137 wpm and 61ORIGINAL, who has 157 words and 168 wpm. 08SB60FC has 139 words in the combined mean of two stories and has a fluency rate of 153 words, in comparison with 57MEANFC with 148 words and 139 wpm and 61ORIGINAL, who has 174 words and 166 wpm. 09SB33FC spoke 158 words in story 1 and a fluency rate of 150 words in comparison with 57MEANFC with 156 words and 141 wpm and 61ORIGINAL, who has 182 words and 156 wpm. 09SB33FC spoke 185 words in story 2 and a fluency rate of 144 words in comparison with 57MEANFC with 138 words and 137 wpm and 61ORIGINAL, who has 157 words and 168 wpm. 09SB33FC has 139 words in the combined mean of two stories and has a fluency rate of 153 words, in comparison with 57MEANFC with 148 words and 139 wpm and 61ORIGINAL, who has 174 words and 166 wpm.

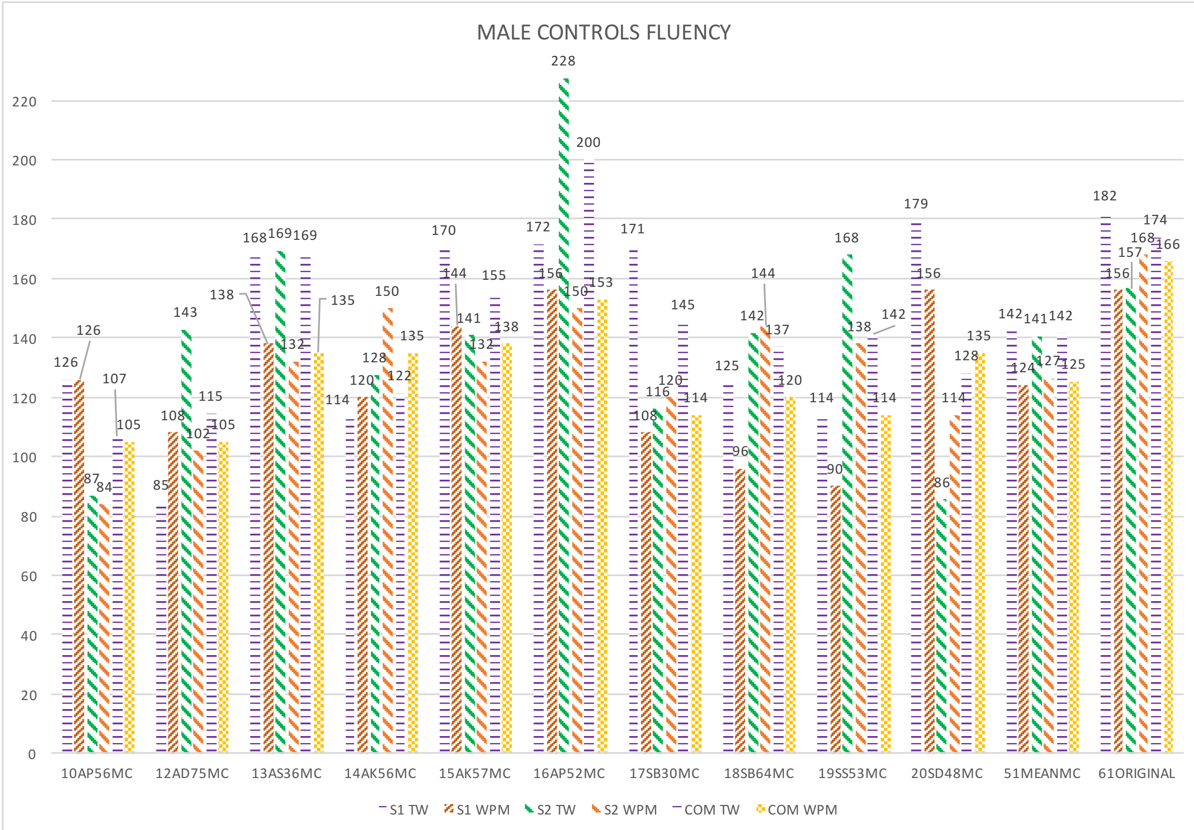


Fig 3.10 above displays the fluency or words per minute in the discourse recordings for the male controls, in comparison with the mean of the whole male control group (51MEAMC) and with that of the original reader 61ORIGINAL. We can observe the following from the figure displayed previously that the original narrator 61ORIGINAL spoke 182 words in story 1 and has a fluency rate of 156 wpm in story 1. He spoke 157 words in story 2 and has a fluency rate of 168 in story 2. He spoke 174 words in the combined mean and has a combined fluency rate of 166 wpm. The mean of the control group 51MEANMC spoke 142 words in story 1 and has a fluency rate of 124 wpm in story 1 in comparison with 61ORIGINAL, who has 182 words and 156 wpm. 51MEANMC has 141 words in story 2 and has a fluency rate of 127 in story 2 in comparison with 61ORIGINAL, who has 157 words and 168 wpm. 51MEANMC has 142 words in the combined mean and has a combined fluency rate of 125 wpm in comparison with 61ORIGINAL, who has 174 words and 166 wpm. 10AP56MC spoke 126 words in story 1 and a fluency rate of 126 words in comparison with 51MEANMC with 142 words and 124 wpm and 61ORIGINAL, who has 182 words and 156 wpm. 10AP56MC spoke 87 words in story 2 and a fluency rate of 84 words in comparison with 51MEANMC with 141 words and 127 wpm and 61ORIGINAL, who has 157 words and 168 wpm. 10AP56MC

has 107 words in the combined mean of two stories and has a fluency rate of 105 words, in comparison with 51MEANMC with 142 words and 125 wpm and 61ORIGINAL, who has 174 words and 166 wpm. 12AD75MC spoke 85 words in story 1 and a fluency rate of 108 words in comparison with 51MEANMC with 142 words and 124 wpm and 61ORIGINAL, who has 182 words and 156 wpm. 12AD75MC spoke 143 words in story 2 and a fluency rate of 102 words in comparison with 51MEANMC with 141 words and 127 wpm and 61ORIGINAL, who has 157 words and 168 wpm. 12AD75MC has 115 words in the combined mean of two stories and has a fluency rate of 105 words, in comparison with 51MEANMC with 142 words and 125 wpm and 61ORIGINAL, who has 174 words and 166 wpm. 13AS36MC spoke 168 words in story 1 and a fluency rate of 138 words in comparison with 51MEANMC with 142 words and 124 wpm and 61ORIGINAL, who has 182 words and 156 wpm. 13AS36MC spoke 169 words in story 2 and a fluency rate of 132 words in comparison with 51MEANMC with 141 words and 127 wpm and 61ORIGINAL, who has 157 words and 168 wpm. 13AS36MC has 169 words in the combined mean of two stories and has a fluency rate of 135 words, in comparison with 51MEANMC with 142 words and 125 wpm and 61ORIGINAL, who has 174 words and 166 wpm. 14AK56MC spoke 114 words in story 1 and a fluency rate of 120 words in comparison with 51MEANMC with 142 words and 124 wpm and 61ORIGINAL, who has 182 words and 156 wpm. 14AK56MC spoke 128 words in story 2 and a fluency rate of 150 words in comparison with 51MEANMC with 141 words and 127 wpm and 61ORIGINAL, who has 157 words and 168 wpm. 14AK56MC has 122 words in the combined mean of two stories and has a fluency rate of 135 words, in comparison with 51MEANMC with 142 words and 125 wpm and 61ORIGINAL, who has 174 words and 166 wpm. 15AK57MC spoke 170 words in story 1 and a fluency rate of 144 words in comparison with 51MEANMC with 142 words and 124 wpm and 61ORIGINAL, who has 182 words and 156 wpm. 15AK57MC spoke 141 words in story 2 and a fluency rate of 132 words in comparison with 51MEANMC with 141 words and 127 wpm and 61ORIGINAL, who has 157 words and 168 wpm. 15AK57MC has 155 words in the combined mean of two stories and has a fluency rate of 138 words, in comparison with 51MEANMC with 142 words and 125 wpm and 61ORIGINAL, who has 174 words and 166 wpm. 16AP52MC spoke 172 words in story 1 and a fluency rate of 156 words in comparison with 51MEANMC with 142 words and 124 wpm and 61ORIGINAL, who has 182 words and 156 wpm. 16AP52MC spoke 228 words in story 2 and a fluency rate of 150 words in comparison with 51MEANMC with 141 words and 127 wpm and 61ORIGINAL, who has 157 words and 168 wpm. 16AP52MC has 200 words in the combined mean of two stories and has a fluency rate of 153 words, in comparison with 51MEANMC with 142 words and 125 wpm and 61ORIGINAL, who has 174 words and 166 wpm. 17SB30MC spoke 171 words in story 1 and a fluency rate of 108 words in comparison with 51MEANMC with 142 words and 124 wpm and 61ORIGINAL, who has 182 words and 156 wpm. 17SB30MC spoke 116 words in story 2 and a fluency rate of 120 words in comparison with 51MEANMC with 141 words and 127 wpm and 61ORIGINAL, who has 157 words and 168 wpm. 17SB30MC has 145 words in the combined mean of two stories and has a fluency rate of 114 words, in comparison with 51MEANMC with 142 words and 125 wpm and 61ORIGINAL, who has 174 words and 166 wpm. 18SB64MC spoke 125 words in story 1 and a fluency rate of 96 words in comparison with 51MEANMC with 142 words and 124 wpm and 61ORIGINAL, who has 182 words and 156 wpm. 18SB64MC spoke 142 words in story 2 and a fluency rate of 144 words in comparison with 51MEANMC with 141 words and 127 wpm and 61ORIGINAL, who has 157 words and 168 wpm. 18SB64MC has 137 words in the combined mean of two stories and has a fluency rate of 120 words, in comparison with 51MEANMC with 142 words and 125 wpm and 61ORIGINAL, who has 174 words and 166 wpm. 19SS53MC spoke 114 words in story 1 and a fluency rate of 90 words in comparison with 51MEANMC with 142 words and 124 wpm and 61ORIGINAL, who has 182 words and 156 wpm. 19SS53MC spoke 168 words in story 2 and a fluency rate of 138 words in comparison with 51MEANMC with 141 words and 127 wpm and 61ORIGINAL, who has 157 words and 168 wpm. 19SS53MC has 142 words in the combined mean of two stories and has a fluency rate of 114 words, in comparison with 51MEANMC with 142 words and 125 wpm and 61ORIGINAL, who has 174 words and 166 wpm. 20SD48MC spoke 179 words in story 1 and a fluency rate of 156 words in comparison with 51MEANMC with 142 words and 124 wpm and 61ORIGINAL, who has 182 words and 156 wpm. 20SD48MC spoke 86 words in story 2 and a fluency rate of 114 words in comparison with 51MEANMC with 141 words and 127 wpm and 61ORIGINAL, who has 157 words and 168 wpm. 20SD48MC has 128 words in the combined mean of two stories and has a fluency rate of 135 words, in comparison with 51MEANMC with 142 words and 125 wpm and 61ORIGINAL, who has 174 words and 166 wpm.

3.4.1.3. DURATION OF DISCOURSE

The following bar graphs display the length or duration of the discourse recordings for the individual controls in comparison with the mean of the whole group. The duration of the discourse is the total time each participant took to complete narrating the whole story, namely both stories 1 and 2, which was read out to them by the reader, prior to their recordings.

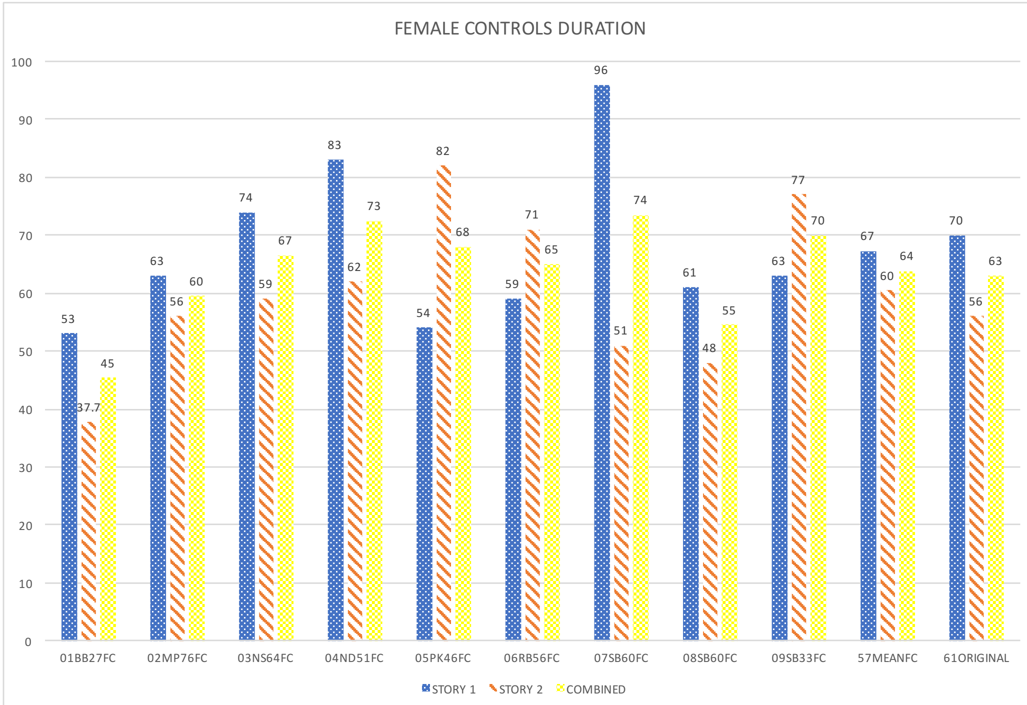


Fig 3.11 above displays the duration or length of the discourse recordings for the female controls, in comparison with the mean of the whole female control group (57MEANFC) and with that of the original reader 61ORIGINAL. We can observe the following from the figure displayed previously that the mean of the group 57MEANFC took 67 seconds (141 words per minute) for story 1 and 60 seconds (137 words per minute) for story 2, and is pretty consistent with the original reader 61ORIGINAL, at 70 (156 words per minute) for story 1 and 56 (168 words per minute) for story 2. 07SB60FC, with a duration of 96 seconds (102 words per minute) took the longest to narrate story 1 in comparison with 01BB27FC who took only 53 seconds (188 words per minute) to narrate the first story. The original narrator took 70 seconds (156 words per minute) in comparison. 05PK46FC, with a duration of 82 seconds (174 words per minute) took the longest to narrate story 2 in comparison with 01BB27FC who took only 37.7 seconds (162 words per minute) to narrate the first story. The original narrator took 56 (168 words per minute) seconds in comparison. 01BB27FC is also has the shortest mean time of 45 seconds (171 words per minute), in the combined mean of both stories, whereas 07SB60FC, has the longest time of 74 seconds (111 words per minute), in terms of mean of both the stories. The original narrator took 63 seconds (162 words per minute) in comparison.

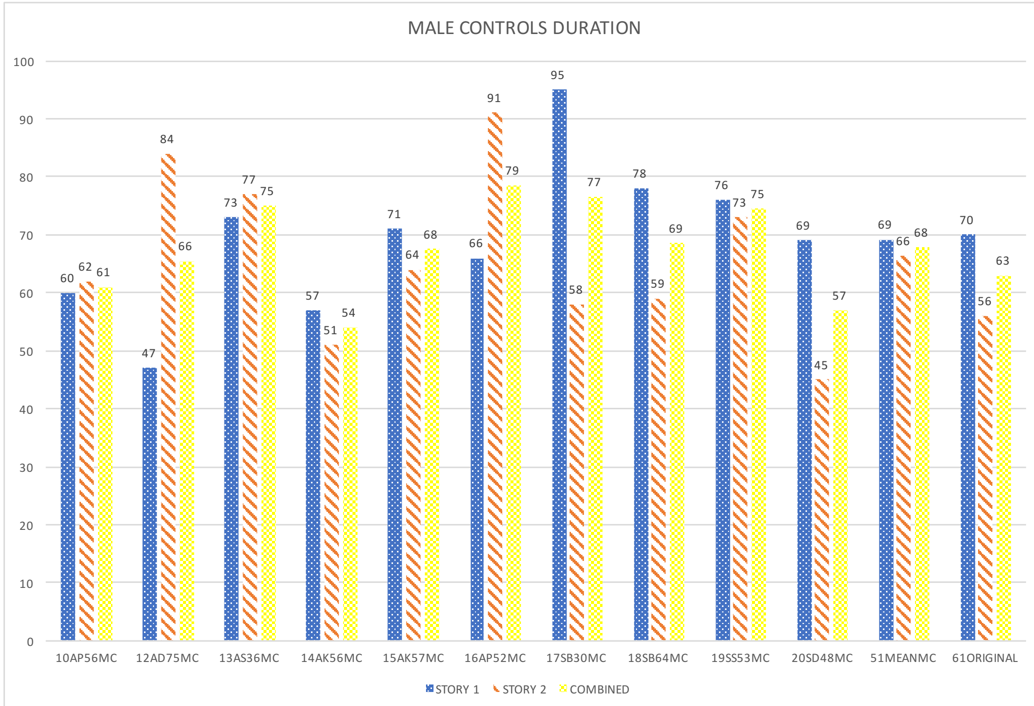


Fig 3.12 above displays the duration or length of the discourse recordings for the male controls, in comparison with the mean of the whole male control group (51MEANMC) and with that of the original reader 61ORIGINAL. We can observe the following from the figure displayed previously that the mean of the group 51MEANMC took 69 seconds (124 words per minute) for story 1 and 66 seconds (127 words per minute) for story 2, and is very close to the duration of the original reader 61ORIGINAL, at 70 seconds (156 words per minute) for story 1 and 56 seconds (168 words per minute) for story 2. 17SB30MC, with a duration of 95 seconds (108 words per minute) took the longest to narrate story 1 in comparison with 12AD75MC who took only 47 seconds (108 words per minute) to narrate the first story. The original narrator took 70 (156 words per minute) seconds in comparison. 16AP52MC, with a duration of 91 seconds (150 words per minute) took the longest to narrate story 2 in comparison with 20SD48MC who took only 45 seconds (114 words per minute) to narrate the first story. The original narrator took 56 seconds (168 words per minute) in comparison. 14AK56MC has the shortest mean time in the combined mean of both stories at 54 seconds (135 words per minute), whereas 16AP52MC, has the longest time at 79 seconds (153 words per minute), in terms of mean of both the stories. The original narrator took 63 seconds (162 words per minute) in comparison.

3.4.1.4. DIGRESSIONS IN DISCOURSE

In this section, we will compare the digressions in the discourse recordings. When the normal continuity of a thematic progression is broken, to either describe something (for adding characteristic features to an object mentioned previously) or to mention something completely removed from the main subject are called digressions. We shall first take a look at the English translation of the story, the narrator narrated to each participant. It has already been produced in the last chapter, but here we shall take a look at the story in a tabulated form, in order to be compared with the controls here and the case studies later on. The same format will be used for the case studies as well. Comparing the original story, narrated by the narrator directly with the RHD participant and individual control participant, side by side would make it much simpler to find out digressions.

Story 1 (Narrator)	RHD participant	Control participant
There was a deer. It was standing at the edge of the river. It saw its majestic antlers in the river, as a reflection. It kept praising it. Next it saw its feet and started to insult it because it was thin and did not match the overall beauty of the whole body. In the meantime, a hunter shot an arrow but missed. The deer started running in fear but ultimately got caught by the antlers in a bushy area. He exclaimed that the antlers he was praising put him in utter danger but his legs he was insulting, tried to help him run that far.	This is empty because we are comparing the controls here.	This is empty because we are comparing the whole control group objectively.

Story 2 (Narrator)	RHD participant	Control participant
Thousands of frogs lived in a small pond. They were happy but they wanted a king. So, they prayed to God for a king. God sent a big tree trunk to them. At first, they were intimidated by its size but soon they discovered, their new king did not move and did not talk. One brave frog climbed to the top of the trunk and after that many others gathered the courage and climbed to the top. They were unhappy and they prayed to God again stating that the king they were sent was inanimate and they want a new king who would be alive and actually rule over them. God got a bit angry. He sent a stork to the pond and the stork ate up all the frogs.	This is empty because we are comparing the controls here.	This is empty because we are comparing the whole control group objectively

The following bar graphs display the number of times participants have digressed in the process of narrating the story back to the reader. Here, the control participants have been compared to the mean of the whole control group. Digressions have been calculated manually by listening to spatial and temporal displacements in the discourse recordings. The participants have been put back to the non-digressed versions of the story, as many times they have digressed.

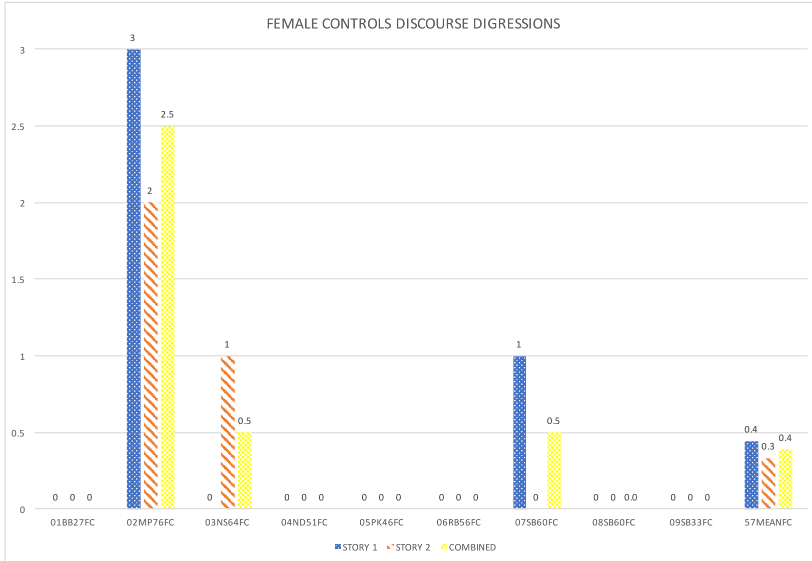


Fig 3.13 above displays the number of digressions made by each female control participant in comparison with the mean of the whole female control group. We can observe the following from the figure displayed previously that 02MP76FC has 3 digressions in story 1, all of them spatial displacements, as discerned from the recordings; in comparison with the mean 1.4 for 57MEANFC. 02MP76FC also has 2 spatial displacements in story 2, as discerned from the recordings; in comparison with the mean 0.7 for 57MEANFC. A total of three control participants have digressed during their discourse recordings, including 02MP76FC; 03NS64FC who has 1 digression in story 2 and 07SB60FC who has 1 digression in story 1.

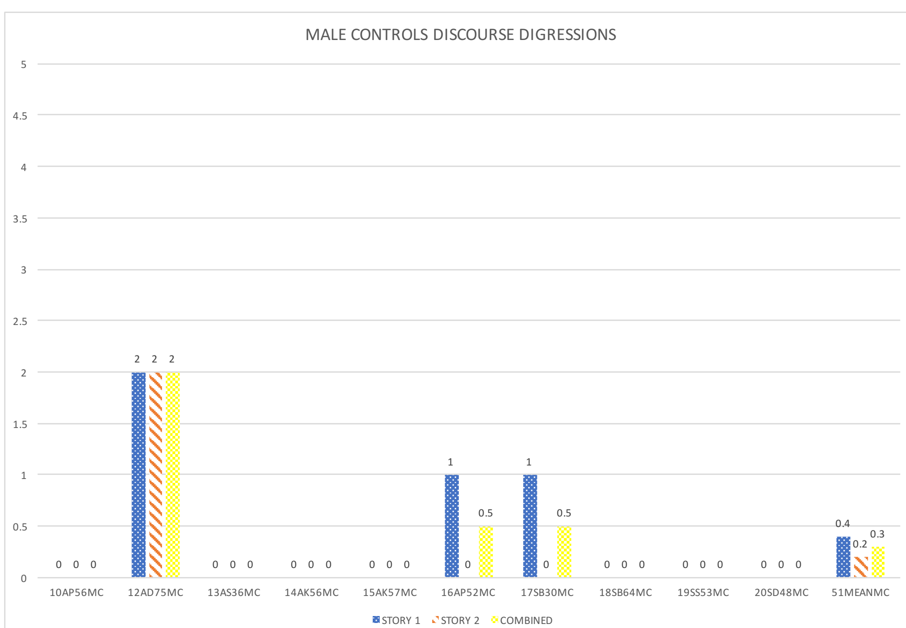


Fig 3.14 above displays the number of digressions made by each male control participant in comparison with the mean of the whole male control group. We can observe the following from the figure displayed previously that 12AD75MC has 2 digressions in story 1, 2 digressions in story two and as a result 2 digressions on an average, for the combined mean of the two stories. The displacements made were both spatial and temporal in nature. In comparison, the mean was 0.4 digressions for story 1 and 0.2 for story 2; for 57MEANFC. A total of three control participants have digressed during their discourse recordings, including 12AD75MC, who has been discussed in the point above and 16AP52MC who has 1 spatial digression in story 1; and 17SB30MC who has 1 digression in story 1. The mean of digressions for story 1 is 0.4, while the same for story 2 is 0.2 and the combined mean is 0.3, proving digressions were very less.

3.4.1.5. ANSWERS MADE TO QUESTIONS MADE IN DISCOURSE

In this section, we shall take a look at the questions answered by the controls in comparison with the mean of the control group. First let us take a look at the questions and their answers.

STORY 1		
	Questions	Actual answer
1	Which animal(s) were mentioned in the story?	A deer
2	What was the deer doing?	Looking at his reflection
3	Why did the deer run?	A hunter shot an arrow but it didn't touch
4	Why was he caught?	His big antlers were caught in a bush
5	What was the deer insulting, in the beginning?	His thin legs, that don't match his antlers and body.

STORY 2		
	QUESTIONS	**ACTUAL ANSWER**
1	Which animal(s) were mentioned in the story?	Frogs, stork
2	Where did the frogs live?	In a small pond
3	What did the frogs want the first time?	A king
4	What did the frogs want the second time?	A king who would actually be alive and rule over them
5	Why did all the frogs die?	The stork ate them all

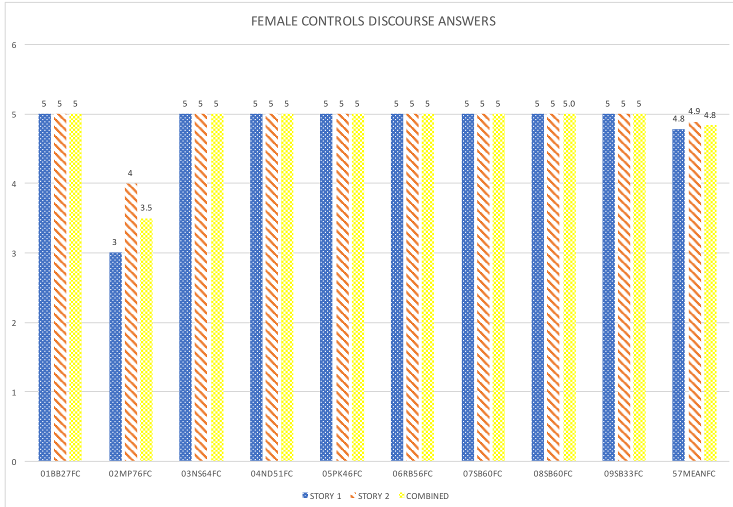


Fig 3.15 above displays the number of answers, made by each female control participant in comparison with the mean of the whole female control group 57MEANFC. We can observe the following from the figure displayed previously that everyone except 02MP76FC could answer all 5 questions, asked to them and 02MP76FC could answer 3 questions in the first story and 4 questions in the second story.

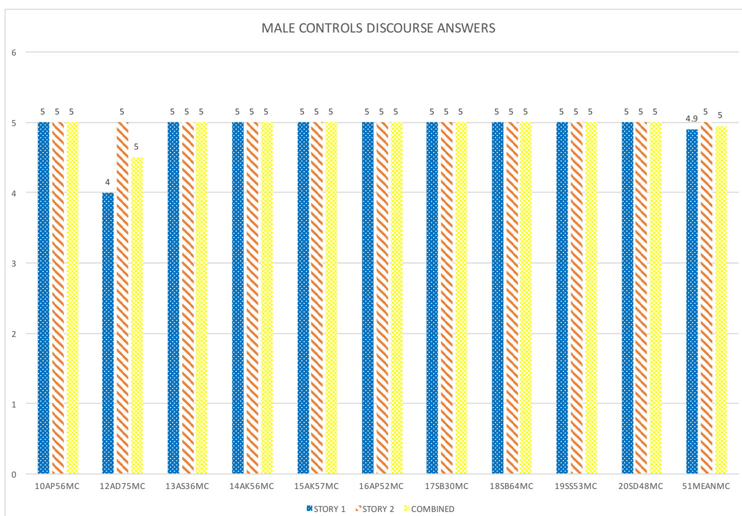


Fig 3.16 above displays the number of answers, made by each female control participant in comparison with the mean of the whole female control group 51MEANMC. We can observe the following from the figure displayed previously that everyone except 12AD75MC could answer all 5 questions, asked to them. 02MP76FC could answer 4 questions in the first story but answered all 5 questions in the second story.

3.4.2. PATTERNS AT THE LEVEL OF SENTENCES

This section consists of 9 linked line scatter charts, which denote the 9 sentences (3 declarative, 3 imperative and 3 interrogative) recorded from each participant. Every sentence has been divided into three parts and the f0 or fundamental frequency of the vowel(s) in those segments have been noted down. Then they have been plotted for the line scatter diagrams. Each chart contains every control participant, in comparison with the mean of the whole group. Here, it is important to notice that pitch patterns depend on the kind of meaning being depicted in a sentence. A sentence can make different meanings, just by being used with varied emphasis on various words or different pitch patterns. Pitch patterns depend on content and context, emotional patterns, listener and speaker relationship and so on.

Let us take a look at the sentences first.

Sentences	Meaning	Important words and expected stress on
1. ɑmi bʰɑlo ɑcʰi	I am in good health.	ɑmi (me)
2. ɑmɑr bari ʃɔhore	My house is in the city.	ɑmɑr bari (my house)
3. ɑmi bʰɑt̪ kʰɑi	I eat rice.	ɑmi (me), bʰɑt̪ (rice)
4. ed̪ike eʃo	Come here.	ed̪ike (here)
5. d̪ɔrʝɑ tɑ kʰolo	Open the door.	d̪ɔrʝɑ (door)
6. ɑmake ʝɔl d̪ao	Give me water to drink.	ɑmake (me), ʝɔl (water)
7. t̪omɑr nɑm ki?	What is your name?	t̪omɑr (your), nɑm (name)
8. t̪omar bari kot̪ʰae?	Where do you live?	t̪omɑr (your), bari (house)
9. t̪umi kot̪ʰɑ t̪ʰeke ɑscʰo?	Where are you coming from?	t̪umi (you), kot̪ʰɑ t̪ʰeke (where from)

Table 3.5: The 9 sentences used in the present study.

Table above displays the 9 sentences, that were used during the field work, to record sentences from RHD participants and controls. The important words in each sentence have been marked in the table above, so that we understand which words might carry more pitch than the others.

The following four kinds of sentence curves were found in the sentences recorded by all controls and all RHD participants. Although, in this section, we discuss only control participants, but we shall use the same 4 types of sentences discussed below, to discuss the sentences recorded by the case studies later on. The graph below displays the kinds of variation seen in three kinds of sentences being studied, namely declarative, imperative and interrogative.

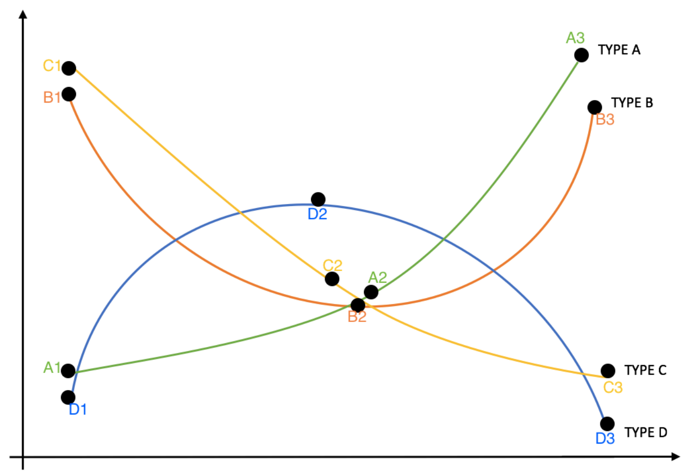


Fig 3.17 above, displays the four varieties of sentences, found in the sentence recordings. It can be noted that:

1. **Type A:** The first measured point A1 starts low, followed by the mid-point A2 which is higher and ends at A3, which is highest. In such sentences, it may be noted that the maximum pitch can be attributed to the third measurement point in sentences. **Such sentence curves can be associated with yes/no interrogative questions but since no such questions were asked at the field study, such pitch patterns are very rare in my data.** A declarative sentence or an imperative sentence generally does not have important words at the end of the sentence in Bangla.

2. **Type B:** The first measured point begins high at B1, followed by the mid-point B2, which is lower than B1, and ends at B3, which is definitely higher than B2, but might or might not be higher than B1. In such sentences, maximum pitch can be seen in the first or the last measurement point and the measurement point in between, generally carries much lower pitch than the other two points. **Such sentence curves can be associated with imperative sentences and interrogative sentences.**

3. **Type C:** The first measured point begins at C1, which is high, followed by C2 which us lower than C1 and ends at C3, which is lower than both C1 and C2. In such sentences, it may be noted that the maximum pitch can be attributed to the first measurement point in sentences. **Such types of curves can be associated with declarative sentences**.

4. **Type D:** The first measured point begins at D1, which is low, followed by D2, which is higher than D1 and ends at D2, which is definitely lower than D2, but might or might

not be lower than D1. In such sentences, it may be noted that the maximum pitch can be attributed to the second measurement point in sentences. **Such types of curves can be associated with imperative sentences, declarative sentences and interrogative sentences when the mid part of the sentence carry the important words like sentence 9.**

But in the end, we must remember that these 4 types of sentence curves discussed above are not air-tight containers. A sentence can make different meanings, just by being used with varied emphasis on various words or different pitch patterns. Pitch patterns depend on content and context, emotional patterns, listener and speaker relationship and so on. The following tables show the number of times specific pitch patterns have been used, in the present study. The first table displays the values for female control participants while the second table lays down the same for female RHD participants.

CONTROLS					
FEMALES					
		S1	S2	S3	Total
DECLARATIVE	A	1	0	1	2
	B	0	0	2	2
	C	6	3	6	**15**
	D	2	6	0	8
		S4	S5	S6	Total
IMPERATIVE	A	2	3	0	5
	B	1	0	0	1
	C	0	0	6	6
	D	6	6	3	**15**
		S7	S8	S9	Total
INTERROGATIVE	A	1	1	1	3
	B	5	6	0	**11**
	C	1	2	2	5
	D	2	0	6	8

RHD					
FEMALES					
		S1	S2	S3	Total
DECLARATIVE	A	0	0	1	1
	B	1	0	1	2
	C	3	1	1	**5**
	D	0	3	1	4
		S4	S5	S6	Total
IMPERATIVE	A	0	2	0	2
	B	0	0	1	1
	C	1	0	3	4
	D	3	2	0	**5**
		S7	S8	S9	Total
INTERROGATIVE	A	0	1	1	2
	B	0	0	0	**0**
	C	2	2	0	4
	D	2	1	3	**6**

Table 3.6: A comparison of the pitch curves in sentences: Female RHD vs control

In the table above the vertical divisions on the left show the type of sentences (declarative, imperative and interrogative), followed by the types of pitch patterns, namely A, B, C and D types. The horizontal divisions show the sentences (S1 – sentence 1, S2 – sentence 2 and so on). Table above helps us discern the following:

Declaratives

Sentence 1 in female control participants have a maximum of type **C** curves, in comparison with female RHD participants who have also used a maximum of type **C**. **Sentence 2** in female control participants have a maximum of type **D** curves, in comparison with female RHD participants who have also used a maximum of type **D**. **Sentence 3** in female control participants have a maximum of type **C** curves, in comparison with female RHD participants who have one of each kind of sentence.

Imperatives

Sentence 4 in female control participants have a maximum of type **D** curves, in comparison with female RHD participants who have used type **D**. **Sentence 5** in female control participants have a maximum of type **C** curves, in comparison with female RHD participants who have used both type **A** and **D**. **Sentence 6** in female control participants have a maximum of type **C** curves, in comparison with female RHD participants who have also used a maximum of type **C**.

Interrogatives

Sentence 7 in female control participants have a maximum of type **B** curves, in comparison with female RHD participants who have used both of types **C** and **D**. **Sentence 8** in female control participants have a maximum of type **B** curves, in comparison with female RHD participants who have used a maximum of type **C**. **Sentence 9** in female control participants have a maximum of type **D** curves, in comparison with female RHD participants who have also used a maximum of type **D**.

The first table displays the values for male control participants while the second table lays down the same for male RHD participants.

CONTROLS					
MALES					
		S1	S2	S3	Total
DECLARATIVE	A	2	0	2	4
	B	1	1	5	7
	C	6	1	5	12
	D	3	10	0	13
		S4	S5	S6	Total
IMPERATIVE	A	4	3	3	10
	B	0	0	1	1
	C	0	0	6	6
	D	8	9	2	19
		S7	S8	S9	Total
NTERROGATIVE	A	4	3	1	8
	B	2	4	1	7
	C	3	3	0	6
	D	3	2	10	15

RHD					
MALES					
		S1	S2	S3	Total
DECLARATIVE	A	2	3	0	5
	B	2	1	7	10
	C	12	3	8	23
	D	2	11	3	16
		S4	S5	S6	Total
IMPERATIVE	A	1	3	1	5
	B	0	0	1	1
	C	1	1	3	5
	D	16	14	13	43
		S7	S8	S9	Total
NTERROGATIVE	A	1	2	1	4
	B	1	1	0	2
	C	6	6	6	18
	D	10	9	11	30

Table 3.7: A comparison of the pitch curves in sentences: Male RHD vs control.

In the table above the vertical divisions on the left show the type of sentences (declarative, imperative and interrogative), followed by the types of pitch patterns, namely A, B, C and D types. The horizontal divisions show the sentences (S1 – sentence 1, S2 – sentence 2 and so on). Table above helps us discern the following:

Declaratives

Sentence 1 in male control participants have a maximum of type **C** curves, in comparison with male RHD participants who have also used a maximum of type **C**. **Sentence 2** in male control participants have a maximum of type **D** curves, in comparison with male RHD participants who have also used a maximum of type **D**. **Sentence 3** in male control participants have both type **B** and **C** curves, in comparison with male RHD participants who have used type **C**.

Imperatives

Sentence 4 in male control participants have a maximum of type **D** curves, in comparison with male RHD participants who have also used type **D**._**Sentence 5** in male control participants have a maximum of type **D** curves, in comparison with male RHD participants who have also used type **D**. **Sentence 6** in male control participants have a maximum of type **C** curves, in comparison with male RHD participants who have used a maximum of type **D**.

Interrogatives

Sentence 7 in male control participants have a maximum of type **A** curves, in comparison with male RHD participants who have used type **D**. **Sentence 8** in male control participants have a maximum of type **B** curves, in comparison with male RHD participants who have used a maximum of type **D**. **Sentence 9** in male control participants have a maximum of type **D** curves, in comparison with male RHD participants who have also used a maximum of type **D**.

3.4.2.1. FEMALES

The following line scatter graphs compare female controls to the mean of the whole group, in the process categorizing them into the four types of sentence curves discussed above. The graphs are followed by short discussions which also mention the exceptions in the graphs and mention the common trend.

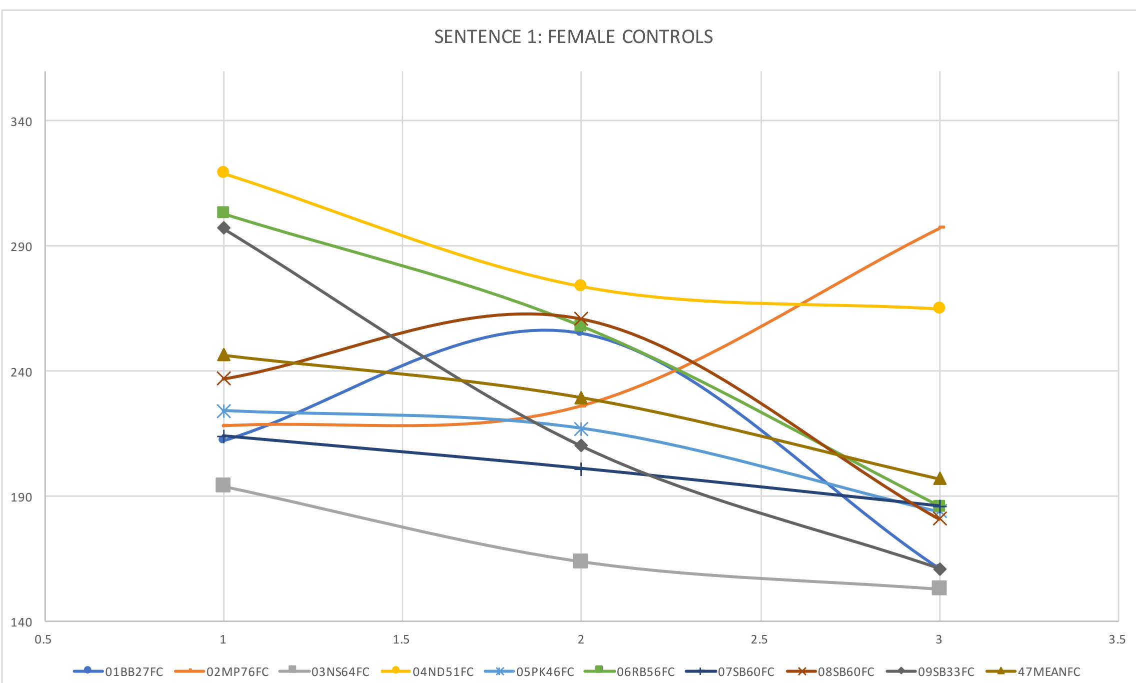
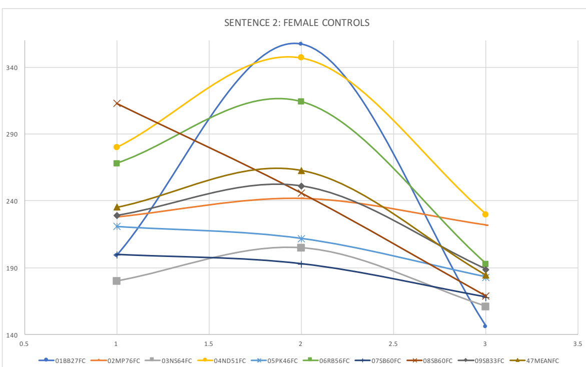
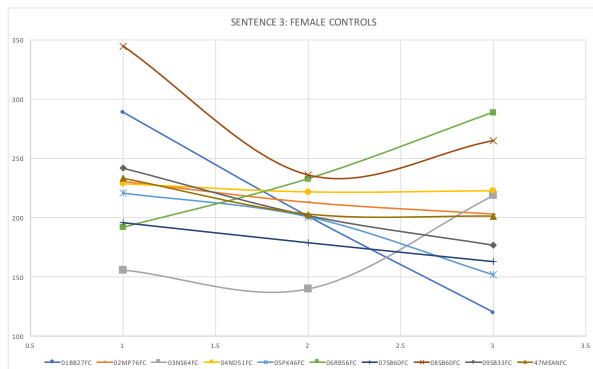
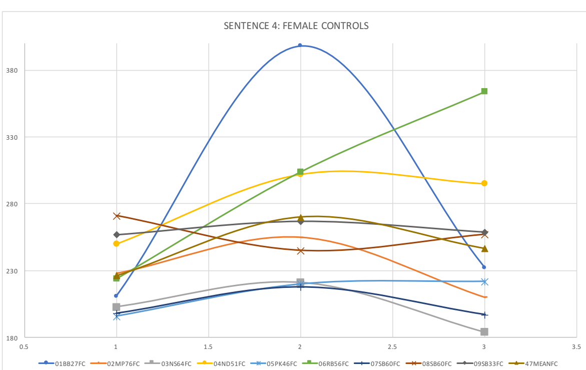


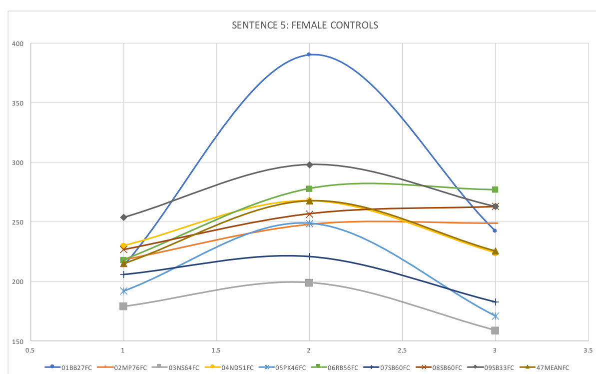
Fig 3.18 above compares all the varieties of sentence 1, “ɑmi bʰɑlo ɑcʰi” recorded from female control participants in comparison with the mean of the whole group. We can observe the following from the figure displayed previously that 6 participants have used the C type of sentence curve, 2 participants have used the D type and 1 participant has used the A type of sentence. Hence it can be seen that this sentence has a general tendency of starting at a high f0 and ending in a low pitch. The only exception is 02MP76FC, uses a type A sentence. Broadly speaking, the maximum number of control participants have used the C variety of sentence, which means that the stress is on the first word.

Rest of the figures have been made smaller, in order for the reader to take a brief look at all the sentences.









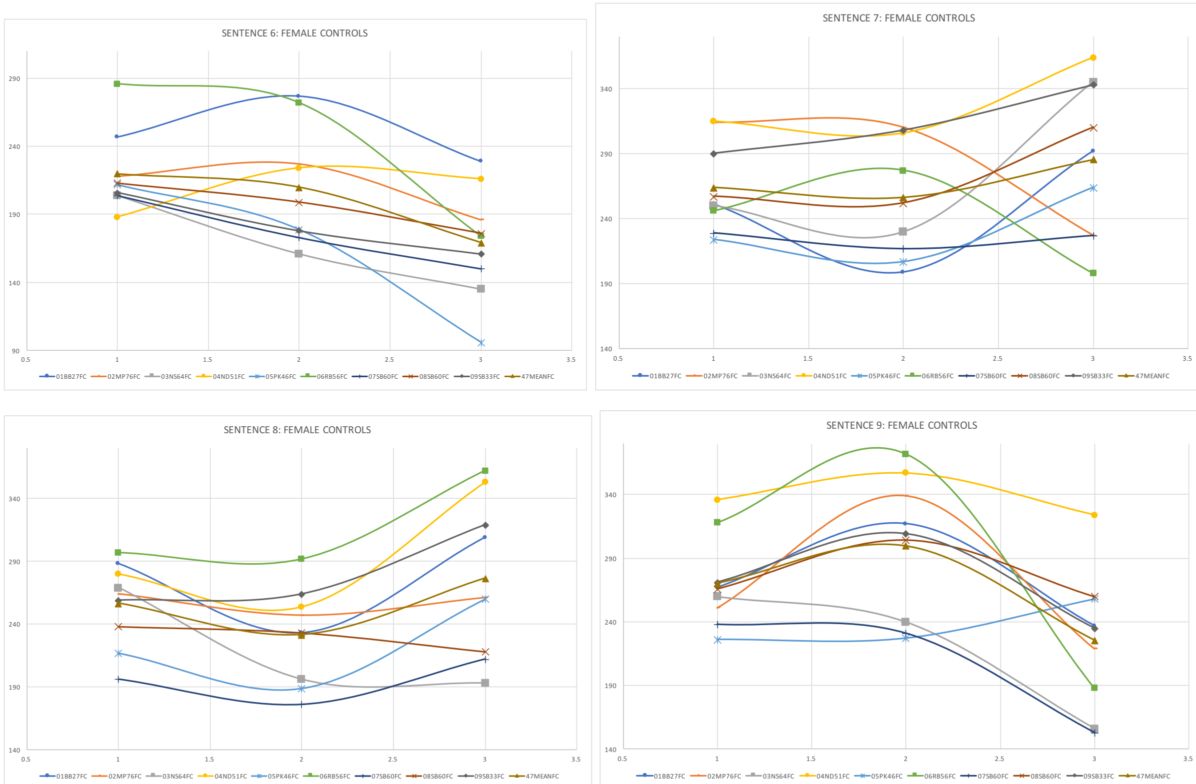


Fig 3.22 – 3.26 – Sentence level scatter graphs for female control participants

Fig 3.19 compares all the varieties of sentence 2, “ɑmɑr bɑri ʃɔhore” recorded from female control participants in comparison with the mean of the whole group. We can observe the following from the figure displayed previously: 6 participants have used the D type of sentence curve and 3 participants have used the C type of sentence. The only exception is 08SB60FC, who begins the sentence at a high f0 and ends at a low f0. Broadly speaking, the maximum number of control participants have used the D variety of sentence, which means that the stress is on the second word, while the first and the last words have low stress.

Fig 3.20 compares all the varieties of sentence 3, “ɑmi bʰɑt̪ kʰɑi” recorded from female control participants in comparison with the mean of the whole group. We can observe the following from the figure displayed previously: 6 participants have used the C type of sentence curve and 2 participants have used the B type of sentence and 1 participant has used the type A of sentence. Exceptions include 08SB60FC and 03NS64FC, who use the type B of sentence and stress on the first and last words; while 06RB56FC uses type A, in which she gives maximum stress to the third word, which has the highest f0. Broadly speaking, the maximum number of control participants have used the C variety of sentence, which means that the stress is on the first word, while the second and the third words have low stress.

Fig 3.21 above compares all the varieties of sentence 4, "e̪dike eʃo" recorded from female control participants in comparison with the mean of the whole group. We can observe the following from the figure displayed previously: 6 participants have used the D type of sentence curve and 2 participants have used the A type of sentence, while only 1 participant used type B. Exceptions include 06RB56FC who has used a type A sentence and seems to put maximum stress to the last syllable measured; 08SB60FC, who has used a type B sentence and 05PK46FC, who has used a type A sentence. Broadly speaking, the maximum number of control participants have used the D variety of sentence, which means that the stress is on the second part of the sentence, while the beginning and the ending parts have low stress, hence lower f0 and the sentence looks like an inverted 'U'.

Fig 3.22 above compares all the varieties of sentence 5, "d̪ɔrɟɑ tɑ kʰolo" recorded from female control participants in comparison with the mean of the whole group. We can observe the following from the figure displayed previously: 6 participants have used the D type of sentence curve and 3 participants have used the A type of sentence. Exceptions include 06RB56FC who has used a type A sentence and seems to put maximum stress to the last part of the sentence measured; 08SB60FC, has used a type A sentence and 02MP76FC, who has used a type A sentence. Broadly speaking, the maximum number of control participants have used the D variety of sentence, which means that the stress is on the second part of the sentence, while the beginning and the ending parts have low stress, hence lower f0 and the sentence looks like an inverted 'U'.

Fig 3.23 above compares all the varieties of sentence 6, "ɑmɑke ɟɔl d̪ɑo" recorded from female control participants in comparison with the mean of the whole group. We can observe the following from the figure displayed previously: 6 participants have used the C type of sentence curve and 3 participants have used the D type of sentence. Exceptions include 01BB27FC, 02MP76FC and 03ND51FC who have used type D sentences and have put maximum stress to the second part of the sentence measured. Broadly speaking, the maximum number of control participants have used the C variety of sentence, which means that the stress is on the first part of the sentence, while the middle has lower than the beginning, while the ending has lowest stress.

Fig 3.24 above compares all the varieties of sentence 7, "t̪omɑr nɑm ki?" recorded from female control participants in comparison with the mean of the whole group. We can observe the following from the figure displayed previously: 5 participants have used the B type of sentence curve, 2 participants have used type D sentences and 1 person each have used A and C types of sentences. Exceptions include 02MP76FC and 06RB56FC who have used type D sentences and have put maximum stress to the second part of the sentence measured. The rest of the sentences end at a point which makes the scatter lines go higher with higher f0. Broadly speaking, the maximum number of control participants have used the B variety of sentence, which means that the stress is on the beginning and ending part of the sentence, while the middle has the lowest stress.

Fig 3.25 above compares all the varieties of sentence 8, "t̪omɑr bɑri kot̪ʰɑe?" recorded from female control participants in comparison with the mean of the whole group. We can observe the following from the figure displayed previously: 6 participants have used the B type of sentence curve, 2 participants have used type C sentences and 1 participant has used type A sentence. 08SB60FC, who uses a type C sentence and begins at the highest f0, while decreasing consequently on the second and the third measured points; is an exception. 03NS64FC is also an exception and she used the C type of sentence. The rest of the sentences end at high f0, which makes the scatter lines go higher with higher f0. 09SB33FC, unlike the others doesn't stress the first part of the sentence and then puts in more consecutive stress to the second and third parts. Broadly speaking, the maximum number of control participants have used the B variety of sentence, which means that the stress is on the beginning and ending part of the sentence, while the middle has the lowest stress.

Fig 3.26 above compares all the varieties of sentence 9, "t̪umi kot̪ʰɑ t̪ʰeke ɑscʰo?" recorded from female control participants in comparison with the mean of the whole group. We can observe the following from the figure displayed previously: 6 participants have used the D type of sentence curve, 2 participants have used type C sentences and 1 participant has used type A sentence. 05PK46FC, an exception, uses a type A sentence and begins at the lowest f0, while increasing f0 consequently on the second and the third measured points. 03NS64FC and 07SB60FC, both exceptions use the C type of sentence. The rest of the sentences end at low f0. It seems like the middle portion of the sentence is most important, because that part of the sentence holds maximum stress, hence maximum f0. Broadly speaking, the maximum number of control participants have used the D variety of sentence, which means that the stress is on the middle portion of the sentence, while the beginning and end have the lowest stress.

3.4.2.2. MALES

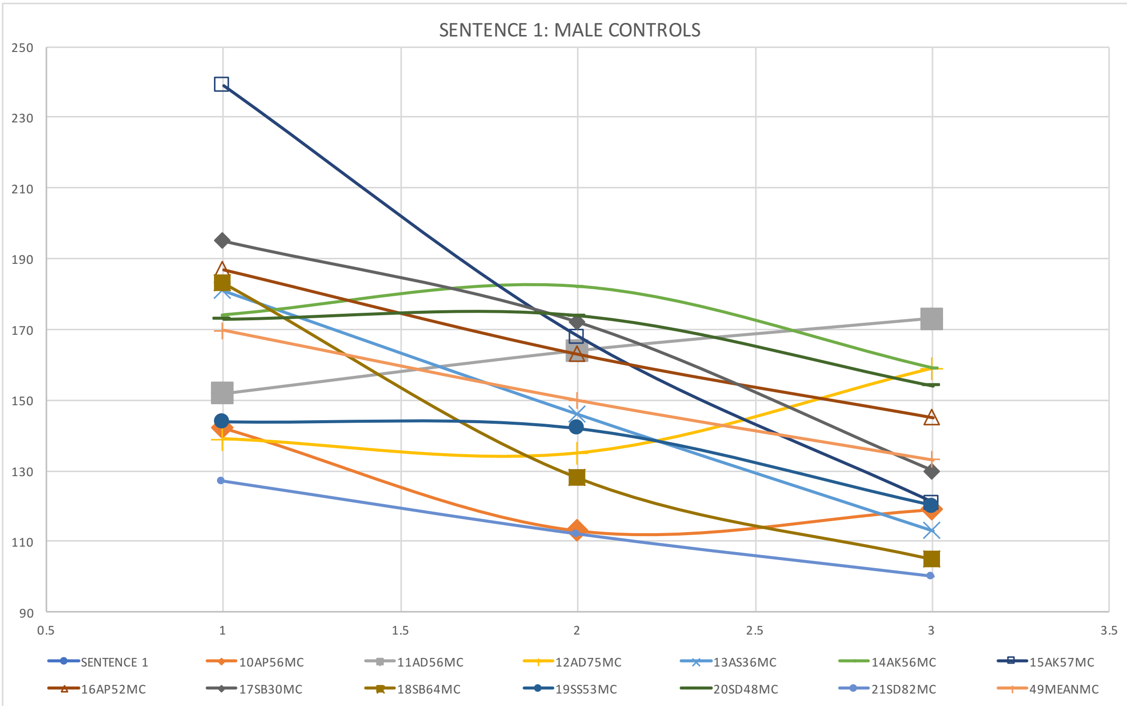
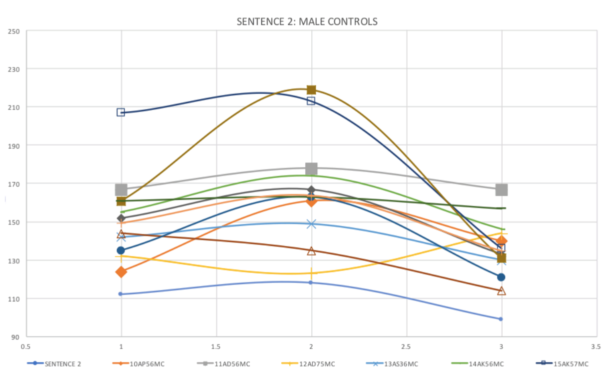
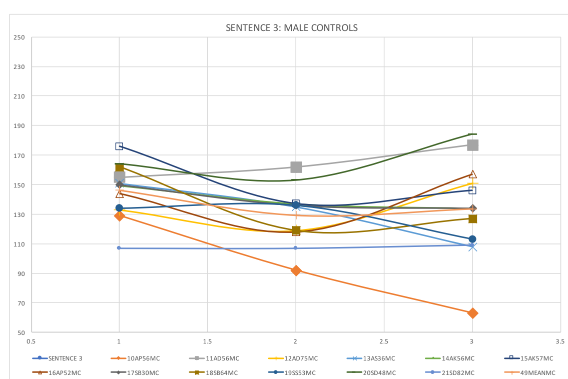


Fig 3.27 above compares all the varieties of sentence 1, “ɑmi b^{h}ɑlo ɑc^{h}i” recorded from male control participants. We can observe the following from the figure displayed previously that 6 participants have used the C type of sentence curve, 3 participants have used the D type, 2 participants have used type A and 1 participant has used the B type of sentence. Hence it can be seen that this sentence has a general tendency of starting at a high f0 and ending in a low pitch. The only exception is 10AP56MC, who uses a type B sentence. Broadly speaking, the maximum number of control participants have used the C variety of sentence, which means that the stress is on the first word. Rest of the figures have been displayed together for the reader to take a brief look at all of them together.





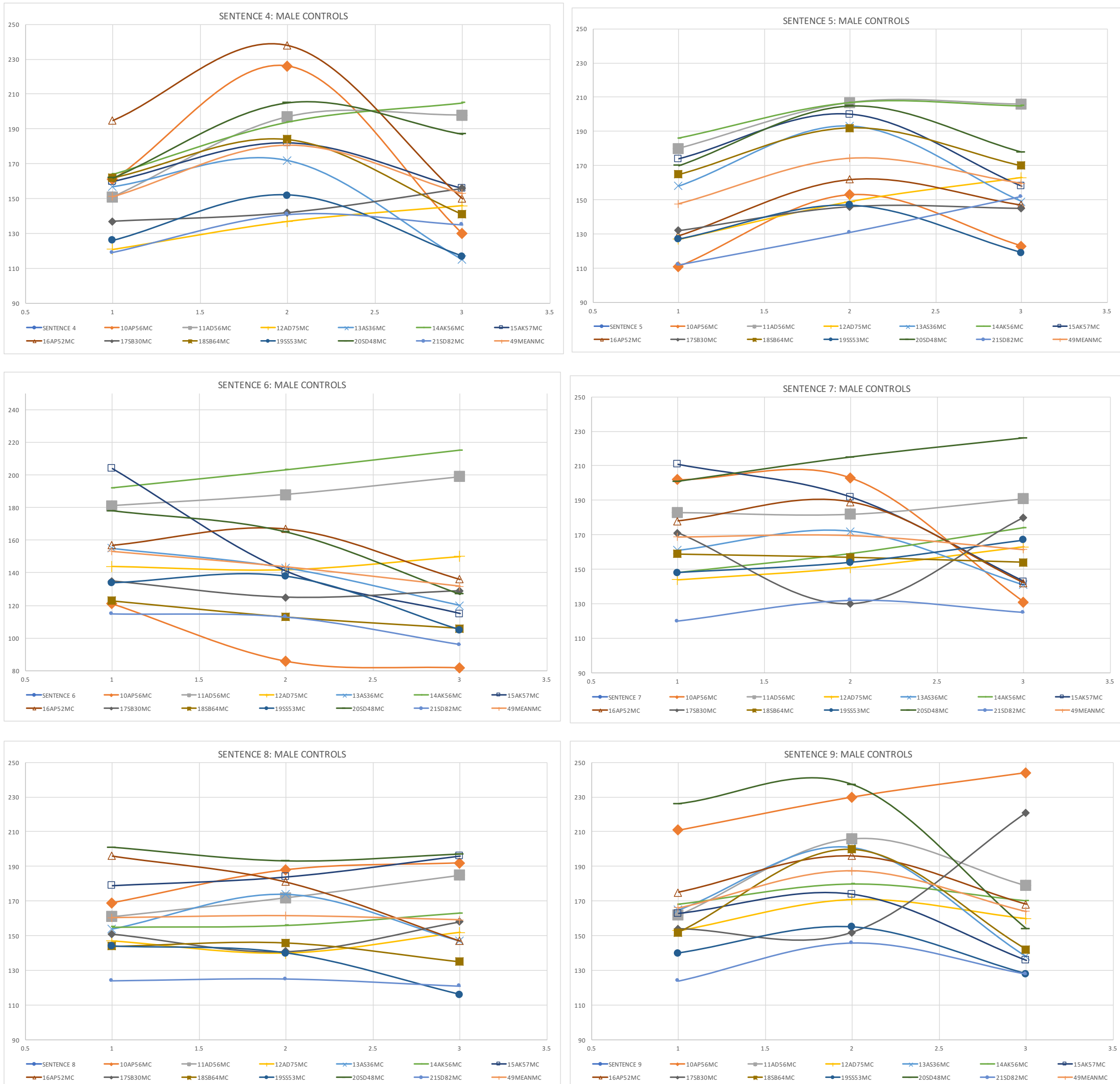


Fig 3.28 – 3.35 – Sentence level scatter graphs for female control participants

Fig 3.28 compares all the varieties of sentence 2, “ɑmɑr bɑri ʃɔhore” recorded from male control participants. We can observe the following from the figure displayed previously: 10 participants have used the D type of sentence curve and 1 participant each have used the B and C. The only exception is 12AD75MC, who uses a type B. Broadly speaking, the maximum number of control participants have used the D variety of sentence, which means that the stress is on the second word, while the first and the last words have low stress, or lower f0.

Fig 3.29 above compares all the varieties of sentence 3, “ɑmi bʰɑt̪ kʰɑi” recorded from male control participants. We can observe the following from the figure displayed previously: 5 participant each have used the type B and type C while 2 participants have used the A type of sentence. Exceptions include 19SS53MC and 11AD56MC, who use the type A of sentence. They begin their sentences at a low f0 while the consecutive two points measures increase. Broadly speaking, the maximum number of control participants have used the B and C variety of sentences. This means that the participants who have used the B type put more stress or importance to the beginning and the ending parts of the sentence while people who have used the type C, put more importance to the first part of the sentence while the two consecutive parts were given less importance and hence lesser stress, which translates to lesser f0 values.

Fig 3.30 above compares all the varieties of sentence 4, "eḏike eʃo" recorded from male control participants. We can observe the following from the figure displayed previously: 8 participants have used the D type of sentence curve and 4 participants have used the A type of sentence. Exceptions include 14AK56MC, 11AD56MC, 12AD75MC and 17SB30MC, who use the type A of sentence. They start with a low f0, like the others but they end of their sentences display the maximum f0 level. Broadly speaking, the maximum number of control participants have used the D variety of sentence, which means that the stress is on the second part of the sentence, while the beginning and the ending parts have low stress, hence lower f0 and the sentence looks like an inverted 'U'.

Fig 3.31 above compares all the varieties of sentence 5, "ḏɔɾɟɑ tɑ kʰolo" recorded from male control participants. We can observe the following from the figure displayed previously: 9 participants have used the D type of sentence curve and 3 participants have used the A type of sentence. Exceptions include 21SD82MC and 12AD75MC, who use type A of sentence. Their sentence begin with low f0 but the two consecutive measured points have higher f0. Broadly speaking, the maximum number of control participants have used the D variety of sentence, which means that the stress is on the second part of the sentence, while the beginning and the ending parts have low stress, hence lower f0 and the sentence looks like an inverted 'U'. Participants who have use the type D of sentence have stressed the third part of the sentence, hence proving that the third part is more important.

Fig 3.32 above compares all the varieties of sentence 6, "ɑmɑke ɟɔl ḏɑo" recorded from male control participants. We can observe the following from the figure displayed previously: 6 participants have used the C type of sentence curve, 3 participants have used the A type of sentence, while 2 participants have used the D type and 1 person has used the type B. We can discern 3 clear exceptions in which the participants have used the type A of sentence. They are 12AD75MC, 11AD56MC, 14AK56MC who start with low f0. Their next two measured points are consecutively higher. Broadly speaking, the maximum number of control participants have used the C variety of sentence, which means that the stress is on the first part of the sentence, while the middle has lower than the beginning, while the ending has lowest stress.

Fig 3.33 above compares all the varieties of sentence 7, "t̪omɑr nɑm ki?" recorded from male control participants. We can observe the following from the figure displayed previously: 4 participants have used the A type of sentence curve, 2 participants have used type B sentences and 3 person each have used C and D types of sentences. 4 participants have used the A variety of sentence like 12AD75MC but 3 participants have used the type C like 15AK57MC and 3 have used type D like 16AP52MC. A clear exception can be seen in 17SB30MC who uses type B.

Fig 3.34 above compares all the varieties of sentence 8, "t̪omɑr bɑri kot̪ʰɑe?" recorded from male control participants. We can observe the following from the figure displayed previously: 3 participants have used the A type of sentence curve, 4 participants have used type B sentences and 3 participants has used type C sentence, while 2 participants have used type D. Most of the sentences rise higher at the ending point of the sentence while we can see that four sentences dip lower at the last measured point, making them exceptions. These four participants are 19SS53MC, 18SB64MC, 16AP52MC and 13AS36MC.

Fig 3.35 above compares all the varieties of sentence 9, "t̪umi kot̪ʰɑ t̪ʰeke ɑscʰo?" recorded from male control participants. We can observe the following from the figure displayed previously: 10 participants have used the D type of sentence curve, 2 participants each have used type A and B. We can see two clear exceptions in the forms of 17SB30MC, who uses a type B sentence and 10AP56MC, who uses a type A sentence. Broadly speaking, the maximum number of control participants have used the D variety of sentence, which means that the stress is on the middle portion of the sentence, while the beginning and end have the lowest stress. This implies that the middle of the sentence is more important than the other two.

3.4.3. PATTERNS AT THE LEVEL OF VOWELS FOR CONTROLS

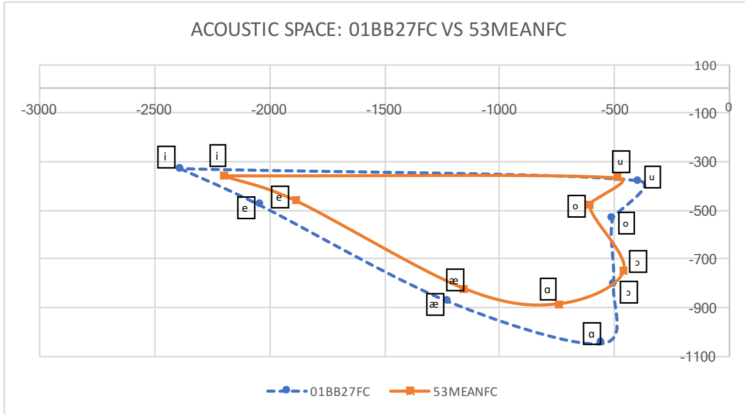


Fig 3.36 above compares female control participant 01BB27FC with the mean of the whole female control group, that is 53MEANFC. We can observe the following from the figure displayed previously that the front vowels, namely /i/, /e/ and /æ/ are more fronted in 01BB27FC than the mean of the control group. The vowels /e/, /æ/, /ɑ/, /o/ and /u/ are lower in 01BB27FC than the mean of the control group. The vowels /o/ is more back in 01BB27FC in comparison with the same vowel of the mean. The area of the acoustic space chart for 01BB27FC is 724100 and for 53MEANFC is 525960. The area of 01BB27FC is 38% larger than that of the mean. This is significant because, it is a lot larger than the area of the mean.

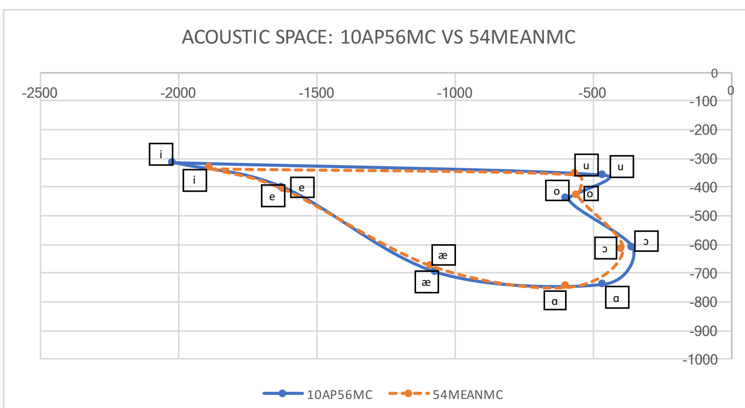


Fig 3.37 above compares male control participant 10AP56MC with the mean of the whole male control group, that is 54MEANMC. We can observe the following from the figure displayed previously that there are no major differences in the position of the vowels between 10AP56MC and 54MEANMC. The area of the acoustic space chart for 10AP56MC is 353753.5 and for 54MEANMC is 327954, making the area of the individual control, 108% of the mean, or in other words, the area of 10AP56MC is 8% larger than that of the mean.

In the same way, we shall take a look at all the individual case controls in comparison with the means of their control groups below. Only controls which display anomalies in their acoustic spaces, shall be discussed in details. Let us first take a look at a table, which compares the individual controls to the mean of the controls, in terms of area.

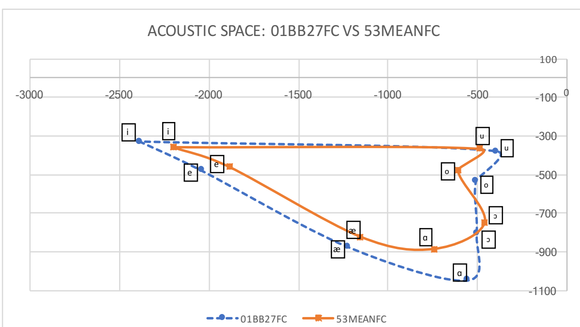
VOWELS: FEMALE CONTROLS		
PARTICIPANT	**Area**	**% of f mean**
01BB27FC	724100	38
02MP76FC	529070	1
03NS64FC	396032.5	-25
04ND51FC	476432.5	-9
05PK46FC	386686	-26
06RB56FC	483885.5	-8
07SB60FC	454780.5	-14
08SB60FC	475190.5	-10
09SB33FC	807465.5	54
98MEANFC	**525960**	

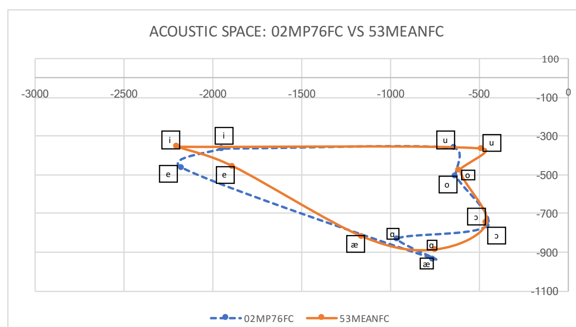
VOWELS MALE CONTROLS		
PARTICIPANT	**Area**	**% of m mean**
10AP56MC	353753.5	8
11AD56MC	462345.5	41
12AD75MC	366966	12
13AS36MC	198261.5	-40
14AK56MC	306181.5	-7
15AK57MC	278398.5	-15
16AP52MC	430473.5	31
17SB30MC	358350	9
18SB64MC	252738.5	-23
19SS53MC	245316	-25
20SD48MC	387032	18
21SD82MC	295629.5	-10
99MEANMC	**327954**	

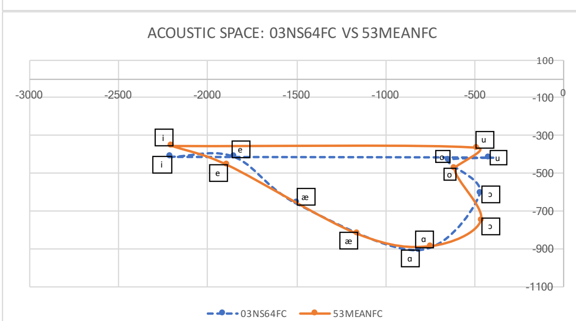
Table 3.8 – 3.9: Area of the individual female and male controls in comparison with the mean of the whole group.

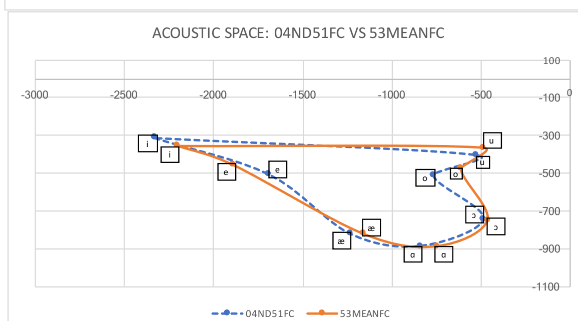
3.4.3.1.FEMALE PARTICIPANTS

Let us take a look at all the female controls in a quick glance. Then, we shall discuss only those controls in details, which display anomaly.









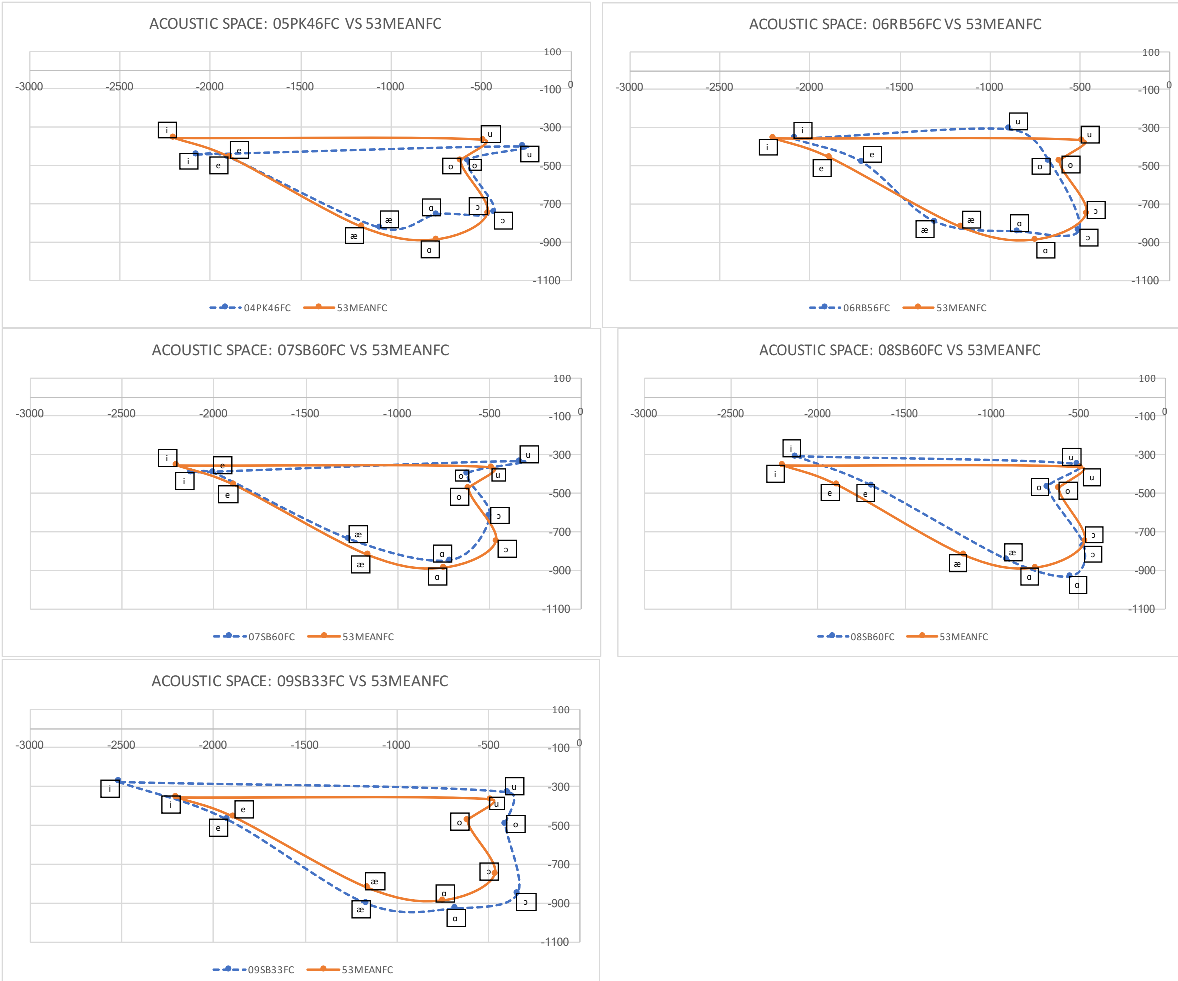
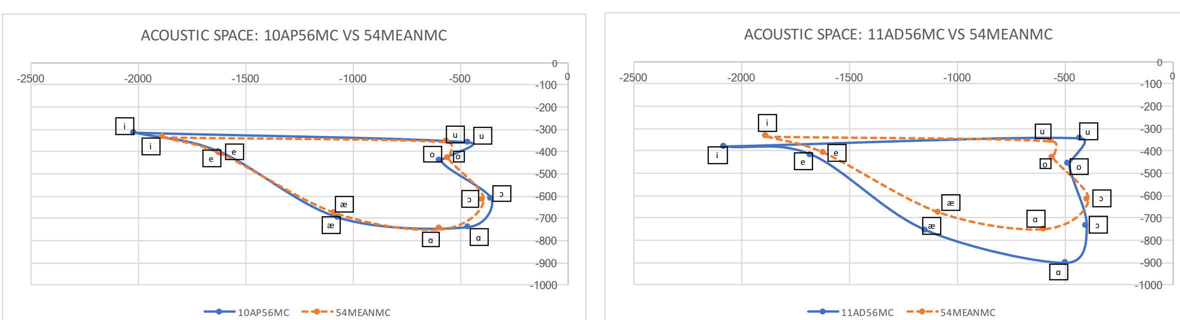


Fig 3.38 to 3.46 – Acoustic space scatter graphs for female control participants.

3.4.3.2. MALE PARTICIPANTS



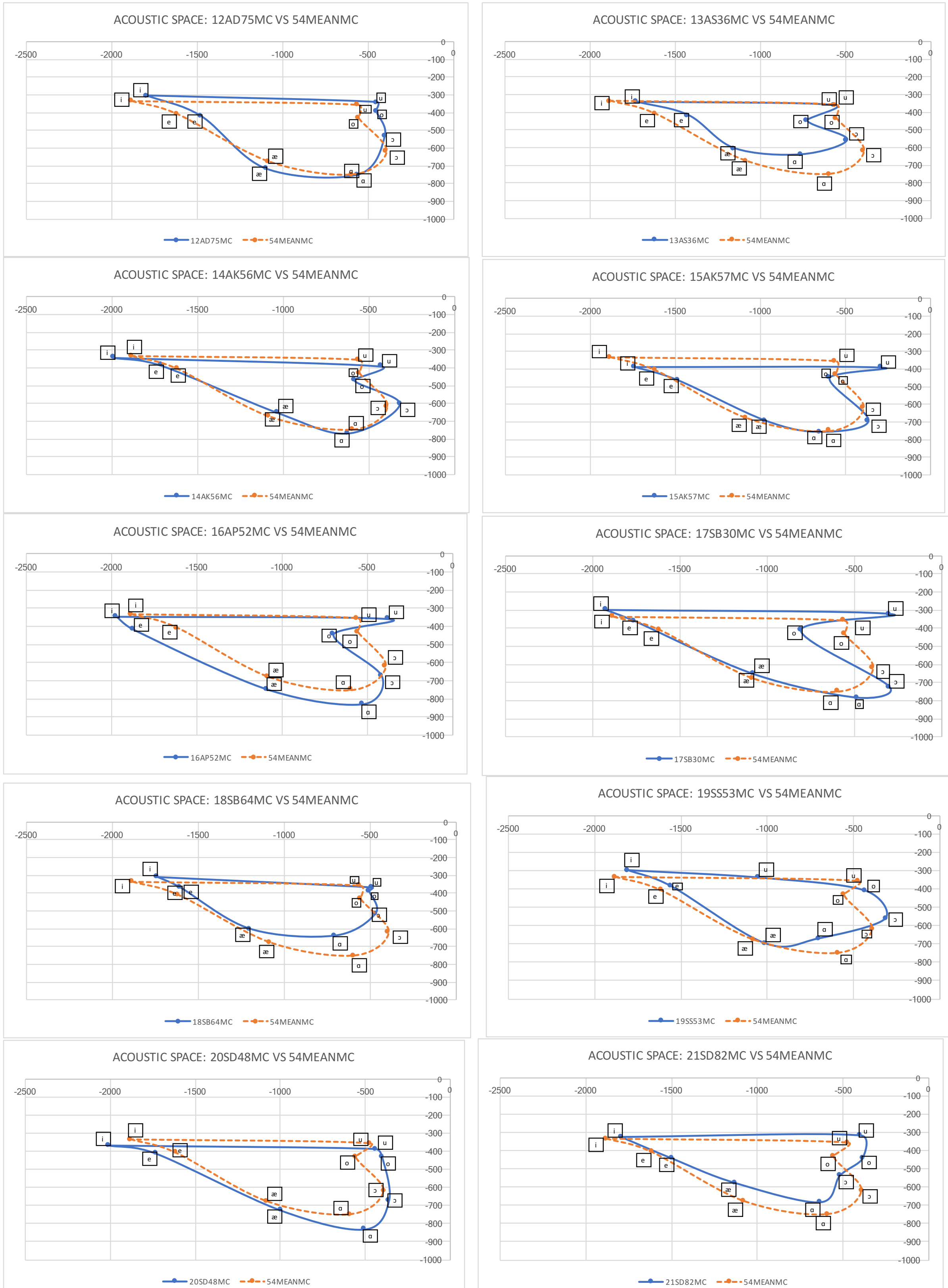


Fig 3.47 to 3.58 – Acoustic space scatter graphs for male control participants. (Figures marked according to how we read in English sentences)

3.5. CASE STUDIES

In the previous section, we discussed all the controls, in comparison with the mean of their group. This gives us an understanding of the nature of the output and responses to our test instruments in the normal age and gender matched control group. In this section, we discuss the individual case studies or RHD participants and present their respective output and responses to our test instruments in comparison with age and gender matched control group participants. The organization of case studies has been discussed and presented in section 3.3. To reiterate the salient features of the case studies, a summarized version of the template from section 3.3, has been presented below:

PRIMARY INFO

- **Codified Name**
- **Age and gender matched control**
- **Time since incidence**

PARTICIPANT INFORMATION

- **Condition of participant as tested in the preliminary examinations by the doctor**
- **Observations made by doctor**
- **Diagnosis made by doctor**
- **Region of damage**

COMPREHENSIVE STUDY OF PARTICIPANT AT THE 3 LEVELS OF COMMUNICATION

A. **Discourse:** Under this heading we will discuss the 5 parameters being studied under discourse

1. **Pitch range**.
2. **Fluency**.
3. **Duration**.
4. **Digressions.**
5. **Questions answered.**

B. **Sentences:** Under this heading, we will look into the 3 kinds (declarative, imperative and interrogative) of sentences (with 3 each) recorded and the various parameters associated with them. Bar graphs compare the RHD participants with the individual control they are paired to and the control group. The charts have been discussed in details.

C. **Vowels:** The vowels were primarily recorded as words, from where the vowels were dissected out, to be studied. The 7 words recorded from the participants were imported to Praat. The first and the second formants of all the vowels for all the participants were imported to MS Excel, where they were compared. Acoustic space in vowels were made using the first formant (f1) in the Y axis and the difference between the second formant (f2) and the first formant (f1) or f2-f1 in the X axis. The charts have also been discussed in details.

3.5.1. CASE STUDY 1

PRIMARY INFO

Codified Name: 22CS62FR

Female, 62 years of age, at the time of recording and case study.

Age and gender matched control: 07SB60FC

Time since incidence: 3 months back, at the time of recording.

PARTICIPANT INFORMATION

Condition of participant: The participant was fully conscious, having scored 11 on the GCS. She also scored 22 on the MMSE. The doctor tested her knee jerk reaction and it was limited. The elbow jerk had the normal reaction. Using a refractometer, the doctor tested her eyes by putting the rays of light into her eyes. The doctor mentioned that the movement of her pupils were normal. The participant could not walk without walking aids. The participant also complained of severe pain in her legs, at various times of the day. The doctor asked her to do some actions with her hands, involving muscle coordination and she could do it. The participant could also perform actions based on instructions, which involved complicated and elaborate instructions. The speech of the participant was slightly slurred but was understandable. The total loudness of her speech went down, according to her family members. The family of the participant also assured that she was facing no problems in eating. The doctor also performed a test in which he held both her hands in his hands and then asked her to keep them where he is holding them, after he lets her hands go. She could maintain the position, but her left hand fell a fair bit, before she regained control. According to the doctor, these are subtle signs of the stroke to the right hemisphere. The participant has problems in remembering things which happen moments back; a problem with the short-term memory. She remembers old facts but incompletely. Her color recognition was intact and she suffered no neglect to the left hemisphere. She is not undergoing any physiotherapy, as her family does not have the financial condition to afford it. She was taught a few exercises by the doctor. She does those exercises at times, only when her family members pressurize her to do so.

Observations made by doctor: The doctor mentions that she has no agraphia, no dementia, as well as no alexia. Participant is not hypertensive.

Diagnosis made by doctor: The doctor mentions that the participant has very less chance of suffering another stroke. She was suggested to continue freehand exercises, along with medication for blood pressure, for the next two months.

Region of damage: A small sub-acute ischemic infarct at **right capsule-thalamic region**.

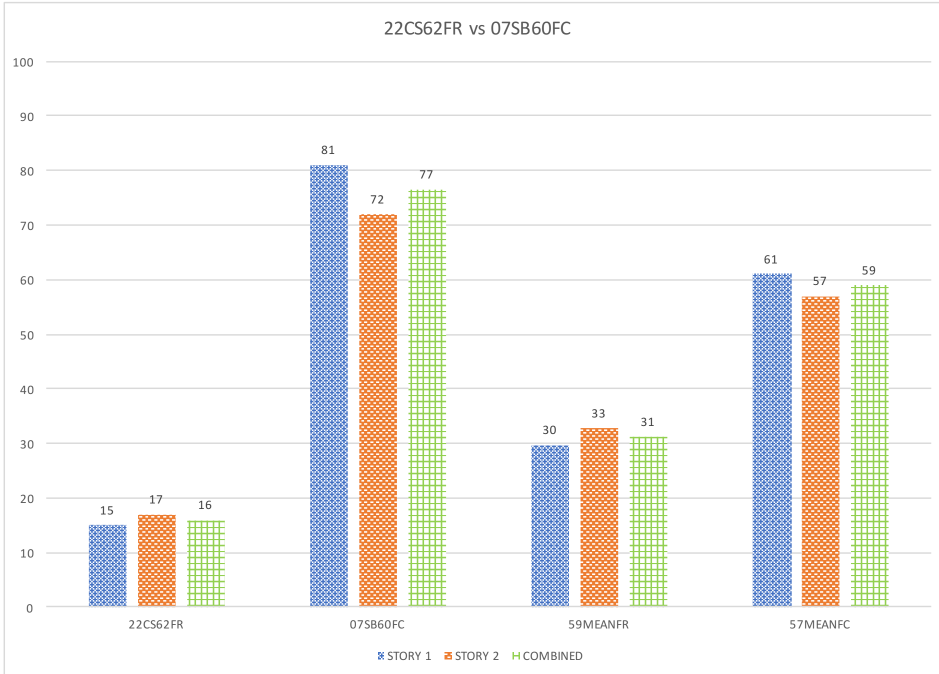
COMPREHENSIVE STUDY OF PARTICIPANT AT THE 3 LEVELS OF COMMUNICATION

A. DISCOURSE

Let us take a look at the five parameters at the level of discourse.

1. Pitch range

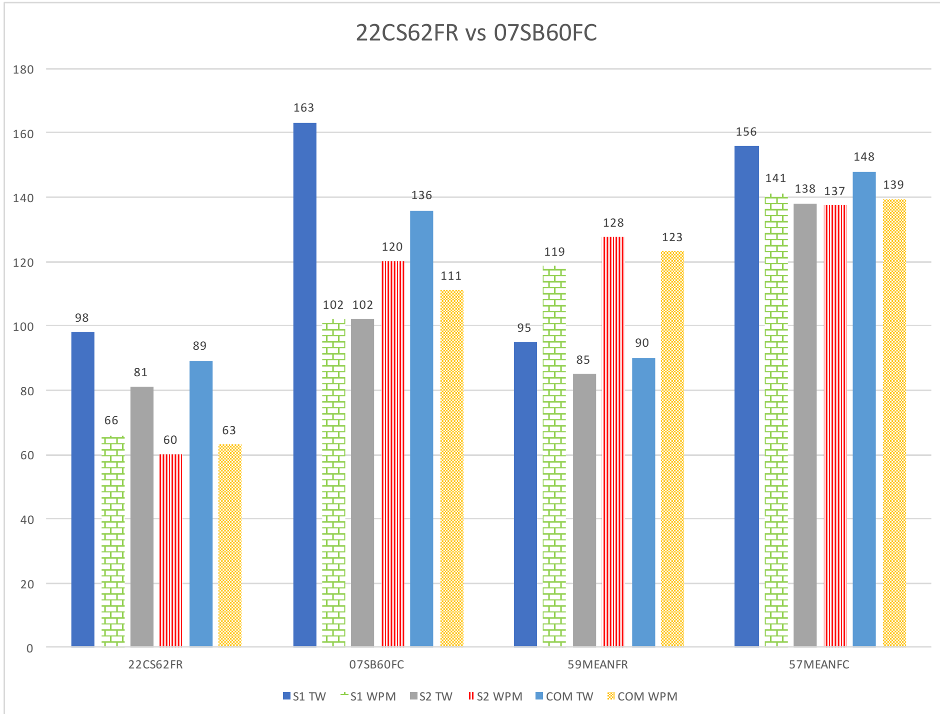
The following bar graph displays the pitch range of 22CS62FR in the first story, second story and the combined mean; in comparisons with her age and gender matched control 07SB60FC, as well as the mean of the whole female control group 57MEANFC and the mean of the whole RHD group, 59MEANFR.



We can observe the following from fig 3.59 displaying pitch variations in 22CS62FR above: 22CS62FR has a pitch range of 15 Hz in the first story in comparison with 07SB60FC, who has a pitch range of 81 Hz. The difference is significant. 59MEANFR has a pitch range of 30 Hz in the first story while 57MEANFC has a pitch range of 61 Hz in the first story. 22CS62FR has a pitch range of 17 Hz in the second story in comparison with 07SB60FC, who has a pitch range of 71 Hz. The difference is significant. The difference is insignificant. 59MEANFR has a pitch range of 33 Hz in the second story while 57MEANFC has a pitch range of 57 Hz in the second story. 22CS62FR has a pitch range of 16 Hz in the mean of the stories in comparison with 07SB60FC, who has a pitch range of 77 Hz. The difference in pitch range is very significant and highlights the massive difference in pitch range.

2. **Fluency**

Every participant has a speed of word flow, at which they speak. This section looks into the number of words a participant speaks in a minute or fluency. The following bar graph displays the words per minute, of 22CS62FR in the first story, second story and the combined mean; in comparisons with her age and gender matched control 07SB60FC, as well as the mean of the whole female control group 57MEANFC and the mean of the whole RHD group, 59MEANFR.



We can observe the following from fig 3.60 displaying fluency in 22CS62FR above: 22CS62FR has 98 words in story 1 in comparison with 07SB60FC, who has 163 words, which is a substantial difference. 22CS62FR has a word rate of 66 wpm in story 1 in comparison with 07SB60FC, who has 102 wpm. 22CS62FR has 81 words in story 2 in comparison with 07SB60FC, who has 102 words. 22CS62FR has a word rate of 60 wpm in story 2 in comparison with 07SB60FC, who has 120 wpm. 22CS62FR has 89 words in the combined mean of the two stories in comparison with 07SB60FC, who has 136 words. 22CS62FR has a word rate of 63 wpm in the combined mean of the two stories in comparison with 07SB60FC, who has 111 wpm. The values of 22CS62FR are much lower than the figures of the control group mean.

3. **Duration**

This section looks into the amount of time, each participant has taken to narrate back the story, they were told, by the narrator. Every participant took a specific amount of time to narrate the stories. This section looks into the duration of the mentioned case study. The following bar graph displays the duration of the discourse recordings, of 22CS62FR in the first story, second story and the combined mean; in comparisons with her age and gender matched control 07SB60FC, as well as the mean of the whole female control group 57MEANFC and the mean of the whole RHD group, 59MEANFR.

We can observe the following from fig 3.61 displaying duration in 22CS62FR above: 22CS62FR took 89 seconds (fluency – 66 words per minute) to complete narrating the first story in comparison with 07SB60FC, who took 96 seconds (fluency – 102 words per minute). Even though the difference in time is very less, the fluency rates are much different and that makes a difference. 59MEANFR took 54 seconds (fluency – 119 words per minute) in 57MEANFC took 67 seconds (fluency – 141 words per minute). 22CS62FR took 81 seconds (fluency – 60 words per minute) to complete narrating the second story in comparison with 07SB60FC, who took 51 seconds (fluency – 120 words per minute). 22CS62FR took more time and also had lower fluency. 59MEANFR took 47 seconds (fluency – 128 words per minute) in 57MEANFC took 60 seconds (fluency – 137 words per minute). 22CS62FR has a mean duration of 85 seconds (fluency – 63 words per minute) whereas, 07SB60FC has a mean of 74 seconds (fluency – 111 words per minute). 59MEANFR took 50 seconds (fluency – 123 words per minute) in 57MEANFC took 64 seconds (fluency – 139 words per minute).

4. Digressions

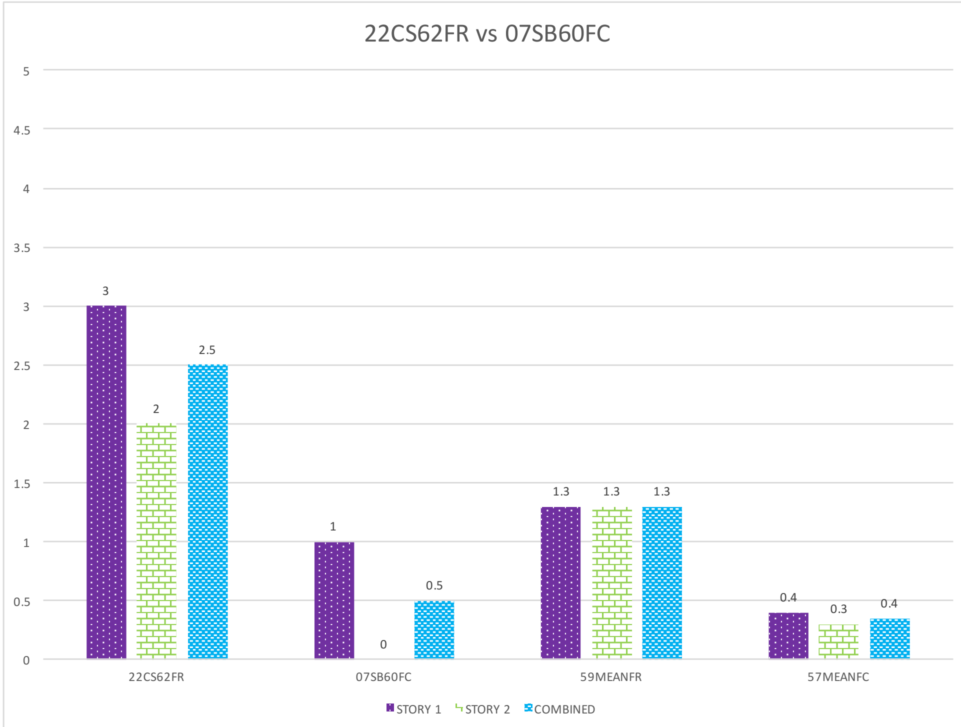
In this section, we shall first note down the digressions made by the participant by comparing the whole story side by side and then use a bar graph to denote the same.

Story 1 (Narrator)	RHD participant	Control participant
There was a deer. It was standing at the edge of the river. It	A deer was at a river side. <u>And a small boy was</u>	A big antlered deer was roaming about at the river side. It

saw its majestic antlers in the river, as a reflection. It kept praising it. Next it saw its feet and started to demean it because it was thin and did not match the overall beauty of the whole body. In the meantime, a hunter shot an arrow but missed. The deer started running in fear but ultimately got caught by the antlers in a bushy area. He exclaimed that the antlers he was praising put him in utter danger but his legs he was demeaning, tried to help him run that far.	appreciating a deer. He said the antlers were beautiful. Then he said that the antlers were good but the body wasn't good at all. He looked at legs and then said, the legs weren't good at all. A hunter shot an arrow and the deer fled. The deer got stuck in a tree. Antlers got stuck. He said I shouldn't have praised the antlers so much.	went to drink water and saw its reflection in the river. He praised the antlers. He noticed his thin legs and insulted them. A hunter shot an arrow but missed. The deer ran fast in fear. But it got caught by the antler in a bush. The antler, it was praising got it caught but the legs it was insulting tried to save it. The hunter killed the deer.

Story 2 (Narrator)	RHD participant	Control participant
Thousands of frogs lived in a small pond. They were happy but they wanted a king. So, they prayed to God for a king. God sent a big tree trunk to them. At first, they were intimidated by its size but soon they discovered, their new king did not move and did not talk. One brave frog climbed to the top of the trunk and after that many others gathered the courage and climbed to the top. They were unhappy and they prayed to God again stating that the king they were sent was inanimate and they want a new king who would be alive and actually rule over them. God got a bit angry. He sent a stork to the pond and the stork ate up all the frogs.	Many frogs stayed at a pond. They had no king. They told God they had no king and asked him to send one. God sent a tree bark. They touched it and said it didn't do anything to them. They climbed the top and said this king wasn't working. They prayed to God to send a good king. God sent a stork and it ate all the frogs.	Many frogs lived in a pond. They prayed to God for a king. God sent them a big tree bark. The frogs climbed up on the tree bark and said it was dead and didn't move. They prayed to God again and this time requested him to send them a king who would rule and keep them in check. God sent a stork to them and the stork ate them all.

We can note that the RHD participant has 3 digressions in the first story and 2 digressions in the second story. The RHD participant also has some lapses in the stories. The control participant has 1 digression in the first story and no digressions in the second story but it is important to note that both the RHD and control participant have skipped out on many descriptions originally told to them. The following bar graph displays the number of digressions made in the discourse recordings, by 22CS62FR in the first story, second story and the combined mean; in comparisons with her age and gender matched control 07SB60FC, as well as the mean of the whole female control group 57MEANFC and the mean of the whole RHD group, 59MEANFR.



We can observe the following from fig 3.62 displaying digressions in 22CS62FR above: 22CS62FR made 3 digressions while narrating the first story. In comparison 07SB60FC has only one digression in story 1. 22CS62FR has 2 digressions in the second story, where she added things to the story again and lost track of the actual story. In comparison 07SB60FC has only no digressions in story.

5. **Questions answered**

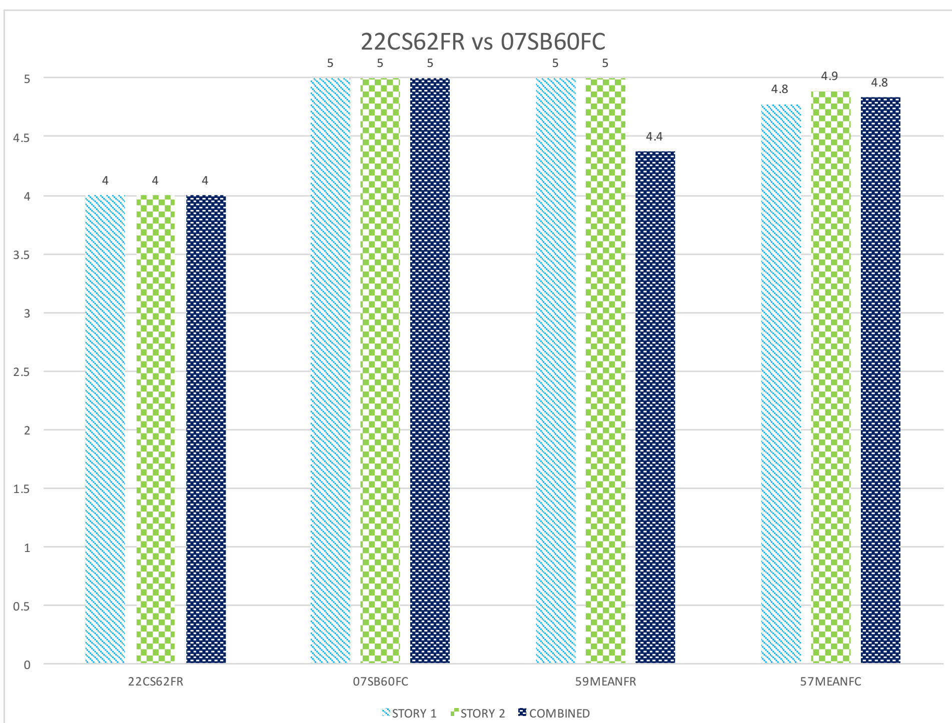
There were 2 stories, which were narrated to the participants. Each story was accompanied by 5 questions which were very easy to answer. The following tables lists down the answers given to the questions.

STORY 1				
	Questions	Actual answer	RHD participant	Control participant
1	Which animal(s) were mentioned in the story?	A deer	A deer	A deer
2	What was the deer doing?	Looking at his reflection	Drinking water and looking at reflection	Drinking water and looking at reflection
3	Why did the deer run?	A hunter shot an arrow but it didn't touch	Hunter shot an arrow	Hunter shot an arrow
4	Why was he caught?	His big antlers were caught in a bush		His big antlers were caught in a bush

5	What was the deer insulting, in the beginning?	His thin legs, that don't match his antlers and body.	His legs	His legs

STORY 2				
	Questions	Actual answer	RHD participant	Control participant
1	Which animal(s) were mentioned in the story?	Frogs, stork	Frogs	Frogs, stork
2	Where did the frogs live?	In a small pond	In a small pond	In a pond
3	What did the frogs want the first time?	A king	A king	A king
4	What did the frogs want the second time?	A king who would actually be alive and rule over them	A king who would actually be alive and rule over them	A king who would actually be alive and rule over them
5	Why did all the frogs die?	The stork ate them all		The stork ate them all

The following bar graph displays the number of questions answered by 22CS62FR in the first story, second story and the combined mean; in comparisons with her age and gender matched control 07SB60FC, as well as the mean of the whole female control group 57MEANFC and the mean of the whole RHD group, 59MEANFR.



We can observe the following from fig 3.63 displaying questions answered in 22CS62FR above that 22CS62FR has been able to answer 4 questions in the first story and 4 questions in the second story. The control participant answered all questions, as well as the mean of the control group 57MEANFC and the mean of the RHD group 59MEANFR.

B. SENTENCES

Under this heading, we will look into the 3 kinds of sentences (with 3 each) recorded and the various parameters associated with them. Three kinds of sentences recorded were declaratives, imperatives and interrogatives. In the sections to follow, we shall take a look at all the 9 sentences and discuss the patterns in the RHD individual in comparison with her individual control, the mean of the whole control group and the mean of the RHD group. The sentences have been determined according to the variations talked about in section 3.4.2 previously. The 9 sentences are as follows.

Declaratives

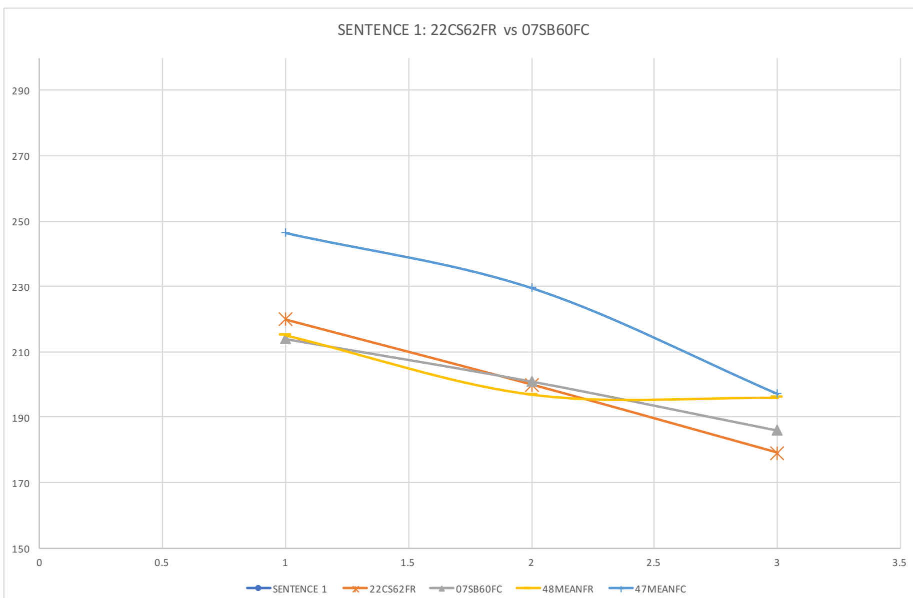


Fig 3.64: Sentence number 1. ‘ɑmi bʰɑlo ɑcʰi' which means ‘I am in good health’ in 22CS62FR

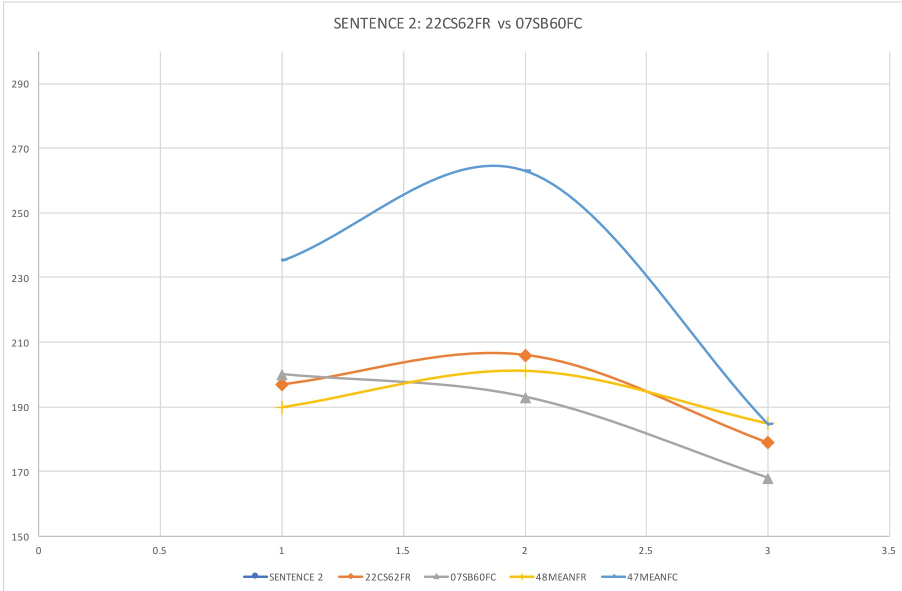


Fig 3.65: Sentence number 2. ‘ɑmɑr bɑri ʃɔhore’ which means ‘I live in the city’ in 22CS62FR

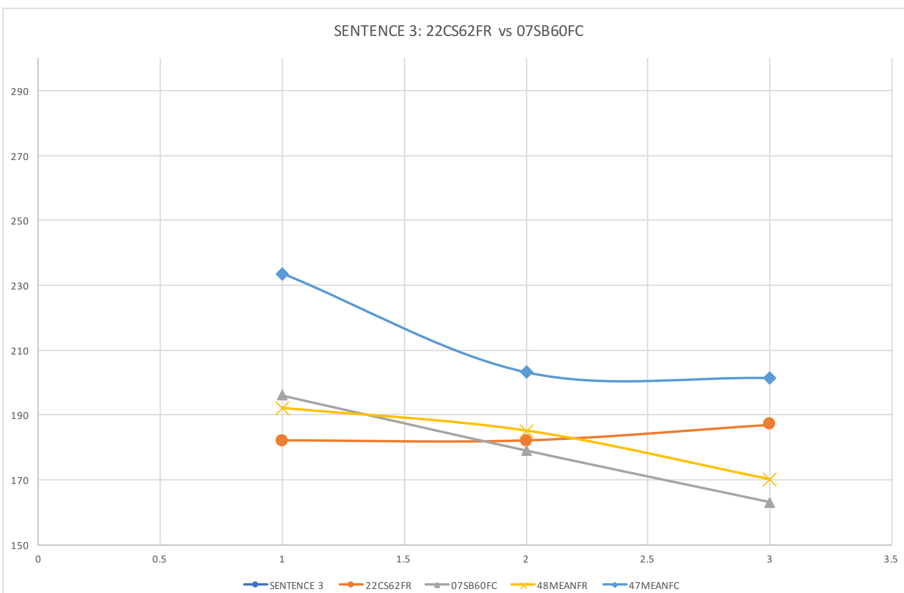


Fig 3.66: Sentence number 3. ‘ɑmi bʰɑt̪ kʰɑi’ which means ‘I eat rice’ in 22CS62FR

Fig 3.64 to 3.66. We can observe the following from the figure displayed previously that in sentence 1, all the sentence, namely 22CS62FR, 07SB60FC, 48MEANFR and 47MEANFC, curves belong to the type C of sentence. In sentence 2, we see three type D sentences, namely for 22CS62FR, 48MEANFR and 47MEANFC. 07SB60FC has recorded a type C sentence, unlike the others. 22CS62FR is in a similar range with that of 48MEANFR, but even though 22CS62FR, 48MEANFR and 47MEANFC belong to type D sentences, 47MEANFC has a much higher range of pitch used in the sentences, as can be seen in the chart. In sentence 3, 22CS62FR has used a type A sentence, in comparison with 07SB60FC, 48MEANFR and 47MEANFC, who have used type C sentences. The pitch in sentences for type C begin at a high point and gradually go down but 22CS62FR has actually increased the pitch in her sentences gradually, as the sentence progressed and ended at the highest pitch level.

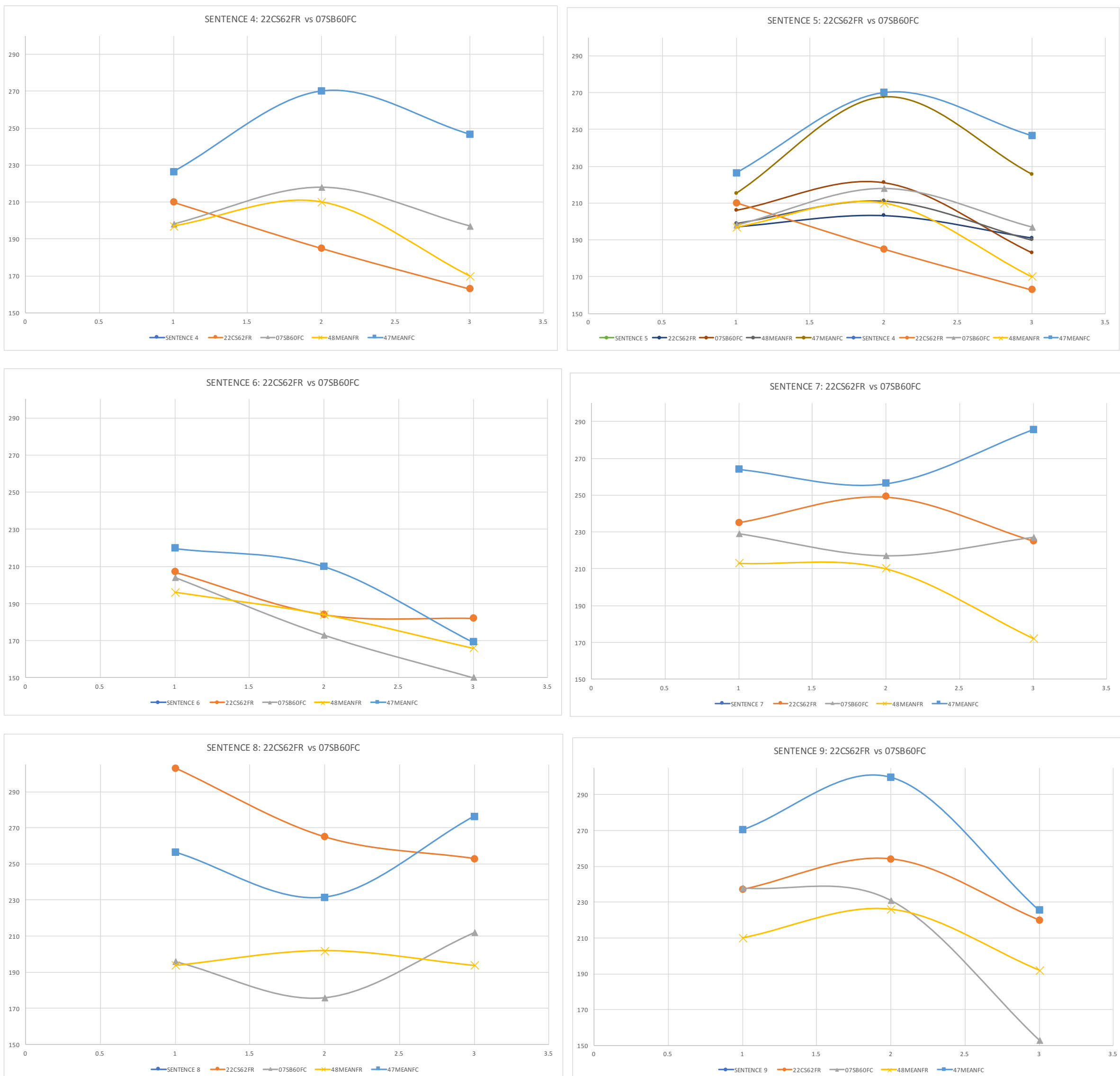


Fig 3.67 to 3.72 – Imperative and Interrogative Sentences for 22CS62FR.

<u>Imperatives</u>

Fig 3.67 to 3.69. We can observe the following from the figure displayed previously: In sentence 4, 07SB60FC, 48MEANFR and 47MEANFC have made type D curves but 22CS62FR has made a type C curve. In a type D sentence, the highest pitch point in a sentence is in the middle but in a type C sentence the highest pitch point in a sentence is in the beginning. In

sentence 5, all the sentences recorded were of type D. But we can notice a much higher range in 47MEANFC, the mean of the control group in comparison with the 48MEANFR and 22CS62FR. In sentence 6, 22CS62FR has used a type B sentence, in comparison with 07SB60FC, 48MEANFR and 47MEANFC, who have used type C sentences. The pitch in sentences for type C begin at a high point and gradually go down, hence making the last pitch point in a sentence the lowest, but 22CS62FR has actually begun her sentence at a high pitch point, gone down in the second pitch point and in the last pitch point, slightly increased her pitch.

Interrogatives

Fig 3.70 to 3.72. We can observe the following from the figure displayed previously: In sentence 7, 22CS62FR has recorded a type D sentence in comparison with her control 07SB60FC, who has recorded a type B sentence. The mean of the control group 47MEANFC has also recorded a type B sentence. The mean of the RHD group has recorded a type C sentence. The D type sentence curve made by 22CS62FR lies much higher than the RHD group mean. Although even here, 47MEANFC lies in a much higher range than all the other sentence curves. In sentence 8, 22CS62FR has recorded a type C sentence, in comparison with her control 07SB60FC, who has recorded a type B sentence. Here we can notice that the mean of the RHD group 48MEANFR has recorded a type D sentence and the mean of the control group 47MEANFC, has recorded a type B sentence. But this is the first sentence in which 22CS62FR has used a pitch point which is higher than any pitch point in 47MEANFC. In sentence 9, 22CS62FR has recorded a type D sentence, in comparison with 07SB60FC, who has recorded a type C sentence. 48MEANFR and 47MEANFC also have recorded type D sentences. Unlike sentence 8, here again, 22CS62FR has recorded the sentences in a pitch range which is much lower than that of 47MEANFC.

C. Vowels

The vowels were primarily recorded as words, from where the vowels were dissected out, to be studied. This section looks into the acoustic space chart of 22CS62FR in the 7 words, for the 7 vowels in Bangla, in comparisons with her age and gender matched control 07SB60FC. The following is the vowel chart.

VOWELS RHD					
RHD PARTICIPANT	Area	Control	Area	% of ind control	% of rhd mean
22CS62FR	377549.5	07SB60FC	454780.5	-17.0	0.1
23GD65FR	351705	03NS64FC	396032.5	-11.2	-6.8
24NB50FR	261075	04ND51FC	476432.5	-45.2	-30.8
25UG58FR	518600	06RB56FC	483885.5	7.2	37.5
96MEANFR	**377232.375**				

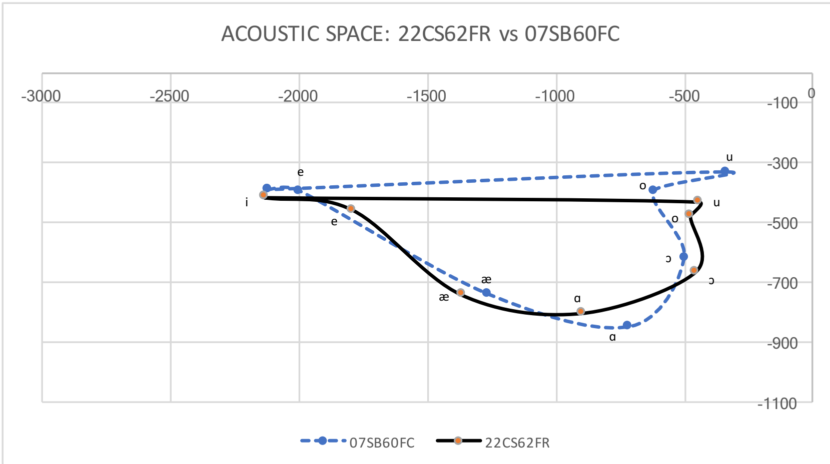


Fig 3.73 above compares female RHD participant 22CS62FR with the individual age and gender matched female, that is 07SB60FC. We can observe the following from the figure displayed previously: The vowel /e/ (f1=-456, f2-f1=-1789) in 22CS62FR is lower and backed than vowel /e/ (f1=-394, f2-f1=-2002) in 07SB60FC. The vowel /ɑ/ (f1=-801, f2-f1=-899) in 22CS62FR is higher and fronted than vowel /ɑ/ (f1=-849, f2-f1=-714) in 07SB60FC. The vowel /ɔ/ (f1=-663, f2-f1=-456) in 22CS62FR is lower and backed than vowel /ɔ/ (f1=-620, f2-f1=-500) in 07SB60FC. The vowel /o/ (f1=-475, f2-f1=-476) in 22CS62FR is lower and backed than vowel /o/ (f1=-396, f2-f1=-619) in 07SB60FC. The vowel /u/ (f1=-429, f2-f1=-443) in 22CS62FR is lower and fronted than vowel /u/ (f1=-333, f2-f1=-337) in 07SB60FC. The vowel /o/ and /u/ in 22CS62FR are very nearby, which would make them sound similar to some extent. The area of the acoustic space chart for 22CS62FR is 377549.5 and for 07SB60FC is 454780.5, and 96MEANFR is 377232. The area of 22CS62FR is 17% smaller than that of the individual control but 0.1 % more than the mean. The front back movement of the tongue has not changed much, but the high low movement of the tongue, in comparison with the control is lesser.

3.5.2. CASE STUDY 2

PRIMARY INFO

Codified Name: 23GD65FR

Female, 65 years of age, at the time of recording and case study.

Age and gender matched control: 03NS64FC

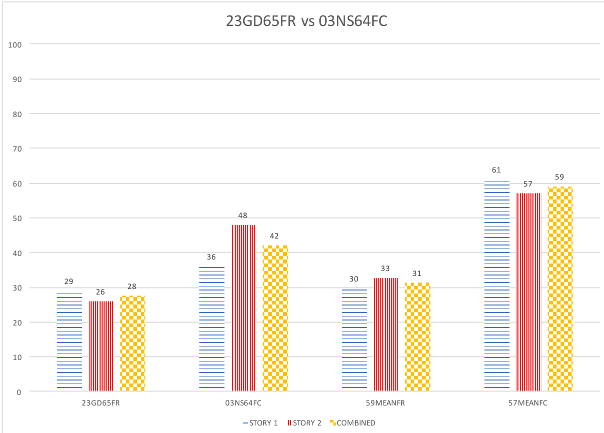
Time since incidence: approximately 6 months back, at the time of recording.

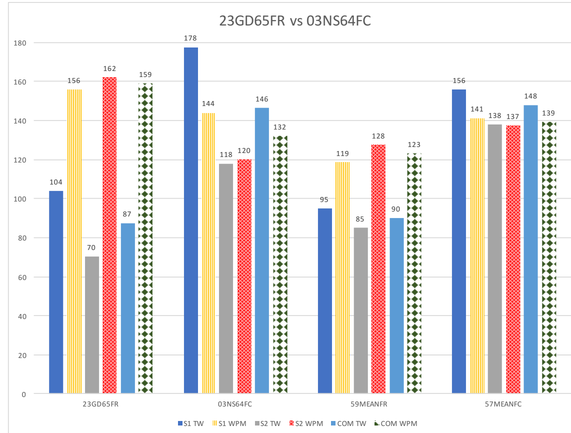
PARTICIPANT INFORMATION

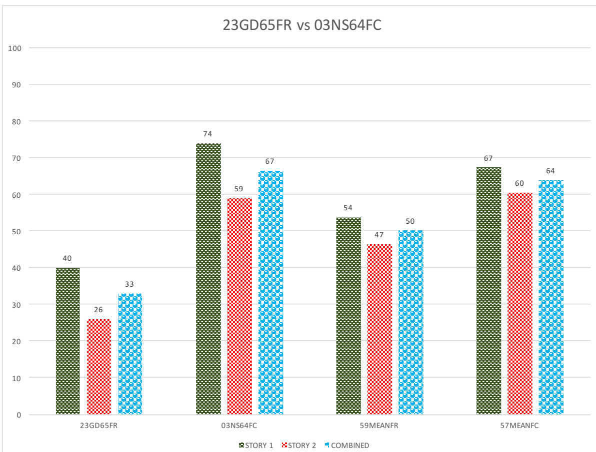
Condition of participant: The participant was fully conscious, having scored 12 on the GCS. She also scored 25 on the MMSE. The doctor tested her knee jerk reaction and it was normal. The elbow jerk had a normal reaction, as well. Using a refractometer, the doctor tested her eyes by putting rays of light into her eyes and the dilation of the pupils according to him was normal. The participant could walk without walking aids. The doctor asked her to do some actions with her hands, involving muscle coordination and she could do it. The participant could also perform actions based on instructions, which involved complicated and elaborate instructions. The speech of the participant was not slurred and was completely understandable. The total loudness of her speech went down, according to her family members and could be noticed while making conversations with her, as well as the recording sessions. The family of the participant assured that she was facing no problems in eating. The doctor also performed a test in which he held both her hands in his hands and then asked her to keep them where he is holding them, after he lets her hands go. She could maintain the position, but her left hand fell a fair bit, before she regained control. According to the doctor, these are subtle signs of the stroke to the right hemisphere. The participant has no problems in remembering things. She remembers old facts and memories completely as well. Her color recognition was intact and she suffered no neglect to the left hemisphere. She is undergoing mild physiotherapy. She does simple freehand exercises with the help of her family members.

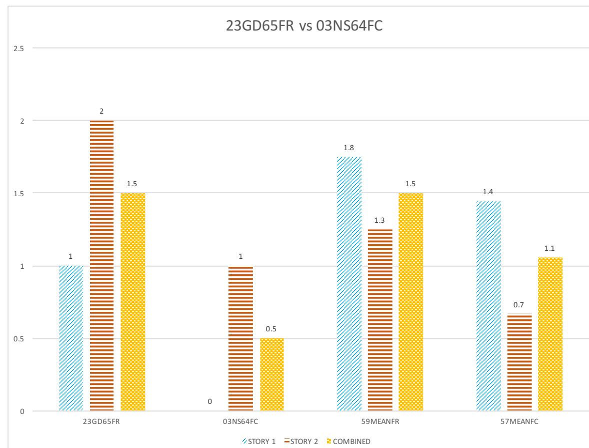
Observations made by doctor: The doctor mentions that she has no agraphia, no dementia, as well as no alexia. Participant is hypertensive. **Diagnosis made by doctor:** The doctor mentions that the participant has very less chances of suffering another stroke. She was suggested to continue freehand exercises. She has also been suggested to avoid high stress situations, which puts too much pressure on her. She's still under medicines for blood pressure. **Region of damage:** An acute lacunar infarct at the **right parietal lobe**.

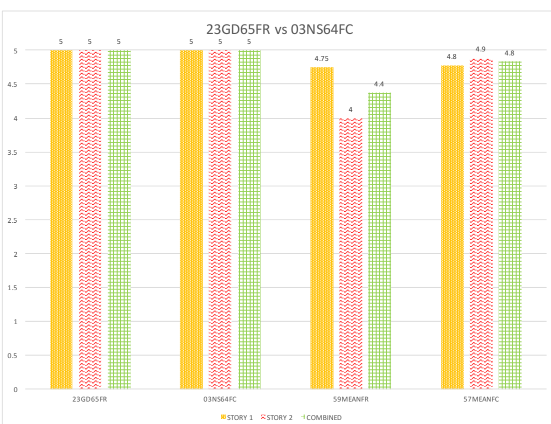
COMPREHENSIVE STUDY OF PARTICIPANT AT THE 3 LEVELS OF COMMUNICATION











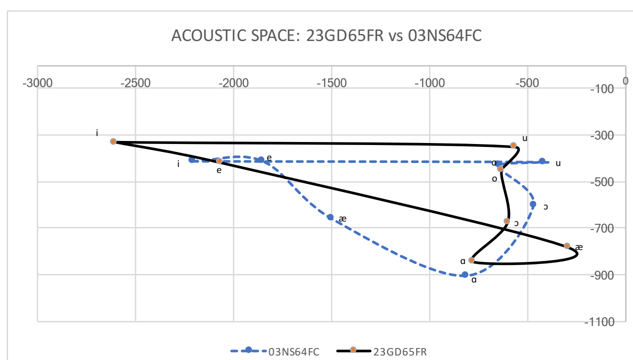


Fig 3.74 to 3.79. 23GD65FR- The bar graphs are comparisons at the level of discourse. The last diagram is an acoustic space.

Fig 3.80 to 3.88: 23GD65FR-First three diagrams in first line are declarative sentences. The next line is composed of 3 imperative sentences and the third line has three interrogative sentences.

A. DISCOURSE

1. Pitch range

We can observe the following from fig 3.74: 23GD65FR has a pitch range of 29 Hz in the first story in comparison with 03NS64FC, who has a pitch range of 36 Hz. The difference is not significant. 59MEANFR has a pitch range of 30 Hz in the first story while 57MEANFC has a pitch range of 61 Hz in the first story. 23GD65FR has a pitch range of 26 Hz in the second story in comparison with 03NS64FC, who has a pitch range of 48 Hz. Here, the difference in range is noticeable, although not very significant. 59MEANFR has a pitch range of 33 Hz in the second story while 57MEANFC has a pitch range of 57 Hz in the second story. 23GD65FR has a pitch range of 28 Hz in the mean of the stories in comparison with 03NS64FC, who has a pitch range of 42 Hz. The difference, as we can see, is not very huge, but still is a considerable gap.

2. Fluency

We can observe the following from fig 3.75: 23GD65FR has 104 words in story 1 in comparison with 03NS64FC, who has 178 words, which is a substantial difference. 23GD65FR has a word rate of 156 wpm in story 1 in comparison with 03NS64FC, who has 144 wpm. The RHD participant has a higher word rate than the control participant but a much lower word count. 23GD65FR has 70 words in story 2 in comparison with 03NS64FC, who has 118 words. 23GD65FR has a word rate of 162 wpm in story 2 in comparison with 03NS64FC, who has 120 wpm. 23GD65FR has 87 words in the combined mean of the two stories in comparison with 03NS64FC, who has 146 words. 23GD65FR has a word rate of 159 wpm in the combined mean of the two stories in comparison with 03NS64FC, who has 132 wpm. The RHD participant has high fluency rates, yet has much lower total word count because of the fact that she spoke for a much lesser amount of time.

3. **Duration**

We can observe the following from fig 3.76: 23GD65FR took 40 seconds (fluency – 184 words per minute) to complete narrating the first story in comparison with 03NS64FC, who took 74 (fluency – 179 words per minute) seconds. 23GD65FR took 26 seconds (fluency – 127 words per minute) to complete narrating the second story in comparison with 03NS64FC, who took 59 seconds (fluency – 158 words per minute). 23GD65FR has a mean duration of 33 seconds (fluency – 156 words per minute) whereas, 03NS64FC has a mean of 67 seconds (fluency – 169 words per minute). 23GD65FR, as observed during the recording session was hurrying through the entire recording process, without any reason to do so. Her family members added to this stating that after her stroke, she has been speaking faster than usual. It should also be noted that she did not speak any jargon or half pronounced words, while hastening through the process. What she spoke was understandable completely. We can see that her times are faster than 03NS64FC, 57MEANFC and 59MEANFR who have durations of 64 seconds and 50 seconds, respectively, in the mean of the two stories.

4. Digressions and lapses

Story 1 (Narrator)	RHD participant	Control participant
There was a deer. It was standing at the edge of the river. It saw its majestic antlers in the river, as a reflection. It kept praising it. Next it saw its feet and started to	An antler was standing. No, a deer was standing and was watching its reflection in the water. It was	A deer, on being thirsty, went to a river side. And when it looked at the water, it saw its reflection and looked at its antlers. And it felt good looking at it and praised it. But then looked at its thin

demean it because it was thin and did not match the overall beauty of the whole body. In the meantime, a hunter shot an arrow but missed. The deer started running in fear but ultimately got caught by the antlers in a bushy area. He exclaimed that the antlers he was praising put him in utter danger but his legs he was demeaning, tried to help him run that far.	insulting the legs. Male deer have big antlers and the deer was praising it. But it was what got it caught in the end. The part the deer was insulting was the one which saved him. So, the legs are good.	legs and didn't like it. An arrow landed right in front of the deer and it got scared. The deer started running for life into the jungle and then suddenly, the antlers the deer was happy about got stuck in a bush or hedge. The deer then said that it was the legs, it was insulting but the legs tried to help it run, but the majestic antler it was praising put the deer in utter danger.

Story 2 (Narrator)	RHD participant	Control participant
Thousands of frogs lived in a small pond. They were happy but they wanted a king. So, they prayed to God for a king. God sent a big tree trunk to them. At first, they were intimidated by its size but soon they discovered, their new king did not move and did not talk. One brave frog climbed to the top of the trunk and after that many others gathered the courage and climbed to the top. They were unhappy and they prayed to God again stating that the king they were sent was inanimate and they want a new king who would be alive and actually rule over them. God got a bit angry. He sent a stork to the pond and the stork ate up all the frogs.	There was a pond. Many frogs lived there. The frogs prayed for a king to God. <u>God dropped a wood</u>. <u>The wood didn't move and the frogs got up on the wood.</u> <u>So, God dropped a stork and then the stork started eating the frogs.</u>	Many frogs lived in a pond. The frogs thought that they need a king and they prayed to God for a king. God thought about it <u>and pushed a log of wood into the water</u>. The frogs noticed that the log didn't move and they didn't like it. They went to God again and prayed for a king who would actually be alive and would be willing to rule over them properly. God didn't like the fact that they didn't like his earlier decision. God sent a stork to their pond and the pond killed the frogs one by one and ate them all.

We can notice some major lapses in the recording for the RHD participant, for the first story. Although, there are not many digressions, 1 to be precise, we can clearly see that the person doesn't mention major plotlines of the story narrated to them. The RHD participant also has major lapses in the second story. The RHD participant tries to cover the lapses with a few digressions to make sense of the story. When we compare the content of the original narration with the RHD participant's recording, its much smaller as well, proving the major lapses. The control participant on the other hand had no digressions in story 1 but one small digression in story 2. There were no lapses in the narration of the control participant as well, in both the stories.

5. **Questions answered**

STORY 1				
	Questions	**Actual answer**	**RHD participant**	**Control participant**
1	Which animal(s) were mentioned in the story?	A deer	A deer	A deer

2	What was the deer doing?	Looking at his reflection	Drinking water and looking	Looking at his reflection
3	Why did the deer run?	A hunter shot an arrow but it didn't touch	Being afraid of an arrow	A hunter shot an arrow but it didn't touch
4	Why was he caught?	His big antlers were caught in a bush	Antlers	His big antlers were caught in a bush
5	What was the deer insulting, in the beginning?	His thin legs, that don't match his antlers and body.	The legs	His thin legs, that don't match his antlers and body.

STORY 2				
	Questions	Actual answer	RHD participant	Control participant
1	Which animal(s) were mentioned in the story?	Frogs, stork	Frogs	Frogs, stork
2	Where did the frogs live?	In a small pond	In a small pond	In a small pond
3	What did the frogs want the first time?	A king	A king	A king
4	What did the frogs want the second time?	A king who would actually be alive and rule over them	An actual ruler	A king who would actually be alive and rule over them
5	Why did all the frogs die?	The stork ate them all	The stork killed them all	The stork ate them all

We can observe the following from fig 3.78: 23GD65FR has been able to answer all 5 questions in the first story and all 5 questions in the second story. It is worth noticing that, her answers were to the point, but even here, she hastened with the answers, as if she was in extreme hurry. She also kept repeating the answers, because, maybe she realized she was speaking faster than what she used to speak. The control participant answered all questions, as well as the mean of the control group 57MEANFC and the mean of the RHD group 59MEANFR.

B. **SENTENCES**

Declaratives

Fig 3.80– 3.82. We can observe the following from the figure displayed previously: In sentence 1, 03NS64FC, 48MEANFR and 47MEANFC, have recorded curves belonging to the type C of sentence. 23GD65FR, on the other hand has a type B sentence. The type C sentence begins at the highest pitch point, the second point is lower than the starting point and the third point is either equal to or lower than the pitch point in the middle. Type B in 23GD65FR began high and dipped low at the second point, while rising again in the third point. In sentence 2 we see that all the sentence curves are of type D sentences. 47MEANFC recorded at a pitch range which is much higher than the mean of the RHD group 48MEANFR, the individual control 03NS64FC and the RHD participant 23GD65FR. In sentence 3, 23GD65FR has used a type C sentence in comparison with 03NS64FC, who has used a type B sentence. 48MEANFR and 47MEANFC like 23GD65FR have also used type C sentences. The pitch in sentences for type C begin at a high point and gradually go down but 03NS64FC has actually began her sentence at a high pitch, gone down at the second point and then increased the pitch at the third point. We also notice that the third point in the third sentence for 23GD65FR goes down to 121 Hz, which is a lot lower than the lowest points of the others.

<u>Imperatives</u>

Fig 3.83- 3.85. We can observe the following from the figure displayed previously: In sentence 4, 23GD65FR, 03NS64FC, 48MEANFR and 47MEANFC have made type D curves. In a type D sentence, the highest pitch point in a sentence is in the middle. In sentence 5, 23GD65FR, 03NS64FC, 48MEANFR and 47MEANFC have made type D curves. In a type D sentence, the highest pitch point in a sentence is in the middle. In sentence 6, 23GD65FR, 03NS64FC, 48MEANFR and 47MEANFC have made type C curves. In a type D sentence, the highest pitch point in a sentence is in the middle. In all the three charts the pitch range of 47MEANFC is higher than 23GD65FR, 03NS64FC and 48MEANFR.

<u>Interrogatives</u>

Fig 3.86 3.88. We can observe the following from the figure displayed previously: In sentence 7, 23GD65FR has recorded a type C sentence in comparison with 03NS64FC who has recorded a type B sentence. Just like 23GD65FR, 48MEANFR has also recorded a type C sentence while 47MEANFC has recorded a type B sentence. It should be noted that in sentence 1, the third point in the type C sentence 23GD65FR makes, the pitch dips down to 109 Hz, which is much lower than the lowest points in the other sentence curves. In sentence 8, 23GD65FR has recorded a type A sentence, in comparison with her control 03NS64FC, who has recorded a type C sentence. Here we can notice that the mean of the RHD group 48MEANFR has recorded a type D sentence and the mean of the control group 47MEANFC, has recorded a type B sentence. We can also notice that the pitch range in which 23GD65FR has recorded the sentence is much lower than the other sentence curves. In sentence 9, 23GD65FR, 48MEANFR and 47MEANFC have all recorded type D sentences in comparison with 03NS64FC, who has recorded a type C sentence. We can notice that the operating pitch range in 47MEANFC is as usual, higher than the rest of the sentence curves. The only exception in this chart is 03NS64FC, who has used a type C sentence, as mentioned above. As per the

chart, all the others except 03NS64FC have given maximum pitch to the second part of the sentence, while 03NS64FC, has given maximum pitch to the first part of the sentence.

C. VOWELS

Fig 3.79 compares female RHD participant 23GD65FR with the individual age and gender matched female, that is 03NS64FC. We can observe the following from the figure displayed previously: The vowel /i/ (f1=-331, f2-f1=-2606) in 23GD65FR is higher and much more fronted than vowel /i/ (f1=-411, f2-f1=-2210) in 03NS64FC. The vowel /e/ (f1=-419, f2-f1=-2070) in 23GD65FR is more fronted than vowel /e/ (f1=-409, f2-f1=-1853) in 03NS64FC. The vowel /æ/ (f1=-784, f2-f1=-293) in 23GD65FR is and exception and occurs at a region which is more backed and lower than vowel /ɑ/ (f1=-906, f2-f1=-814) in 03NS64FC. In comparison vowel /æ/ (f1=-659, f2-f1=-1499) in 03NS64FC is lower and backed than vowel /e/ of 03NS64FC. The vowel /ɑ/ (f1=-845, f2-f1=-779) in 23GD65FR is higher and slightly backed than vowel /ɑ/ (f1=-906, f2-f1=-814) in 03NS64FC. The vowel /ɔ/ (f1=-674, f2-f1=-603) in 23GD65FR is lower and fronted than vowel /ɔ/ (f1=-605, f2-f1=-470) in 03NS64FC. The vowel /o/ (f1=-450, f2-f1=-636) in 23GD65FR is very slightly lower and fronted than vowel /o/ (f1=-428, f2-f1=-650) in 03NS64FC. The vowel /u/ (f1=-352, f2-f1=-567) in 23GD65FR is higher and fronted than vowel /u/ (f1=-415, f2-f1=-418) in 03NS64FC. The area of the acoustic space chart for 23GD65FR is 351705 and for 03NS64FC is 396032.5, and 96MEANFR is 377232. The area of 22CS62FR is 11% smaller than that of the individual control but 6.8 % smaller than the mean of RHD participants. The RHD participant could produce a much more fronted 'i' in comparison with the control but the /æ/ vowel has been produced as a back vowel, which is a big anomaly.

3.5.3. CASE STUDY 3

PRIMARY INFO

Codified Name: 24NB50FR

Female, 50 years of age, at the time of recording and case study.

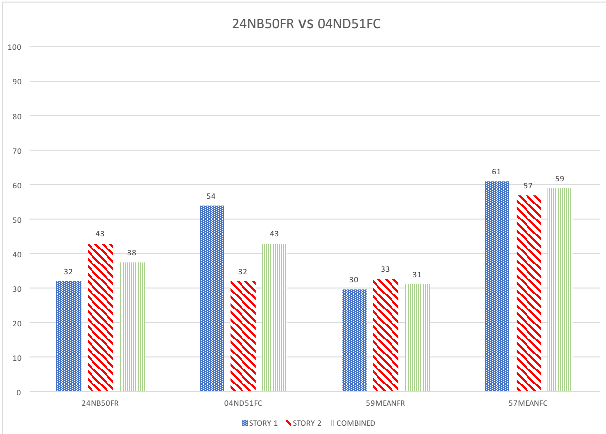
Age and gender matched control: 04ND51FC

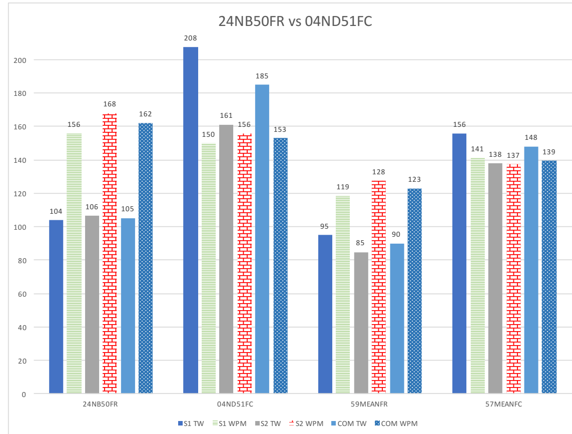
Time since incidence: approximately 4 months back, at the time of recording.

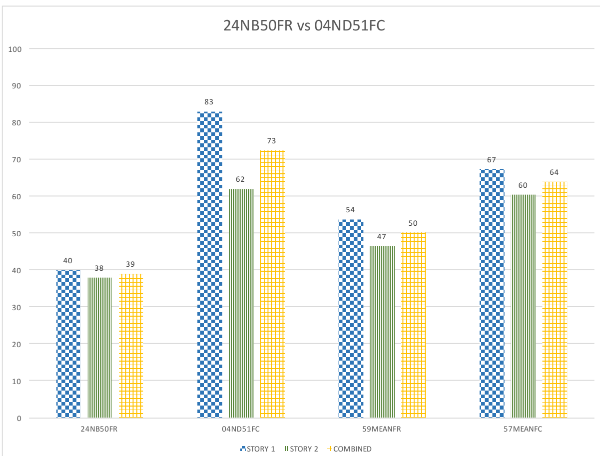
PARTICIPANT INFORMATION

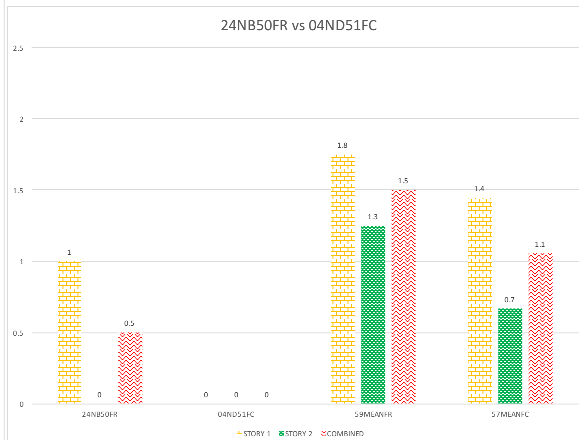
Condition of participant: The participant was fully conscious, having scored 14 on the GCS. She also scored 26 on the MMSE. The participant is under left hemiparesis and she has very less control over the left side of her body. After months of physiotherapy, she can now move her fingers and twitch her feet. The participant has lost her ability to walk without walking aids. The doctor asked her to do some actions with her hands, involving muscle coordination and she could do it, using only her right hand. The participant could also perform actions based on instructions, which involved complicated and elaborate instructions, but it was difficult for her. The speech of the participant was slightly slurred, due to left hemiparesis, but was understandable. On being asked to name colors, she could name them correctly. The family of the participant mentioned that she faces problems while eating, as the left side of her mouth is under hemiparesis. The doctor also performed a test in which he held both her hands in his hands and then asked her to keep them where he is holding them, after he lets her hands go. She could maintain the position of the right hand, but her left hand fell down. She kept trying, but she could barely move her left hand. The participant has no problems in remembering things. She remembers old facts and memories completely as well. She suffers from left hemisphere neglect. The doctors tested it and found inconsistent results. Sometimes she could notice things at the left side of her field of vision, sometimes she just could not. She is undergoing no physiotherapy, due to the financial condition of her family. **Observations made by doctor:** The doctor mentions that she has no agraphia, no dementia, as well as no alexia. Participant is hypertensive. **Diagnosis made by doctor:** The doctor mentions that the participant has very less chances of suffering another stroke. She was suggested to continue freehand exercises. She has also been suggested to avoid high stress situations, which puts too much pressure on her. She's under medication for blood pressure. **Region of damage:** Hemorrhage in the **right basal ganglia**.

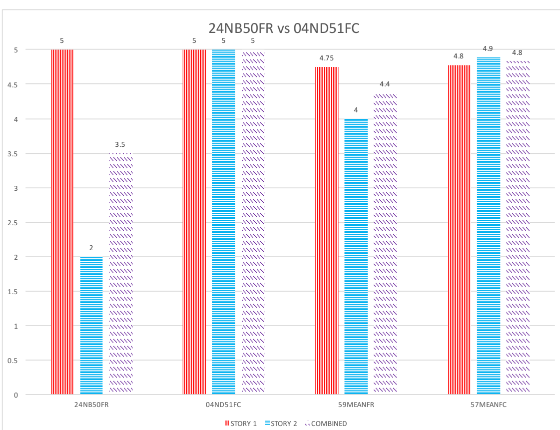
COMPREHENSIVE STUDY OF PARTICIPANT AT THE 3 LEVELS OF COMMUNICATION











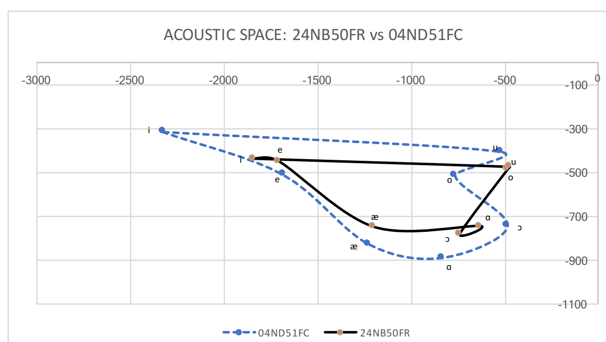
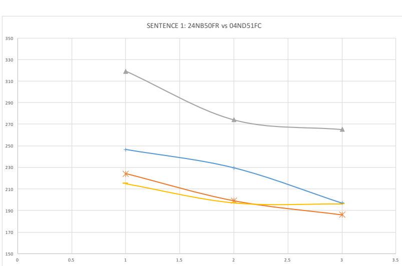
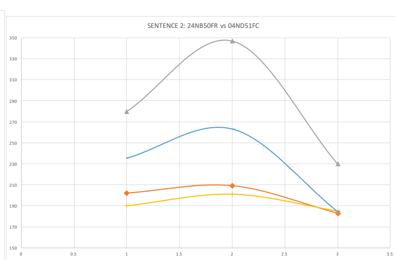
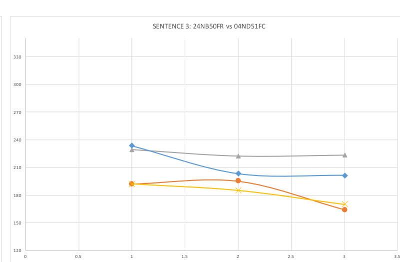


Fig 3.89 to 3.93: 24NB50FR - The bar graphs are comparisons at the level of discourse. The last diagram is an acoustic space.







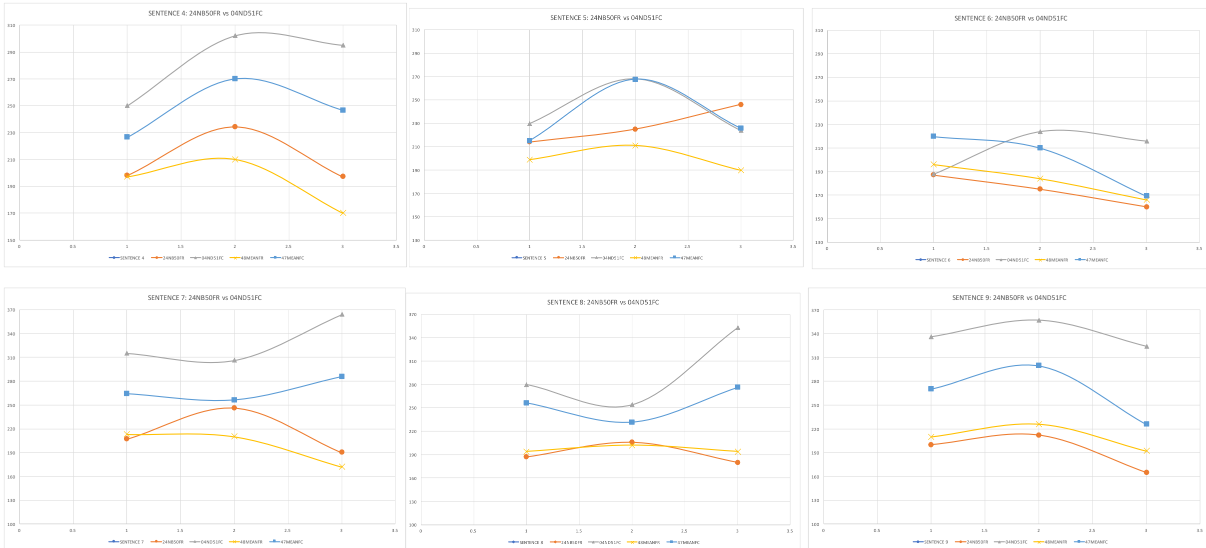


Fig 3.94 to 3.102: 24NB50FR - First three diagrams in first line are declarative sentences. The next line is composed of 3 imperative sentences and the third line has three interrogative sentences.

A. Discourse

1. Pitch range

We can observe the following from fig 3.89: 24NB50FR has a pitch range of 32 Hz in the first story in comparison with 04ND51FC, who has a pitch range of 54 Hz. This is a difference of 20 Hz only. 59MEANFR has a pitch range of 30 Hz in the first story while 57MEANFC has a pitch range of 61 Hz in the first story. 24NB50FR has a pitch range of 43 Hz in the second story in comparison with 04ND51FC, who has a pitch range of 32 Hz. The difference is huge here. 59MEANFR has a pitch range of 33 Hz in the second story while 57MEANFC has a pitch range of 57 Hz in the second story. 24NB50FR has a pitch range of 38 Hz in the mean of the stories in comparison with 04ND51FC, who has a pitch range of 43 Hz. 59MEANFR has a pitch range of 31 Hz in the combined mean while 57MEANFC has a pitch range of 59 Hz in the combined mean. Here, we notice that the RHD participant has more pitch range in the second story. This, for the control participant might be due to boredom or undiagnosed brain damage or specific style of speaking or the participant might just be tired.

2. Fluency

We can observe the following from fig 3.90: 24NB50FR has 104 words in story 1 in comparison with 04ND51FC, who has 208 words, which is a huge difference. 24NB50FR has a word rate of 156 wpm in story 1 in comparison with 04ND51FC, who has 150 wpm. The RHD participant has a higher word rate than the control participant but a much lower word count. 24NB50FR has 106 words in story 2 in comparison with 04ND51FC, who has 161 words. 24NB50FR has a word rate of 168 wpm in story 2 in comparison with 04ND51FC, who has 156 wpm. 24NB50FR has 105 words in the combined mean of the two stories in comparison with 04ND51FC, who has 185 words. 24NB50FR has a word rate of 162 wpm in the combined mean of the two stories in comparison with 04ND51FC, who has 153 wpm. The RHD participant has high fluency rates, which are very close to those of the control group, yet has much lower total word count because of the fact that she spoke for a much lesser amount of time.

3. **Duration**

We can observe the following from fig 3.91: 24NB50FR took 40 seconds (fluency – 156 words per minute) to complete narrating the first story in comparison with 04ND51FC, who took 80 seconds (fluency – 150 words per minute). 24NB50FR took 38 seconds (fluency – 168 words per minute) to complete narrating the second story in comparison with 04ND51FC, who took 62 seconds (fluency – 156 words per minute). 24NB50FR has a mean duration of 39 seconds (fluency – 162 words per minute) whereas, 04ND51FC has a mean of 73 seconds (fluency – 153 words per minute). We can see that 24NB50FR has taken lesser time than 04ND51FC; as well as 57MEANFC and 59MEANFR who have durations of 64 seconds (fluency – 123 words per minute) and 50 seconds (fluency – 139 words per minute), respectively, in the mean of the two stories.

4. Digressions and lapses

Story 1 (Narrator)	RHD participant	Control participant
There was a deer. It was standing at the edge of the river. It saw its majestic antlers in the river, as a reflection. It kept praising it. Next it saw its feet and started to demean it because it was thin and did not match the overall beauty of the whole body. In the meantime, a hunter shot an arrow but missed. The deer started running in fear but ultimately got caught by the antlers in a bushy area. He exclaimed that the antlers he was praising put him in utter danger but his legs he was	<u>The deer everyday was at the river.</u> It was standing and watching the antlers. The antler and the body was beautiful. The legs were bad. Then an arrow came out and went from in front of the deer. It fled. The antler got stuck in a tree side. The antlers were praised but were the ones who put the deer in danger while the legs	A deer went to a river side and in the water, saw its reflection. At first it saw its antlers and praised it. Then it saw its legs which were thin in comparison with his whole body and started insulting it, demeaning it. A hunter saw the deer from far and shot an arrow. The arrow didn't touch the deer but the deer started running for its life coz it realized that its life was in danger. Unfortunately, its antlers got stuck in a hedge and it couldn't move anymore. Then it realized that the part it was

demeaning, tried to help him run that far.	it said were bad, helped it run.	praising put it in danger and the legs, it was insulting tried to save it.

Story 2 (Narrator)	RHD participant	Control participant
Thousands of frogs lived in a small pond. They were happy but they wanted a king. So, they prayed to God for a king. God sent a big tree trunk to them. At first, they were intimidated by its size but soon they discovered, their new king did not move and did not talk. One brave frog climbed to the top of the trunk and after that many others gathered the courage and climbed to the top. They were unhappy and they prayed to God again stating that the king they were sent was inanimate and they want a new king who would be alive and actually rule over them. God got a bit angry. He sent a stork to the pond and the stork ate up all the frogs.	There was a pond and many frogs in it. They needed a king and asked God to send one. A king came but it was inactive. They asked God for a second king and God was angry. Sent a big bird and the bird ate all the frogs.	Many frogs lived in a small pond. They were happy and playing and then they realized they had no king. Then they prayed to God for a king and God in response, sent a big log of wood to them. At first they didn't realize what it was because it wasn't moving on being touched. Then a brave frog climbed it and found that it was inactive and inanimate. They prayed to God again for a new king, who would actually rule over them and be active. God got angry at this and sent a big stork to their pond. The stork ate all the frogs one by one.

We can see one digression in story 1 for the RHD participant but no digressions in story 2. But there are major lapses in the discourse recordings of the RHD participant. She left out many major plotlines. The control participant on the other hand had no digressions in both the stories. There were no lapses in the narration of the control participant as well, in both the stories.

5. Questions answered

STORY 1				
	Questions	Actual answer	RHD participant	Control participant
1	Which animal(s) were mentioned in the story?	A deer	A deer	A deer
2	What was the deer doing?	Looking at his reflection	Looking at its reflection	Looking at his reflection
3	Why did the deer run?	A hunter shot an arrow but it didn't touch	A hunter followed it	A hunter shot an arrow. The deer ran for its life.
4	Why was he caught?	His big antlers were caught in a bush	Antlers	His big antlers were caught in a bush
5	What was the deer insulting, in the beginning?	His thin legs, that don't match his antlers and body.	The legs	His thin legs, that don't match his antlers and body.

STORY 2				
	Questions	Actual answer	RHD participant	Control participant

1	Which animal(s) were mentioned in the story?	Frogs, stork	**<u>God</u>**	Frogs, stork
2	Where did the frogs live?	In a small pond	**<u>On a tree</u>**	In a small pond
3	What did the frogs want the first time?	A king	A king	A king
4	What did the frogs want the second time?	A king who would actually be alive and rule over them	**<u>A stork</u>**	A king who would actually be alive and rule over them
5	Why did all the frogs die?	The stork ate them all	The stork killed them all	The stork ate them all

We can observe the following from fig 3.93: 24NB50FR has been able to answer all 5 questions in the first story but only 2 questions in the second story. After a point, she could not remember anything about the story at all. The control participant answered all questions, as well as the mean of the control group 57MEANFC and the mean of the RHD group 59MEANFR.

B. SENTENCES

<u>Declaratives</u>

Fig 3.94 – 3.96. We can observe the following from the figure displayed previously: In sentence 1, 24NB50FR, 04ND51FC, 48MEANFR and 47MEANFC, have recorded curves belonging to the type C of sentence. The type C sentence begins at the highest pitch point, the second point is lower than the starting point and the third point is either equal to or lower than the pitch point in the middle. In sentence 2 we see that all the sentence curves are of type D sentences. 47MEANFC recorded at a pitch range which is much higher than the mean of the RHD group 48MEANFR, but is still lower than the individual control 03NS64FC. In sentence 3, 24NB50FR has used a type D sentence in comparison with 04ND51FC, who has used a type C sentence. 48MEANFR and 47MEANFC like 04ND51FC have also used type C sentences. The pitch in sentences for type C begin at a high point and gradually go down but 24NB50FR has actually began her sentence at a low pitch, gone up at the second point and then decreased the pitch at the third point. On an average, the pitch points recorded for 04ND51FC are higher than the others. She reached a maximum pitch of more than 345 Hz.

<u>Imperatives</u>

Fig 3.97 – 3.99. We can observe the following from the figure displayed previously: In sentence 4, 24NB50FR, 04ND51FC, 48MEANFR and 47MEANFC have made type D curves. In a type D sentence, the highest pitch point in a sentence is in the middle. In sentence 5, 04ND51FC, 48MEANFR and 47MEANFC have made type D curves but 24NB50FR, in comparison has made a type A curve, which begins low and ends at the highest point. In a type D sentence, the

highest pitch point in a sentence is in the middle. In sentence 6, 24NB50FR, 48MEANFR and 47MEANFC have made type C curves but 04ND51FC has recorded a type D sentence. In a type D sentence, the highest pitch point in a sentence is in the middle.

Interrogatives

Fig 3.100 – 3.102. We can observe the following from the figure displayed previously: In sentence 7, 24NB50FR has recorded a type D sentence in comparison with 04ND51FC, who has recorded a type B sentence. 48MEANFR has also recorded a type C sentence while 47MEANFC has recorded a type B sentence. In sentence 8, 24NB50FR as well as the RHD group 48MEANFR have recorded type D sentences, in comparison with her control 04ND51FC and 47MEANFC, who have recorded a type B sentences. In sentence 9, 24NB50FR, 04ND51FC, 48MEANFR and 47MEANFC have all recorded type D sentences. We can notice that the operating pitch range in 04ND51FC is higher than the rest of the sentence curves.

C. VOWELS

Fig 3.93 compares female RHD participant 24NB50FR with the individual age and gender matched female, that is 04ND51FC. We can observe the following from the figure displayed previously: The vowel /i/ (f1=-436, f2-f1=-1846) in 24NB50FR is much more backed and lower than vowel /i/ (f1=-314, f2-f1=-2329) in 04ND51FC. The vowel /e/ (f1=-446, f2-f1=-1710) in 24NB50FR is higher than vowel /e/ (f1=-508, f2-f1=-1688) in 04ND51FC. The vowel /æ/ (f1=-748, f2-f1=-1201) in 24NB50FR is slightly higher and backed in comparison vowel /æ/ (f1=-823, f2-f1=-1234) in 04ND51FC is lower and backed than vowel /e/ of 04ND51FC. The vowel /ɑ/ (f1=-744, f2-f1=-634) in 24NB50FR is higher and slightly backed than vowel /ɑ/ (f1=-887, f2-f1=-837) in 04ND51FC. The vowel /ɔ/ (f1=-780, f2-f1=-742) in 24NB50FR is lower and fronted than vowel /ɔ/ (f1=-742, f2-f1=-488) in 04ND51FC. The vowel /o/ (f1=-485, f2-f1=-488) in 24NB50FR is more backed than vowel /o/ (f1=-512, f2-f1=-769) in 04ND51FC. The vowel /u/ (f1=-474, f2-f1=-476) in 24NB50FR is slightly higher and fronted than vowel /u/ (f1=-405, f2-f1=-525) in 04ND51FC. The area of the acoustic space chart for 24NB50FR is 261075 and for 04ND51FC is 476432.5, and 96MEANFR is 377232. The area of 24NB50FR is 45% smaller than that of the individual control but 30.8 % smaller than the mean of RHD participants. The area of the RHD participant acoustic chart is significantly smaller than the age and gender matched control participant. Both the high low and front back capabilities of the tongue are much smaller in the RHD participant, in comparison with the control.

3.5.4. CASE STUDY 4

PRIMARY INFO

Codified Name: 25UG58FR.

Female, 58 years of age, at the time of recording and case study.

Age and gender matched control: 06RB56FC

Time since incidence: approximately 1 year back, at the time of recording.

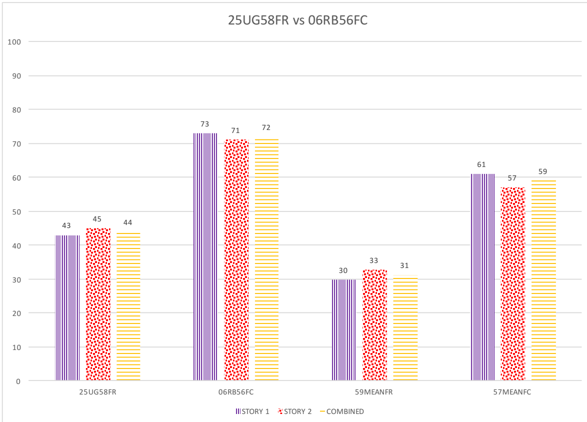
PARTICIPANT INFORMATION

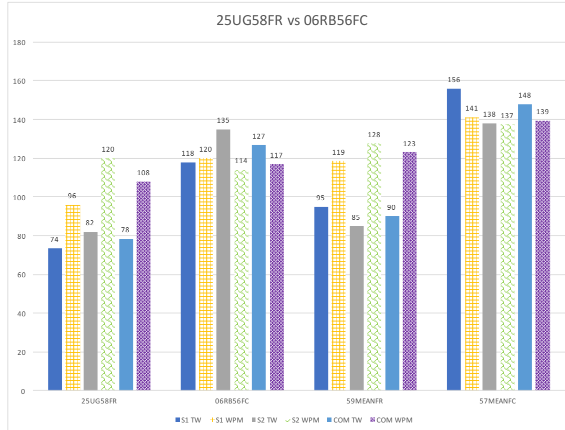
Condition of participant: The participant was fully conscious, having scored a perfect 15 on the GCS. She also scored 29 on the MMSE. The participant can walk without problems.

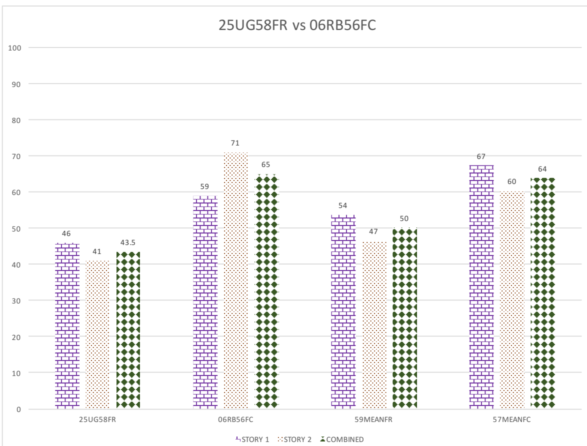
The doctor asked her to do some actions with her hands, involving muscle coordination and she could do it with ease. The participant could also perform actions based on instructions, which involved complicated and elaborate instructions. The speech of the participant was not slurred, and was completely understandable. She mentioned that she has no problems in eating. The doctor also performed a test in which he held both her hands in his hands and then asked her to keep them where he is holding them, after he lets her hands go. She could maintain the position of both the hands. The participant has no problems in remembering things. She remembers old facts and memories completely as well. She could narrate the day she suffered the stroke, with all intricate details. She does not suffer from left hemisphere neglect.

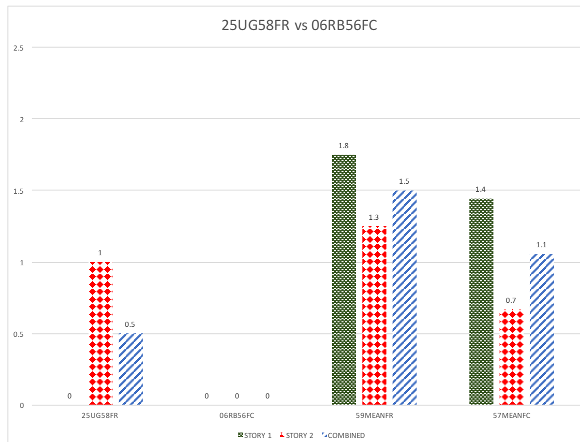
She is undergoing no physiotherapy, and she has resumed her normal life. **Observations made by doctor:** The doctor mentions that she has no agraphia, no dementia, as well as no alexia. Participant is not hypertensive. **Diagnosis made by doctor:** The doctor mentions that the participant has very less chances of suffering another stroke. She was asked to follow up after a year. **Region of damage:** Infarct at the **right basal ganglia**.

COMPREHENSIVE STUDY OF PARTICIPANT AT THE 3 LEVELS OF COMMUNICATION









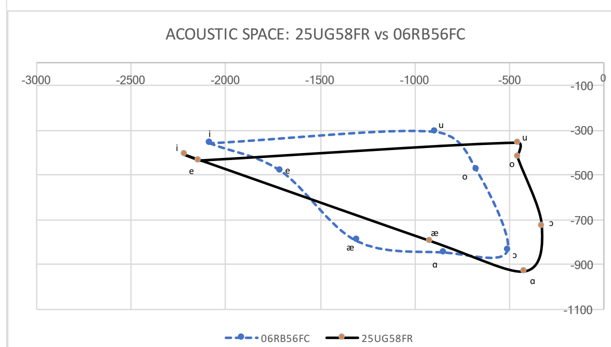
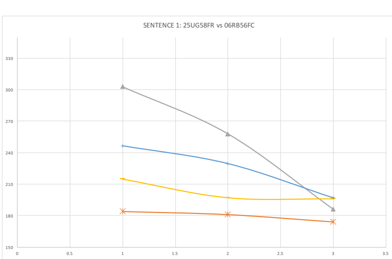
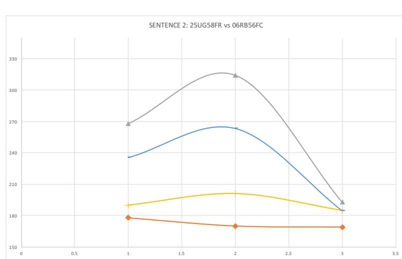
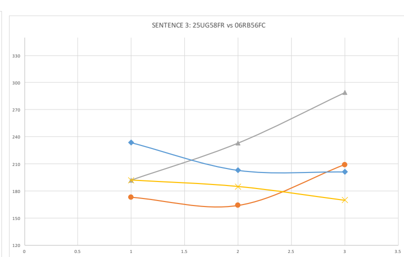


Fig 3.103 to 3.108: 25UG58FR - The bar graphs are comparisons at the level of discourse. The last diagram is an acoustic space.







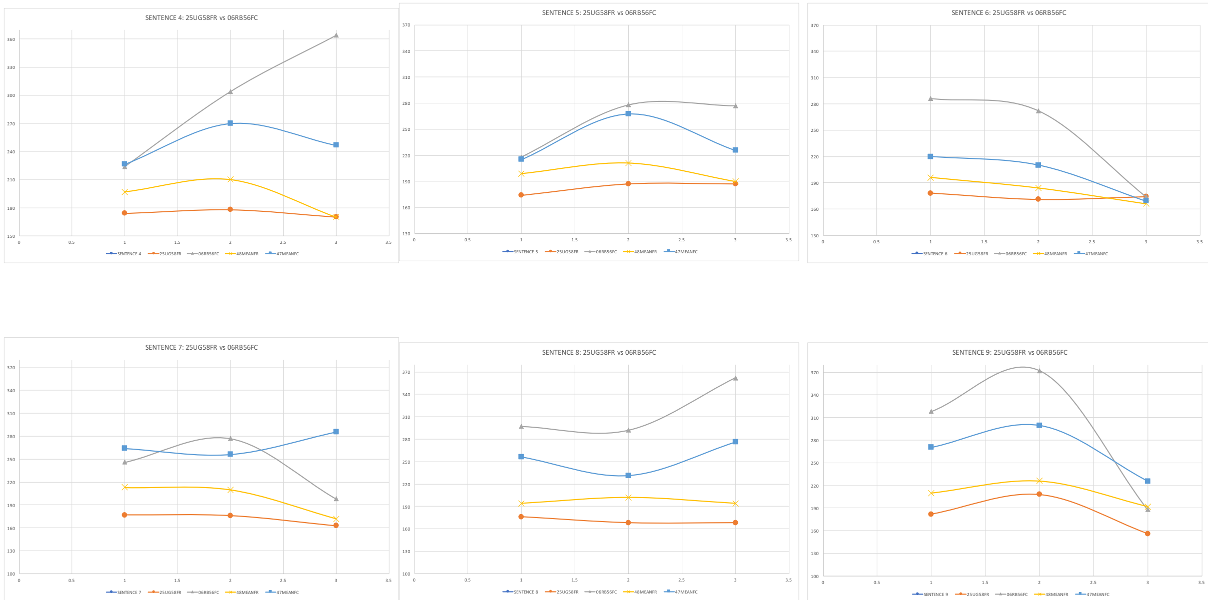


Fig 3.109 to 3.117: 25UG58FR - First three diagrams in first line are declarative sentences. The next line is composed of 3 imperative sentences and the third line has three interrogative sentences.

A. DISCOURSE

1. Pitch range

We can observe the following from fig 3.103: 25UG58FR has a pitch range of 43 Hz in the first story in comparison with 06RB56FC, who has a pitch range of 73 Hz. This is a substantial difference. 59MEANFR has a pitch range of 30 Hz in the first story while 57MEANFC has a pitch range of 61 Hz in the first story. 25UG58FR has a pitch range of 45 Hz in the second story in comparison with 06RB56FC, who has a pitch range of 71 Hz. The difference is huge as well. 59MEANFR has a pitch range of 33 Hz in the second story while 57MEANFC has a pitch range of 57 Hz in the second story. 25UG58FR has a pitch range of 44 Hz in the mean of the stories in comparison with 06RB56FC, who has a pitch range of 72 Hz. We can see a significant difference in the pitch ranges of the RHD participant and the control participant, meaning a loss in pitch information.

2. Fluency

We can observe the following from fig 3.104: 25UG58FR has 74 words in story 1 in comparison with 06RB56FC, who has 118 words, which is a huge difference. 25UG58FR has a word rate of 96 wpm in story 1 in comparison with 06RB56FC, who has 120 wpm. 25UG58FR has 82 words in story 2 in comparison with 06RB56FC, who has 135 words. 25UG58FR has a word rate of 120 wpm in story 2 in comparison with 06RB56FC, who has 114 wpm. 25UG58FR has

78 words in the combined mean of the two stories in comparison with 06RB56FC, who has 127 words. 25UG58FR has a word rate of 108 wpm in the combined mean of the two stories in comparison with 06RB56FC, who has 117 wpm. The RHD participant has very similar figures to that of the RHD group mean but has lesser figures than the control group mean.

3. **Duration**

We can observe the following from fig 3.105: 25UG58FR took 46 seconds (fluency – 96 words per minute) to complete narrating the first story in comparison with 06RB56FC, who took 59 seconds (fluency – 120 words per minute). 25UG58FR took 41 seconds (fluency – 120 words per minute) to complete narrating the second story in comparison with 06RB56FC, who took 71 seconds (fluency – 114 words per minute). 25UG58FR has a mean duration of 43.5 seconds (fluency – 108 words per minute) whereas, 06RB56FC has a mean of 65 seconds (fluency – 117 words per minute). We can see that 25UG58FR has taken lesser time than 06RB56FC; as well as 57MEANFC and 59MEANFR who have durations of 64 seconds (fluency – 139 words per minute) and 50 seconds (fluency – 123 words per minute), respectively, in the mean of the two stories.

4. Digressions and lapses

Story 1 (Narrator)	RHD participant	Control participant
There was a deer. It was standing at the edge of the river. It saw its majestic antlers in the river, as a reflection. It kept praising it. Next it saw its feet and started to demean it because it was thin and did not match the overall beauty of the whole body. In the meantime, a hunter shot an arrow but missed. The deer started running in fear but ultimately got caught by the antlers in a bushy area. He exclaimed that the antlers he was praising put him in utter danger but his legs he was demeaning, tried to help him run that far.	There was a deer standing beside a river and on seeing its reflection, praised its antlers. But on noticing the legs, felt bad that the legs were very thin. Then the deer spotted a hunter with an arrow, which the hunter shot. The deer started running for life and then got caught by the antlers in a hedge. It realized that the antlers although beautiful weren't helpful and got it caught. The legs on the other hand, it thought were bad, tried to help it by running.	A deer was standing at a river side. It saw its reflection in the water and praised the antlers. Then looked at its legs and insulted the legs. In the meantime, a hunter shot an arrow towards the deer but it didn't touch the deer. The deer ran for its life. While running the antlers got stuck in a hedge or a bush. Then the deer realized that the antler it was praising so much, put its life in danger while the legs it was insulting tried to save it.

Story 2 (Narrator)	RHD participant	Control participant
Thousands of frogs lived in a small pond. They were happy but they wanted a king. So, they prayed to God for a king. God sent a big tree trunk to them. At first,	There were many frogs in a small pond. They thought they needed a king. <u>A tree bark was dropped in the pond.</u> But they realized it was lifeless. They wanted	Many frogs, may many frogs lived in a small pond. They thought they had no king, so they wanted a king. They prayed to God for a king. God dropped a

they were intimidated by its size but soon they discovered, their new king did not move and did not talk. One brave frog climbed to the top of the trunk and after that many others gathered the courage and climbed to the top. They were unhappy and they prayed to God again stating that the king they were sent was inanimate and they want a new king who would be alive and actually rule over them. God got a bit angry. He sent a stork to the pond and the stork ate up all the frogs.	something lively and someone who would actually rule. They prayed to God for the same and then God sent a stork to them. The stork ate them all.	tree bark in the pond as a king. The frogs noticed that the king did not move at all. A few brave frogs went and touched the king and yet it didn't move. They were dissatisfied about this and then they prayed to God once again. God got angry at this and sent a stork to the pond as the next king. The stork went to the pond and started eating all the frogs one by one.

We can see one digression in story 2 for the RHD participant but no digressions in story 1. There are no lapses in the discourse recordings of the RHD participant. She could remember the story properly. The control participant on the other hand had no digressions in both the stories. There were no lapses in the narration of the control participant as well, in both the stories.

5. **Questions answered**

STORY 1				
	Questions	Actual answer	RHD participant	Control participant
1	Which animal(s) were mentioned in the story?	A deer	A deer	A deer
2	What was the deer doing?	Looking at his reflection	Looking at its reflection	Looking at his reflection
3	Why did the deer run?	A hunter shot an arrow but it didn't touch	A hunter followed it	A hunter shot an arrow. The deer ran for its life.
4	Why was he caught?	His big antlers were caught in a bush	Antlers	His big antlers were caught in a bush
5	What was the deer insulting, in the beginning?	His thin legs, that don't match his antlers and body.	The legs	His thin legs, that don't match his antlers and body.

STORY 2				
	Questions	Actual answer	RHD participant	Control participant
1	Which animal(s) were mentioned in the story?	Frogs, stork	Frogs and a stork in the end	Frogs, stork
2	Where did the frogs live?	In a small pond	In a marshy and small pond	In a small pond
3	What did the frogs want the first time?	A king	A king	A king

4	What did the frogs want the second time?	A king who would actually be alive and rule over them	A king who would actually rule over them	A king who would actually be alive and rule over them
5	Why did all the frogs die?	The stork ate them all	The stork killed them all	The stork ate them all

We can observe the following from fig 3.107 that 25UG58FR has been able to answer all 5 questions in the first story as well as all 5 questions in the second story. She had no problems in remembering. The control participant answered all questions, as well as the mean of the control group 57MEANFC and the mean of the RHD group 59MEANFR.

B. SENTENCES

Declaratives

Fig 3.109 – 3.111. We can observe the following from the figure displayed previously: In sentence 1, 25UG58FR, 06RB56FC, 48MEANFR and 47MEANFC, have recorded curves belonging to the type C of sentence. The type C sentence begins at the highest pitch point, the second point is lower than the starting point and the third point is either equal to or lower than the pitch point in the middle. In sentence 2 25UG58FR has recorded a type C sentence in comparison with 06RB56FC, 48MEANFR and 47MEANFC who all belong to the type D sentence. 47MEANFC recorded at a pitch range which is much higher than the mean of the RHD group 48MEANFR, but is still lower than the individual control 06RB56FC. In sentence 3, 25UG58FR has used a type B sentence in comparison with 06RB56FC, who has used a type A sentence. 48MEANFR and 47MEANFC have both used type C sentences. The pitch in sentences for type C begin at a high point and gradually go down but 25UG58FR has actually began her sentence at a low pitch, gone further down at the second point and then finally gone higher up than even the first point (in terms of pitch), at the third point. On an average, the pitch points recorded for 06RB56FC are higher than the others. She reached a maximum pitch of more than 300 Hz.

Imperatives

Fig 3.112 – 3.114. We can observe the following from the figure displayed previously: In sentence 4, 25UG58FR, 48MEANFR and 47MEANFC have made type D curves in comparison with 06RB56FC, who has made a type A sentence. In sentence 1, 06RB56FC has reached a maximum pitch of 362 Hz. In sentence 5, 06RB56FC, 48MEANFR and 47MEANFC have made type D curves but 24NB50FR, in comparison has made a type A curve, which begins low and ends at the highest point. In a type D sentence, the highest pitch point in a sentence is in the middle. In sentence 6, 06RB56FC, 48MEANFR and 47MEANFC have made type C curves but 25UG58FR has recorded a type B sentence. In a type B sentence, the highest pitch point is either the beginning or the end part in a sentence. In this case, it's the ending.

Interrogatives

Fig 3.115 – 3.117. We can observe the following from the figure displayed previously: In sentence 7, both 25UG58FR and 48MEANFR have recorded type have recorded type C sentences in comparison with 06RB56FC, who has recorded a type D sentence. 47MEANFC has recorded a type B sentence. For 25UG58FR, the sentence has been spoken within a very limited range, in comparison with the others. In sentence 8, 25UG58FR as well as the RHD group 48MEANFR have recorded type C sentences, in comparison with her control 06RB56FC and 47MEANFC, who have recorded type B sentences. For 25UG58FR, the sentence has been spoken within a very limited range, in comparison with the others. In sentence 9, 25UG58FR, 06RB56FC, 48MEANFR and 47MEANFC have all recorded type D sentences. We can notice that the operating pitch range in 06RB56FC is higher than the rest of the sentence curves, and goes above 370 Hz.

C. **VOWELS**

Fig 3.108 compares female RHD participant 25UG58FR with the individual age and gender matched female, that is 06RB56FC. We can observe the following from the figure displayed previously: The vowel /i/ (f1=-435, f2-f1=-2140) in 25UG58FR is lower and fronted than vowel /i/ (f1=-358, f2-f1=-2085) in 06RB56FC. The vowel /i/ (f1=-435, f2-f1=-2140) in 25UG58FR is very close to vowel /e/ (f1=-410, f2-f1=-2215) of 25UG58FR. The vowel /e/ (f1=-410, f2-f1=-2215) in 25UG58FR is higher and much more fronted than vowel /e/ (f1=-480, f2-f1=-1710) in 06RB56FC. The vowel /æ/ (f1=-794, f2-f1=-922) in 25UG58FR much more backed in comparison vowel with vowel /æ/ (f1=-793, f2-f1=-1307) in 06RB56FC. The vowel /ɑ/ (f1=-932, f2-f1=-420) in 25UG58FR is lower and more backed than vowel /ɑ/ (f1=-844, f2-f1=-844) in 06RB56FC. The vowel /ɔ/ (f1=-726, f2-f1=-326) in 25UG58FR is higher and backed than vowel /ɔ/ (f1=-837, f2-f1=-509) in 06RB56FC. The vowel /o/ (f1=-419, f2-f1=-454) in 25UG58FR is more backed and slightly higher than vowel /o/ (f1=-474, f2-f1=-675) in 06RB56FC. The vowel /u/ (f1=-355, f2-f1=-454) in 25UG58FR is slightly lower and backed than vowel /u/ (f1=-307, f2-f1=-893) in 06RB56FC. The area of the acoustic space chart for 25UG58FR is 518600 and for 06RB56FC is 483885.5, and 96MEANFR is 377232, making the area 107% of the individual control and 137.5 % of the mean, or in other words, the area of

25UG58FR is 7% bigger than that of the individual control but 37.5 % bigger than the mean of RHD participants. The area of the RHD participant acoustic chart is significantly bigger than the mean of the control group participants. We can also notice that the RHD participant has more front and back movement in the tongue, when compared to the control.

3.5.5. CASE STUDY 5

PRIMARY INFO

Codified Name: 26AS60MR.

Male, 60 years of age, at the time of recording and case study.

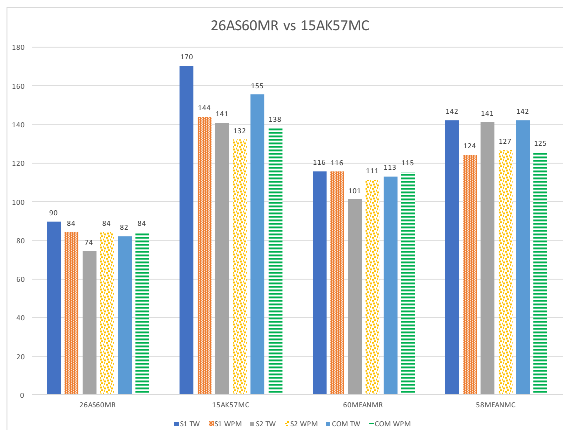
Age and gender matched control: 15AK57MC

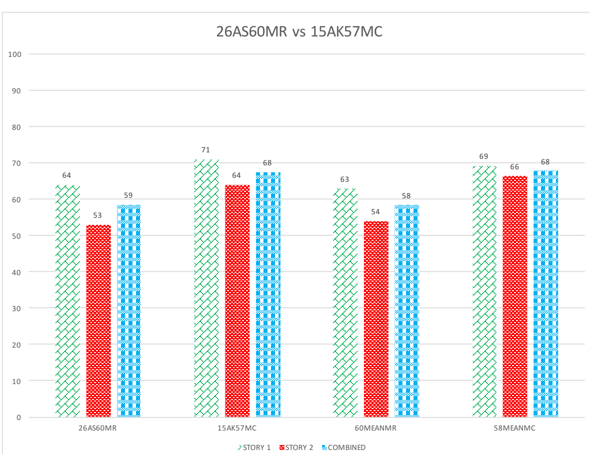
Time since incidence: approximately 1.5 months back, at the time of recording.

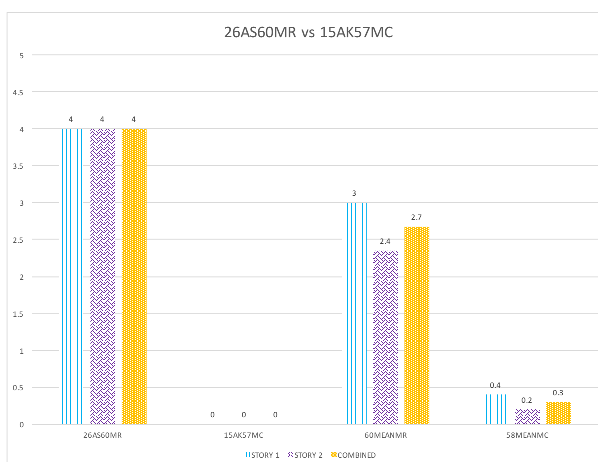
PARTICIPANT INFORMATION

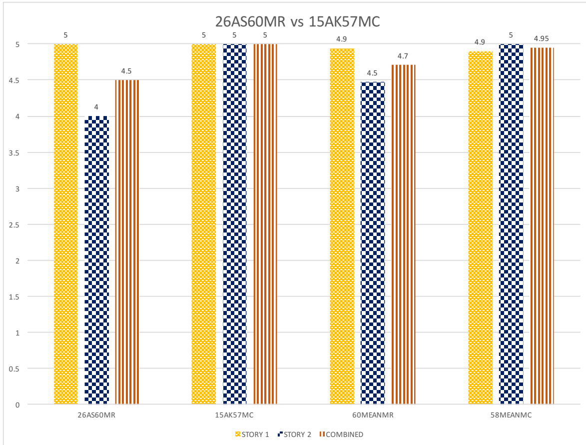
Condition of participant: The participant was fully conscious, having scored 14 on the GCS. He also scored 26 on the MMSE. The participant can walk without problems but is still weak in the left hemisphere. It cannot be termed as hemiparesis, because he can control all his left hemisphere functions, but the doctor noticed a significant lack of strength in the left hemisphere. The doctor asked him to do some actions with his hands, involving muscle coordination and he could do it but the doctor had to repeat the instructions more than once, for him to understand. The participant could also perform actions based on instructions, which involved complicated and elaborate instructions, but again, had to be instructed more than once. The speech of the participant was slurred, and was difficult to understand. The family members mentioned he has problems in eating. He generally ignores food towards the left side of his plate. The doctor also performed a test in which he held both of the participant's hands in his hands and then asked the participant to keep holding them where he is holding them, after he lets them go. He could maintain the position of both the hands. It is worth mentioning here that the doctor instructed him thrice, before he could understand. The doctor placed two pens next to each other and then placed a pencil over them. He asked the participant to name all the three objects. He could only see the pencil on top. He said there's something below, but it's not clear. The doctor mentions that it is not clear, whether it is his sight that is weak (because no test for eyesight was done) or his inability to sense overlapping figures, which caused this. The participant has no problems in remembering things. He remembers old facts and memories completely as well. He suffers from left hemisphere neglect. He is undergoing no physiotherapy. **Observations made by doctor:** The doctor mentions that he has no agraphia, no dementia, but has alexia (he cannot read). Participant is highly hypertensive. Participant is alcoholic and a smoker. Participant has problems in planning and judgement (might also be attributed to comprehension problems we have notices in the last section). Participant speaks very fast. Participant has problems in object recognition but it is inconsistent. **Diagnosis made by doctor:** The doctor mentions that the participant has chances of suffering another stroke, if he does not refrain from strenuous situations. He was also advised to keep away from alcohol and smoking. He was asked to continue medicines for blood pressure and to follow up in two months. **Region of damage:** Gliotic large areas seen in **frontal and parietal lobes on right side.** Large ischemic gliosis in **fronto-parietal lobe.** Blockage in the **whole of right carotid artery.**

COMPREHENSIVE STUDY OF PARTICIPANT AT THE 3 LEVELS OF COMMUNICATION









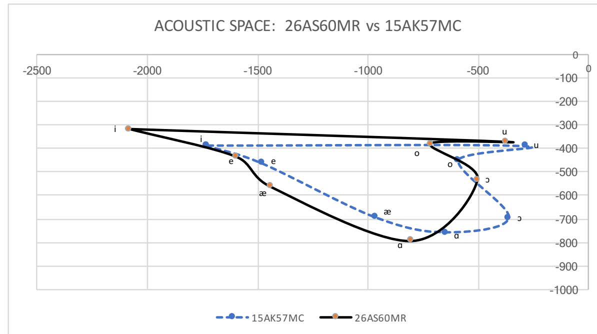


Fig 3.118 to 3.123: 26AS60MR - The bar graphs are comparisons at the level of discourse. The last diagram is an acoustic space.

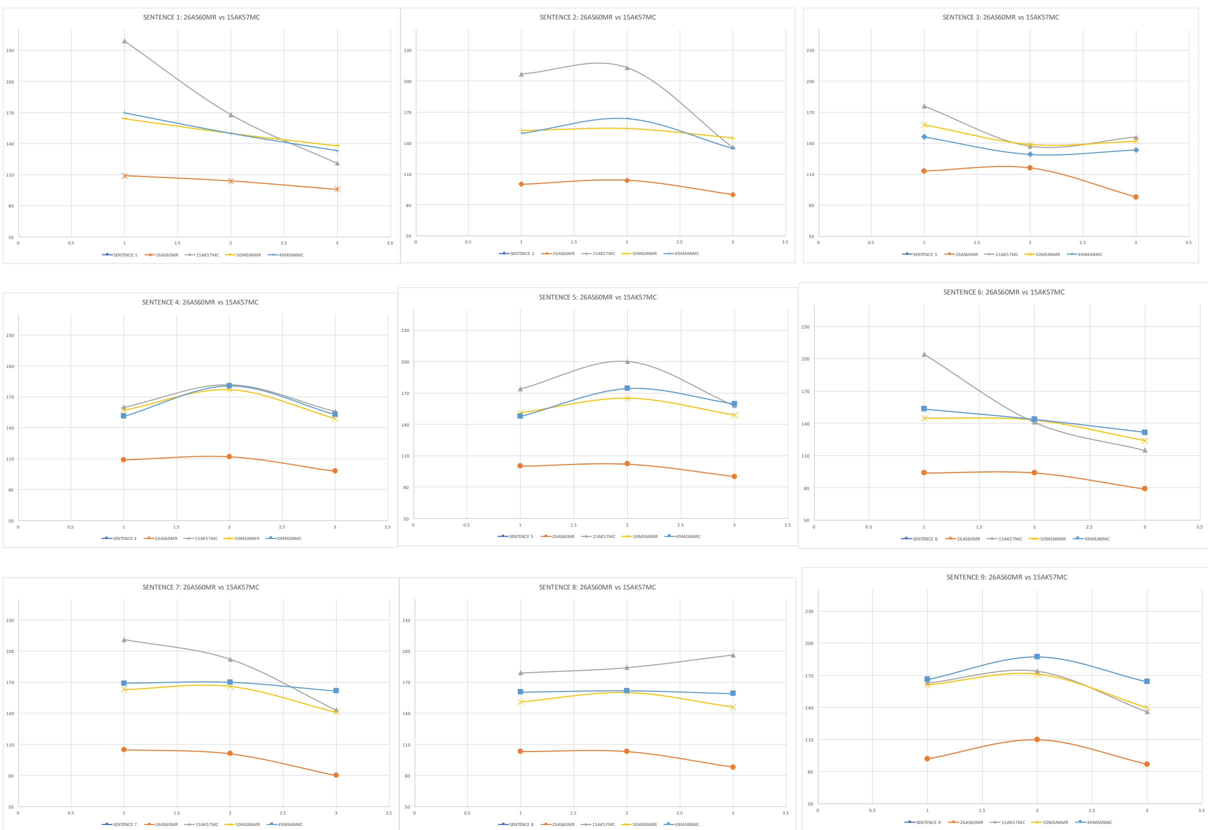


Fig 3.124 to 3.131: 26AS60MR - First three diagrams in first line are declarative sentences. The next line is composed of 3 imperative sentences and the third line has three interrogative sentences.

A. DISCOURSE

1. Pitch range

We can observe the following from fig 3.118: 26AS60MR has a pitch range of 30 Hz in the first story in comparison with 15AK57MC, who has a pitch range of 80 Hz. 60MEANMR has a pitch range of 40 Hz in the first story while 58MEANMC has a pitch range of 53 Hz in the first story. 26AS60MR has a pitch range of 36 Hz in the second story in comparison with 15AK57MC, who has a pitch range of 67 Hz. 60MEANMR has a pitch range of 39 Hz in the first story while 58MEANMC has a pitch range of 55 Hz in the second story. 26AS60MR has a pitch range of 33 Hz in the mean of the stories in comparison with 15AK57MC, who has a pitch range of 74 Hz. The difference is negligible. 60MEANMR has a pitch range of 160 Hz in the mean of the two stories while 58MEANMC has a pitch range of 187 Hz in the same. The pitch range of 26AS60MR are lower than the pitch ranges for 59MEANFR. The RHD male group 60MEANMR has a combined mean range of 39 Hz while 58MEANMC has a combined mean of 54 Hz. We can see a huge difference between the pitch range of the RHD participant and the control participant. This in turn, means that the RHD participant has much lesser pitch range in speech, in comparison with the control participants.

2. **Fluency**

We can observe the following from fig 3.119: 26AS60MR has 90 words in story 1 in comparison with 15AK57MC, who has 170 words, which is a huge difference. 26AS60MR has a word rate of 84 wpm in story 1 in comparison with 15AK57MC, who has 144 wpm. 26AS60MR has 74 words in story 2 in comparison with 15AK57MC, who has 141 words. 26AS60MR has a word rate of 84 wpm in story 2 in comparison with 15AK57MC, who has 132 wpm. 26AS60MR has 82 words in the combined mean of the two stories in comparison with 15AK57MC, who has 155 words. 26AS60MR has a word rate of 84 wpm in the combined mean of the two stories in comparison with 15AK57MC, who has 138 wpm. The RHD participant has much lower number of both total words and words per minute than the mean of the RHD group as well as the mean of the control group.

3. **Duration**

We can observe the following from fig 3.120: 26AS60MR took 64 seconds (fluency – 84 words per minute) to complete narrating the first story in comparison with 15AK57MC, who took 71 seconds (fluency – 144 words per minute). 26AS60MR took 53 seconds (fluency – 84 words per minute) to complete narrating the second story in comparison with 15AK57MC, who took

64 seconds (fluency – 132 words per minute). 26AS60MR has a mean duration of 59 seconds (fluency – 84 words per minute) whereas, 15AK57MC has a mean of 68 seconds (fluency – 138 words per minute). We can see that 26AS60MR has taken lesser time than 15AK57MC in both the stories. This adds to the observation that the participant was speaking in a hurry. 26AS60MR also completed the stories faster than 58MEANMC with a duration of 68 seconds (fluency – 125 words per minute) and 60MEANMR with a duration of 58 seconds (fluency – 113 words per minute), in the mean of the two stories.

4. Digressions and lapses

Story 1 (Narrator)	RHD participant	Control participant
There was a deer. It was standing at the edge of the river. It saw its majestic antlers in the river, as a reflection. It kept praising it. Next it saw its feet and started to demean it because it was thin and did not match the overall beauty of the whole body. In the meantime, a hunter shot an arrow but missed. The deer started running in fear but ultimately got caught by the antlers in a bushy area. He exclaimed that the antlers he was praising put him in utter danger but his legs he was demeaning, tried to help him run that far.	The deer was drinking water and looking at its reflection and insulting and hating its legs. The antlers were beautiful. <u>The antler got caught.</u> <u>It was afraid of a hunter.</u> <u>The deer hated the antlers but those helped it.</u> <u>The legs were beautiful but didn't help at all</u>	A deer, on being thirsty, went to a river side and saw its reflection. At first it saw its antlers and felt proud about it. Then it saw its legs and felt bad about the thin legs. A hunter shot an arrow in the meantime. The deer fled for its life and got caught in a bush or hedge. The hunter was catching up. The deer realized that although he was abusing and demeaning the legs did try to help him run but the antlers which he was praising and feeling good about, got him caught.

Story 2 (Narrator)	RHD participant	Control participant
Thousands of frogs lived in a small pond. They were happy but they wanted a king. So, they prayed to God for a king. God sent a big tree trunk to them. At first, they were intimidated by its size but soon they discovered, their new king did not move and did not talk. One brave frog climbed to the top of the trunk and after that many others gathered the courage and climbed to the top. They were unhappy and they prayed to God again stating that the king they were sent was inanimate and they want a new king who would be	<u>There were storks, frogs and kings.</u> But frogs stayed in a pond and requested God for a king. God threw a tree bark in the pond. <u>But the frogs started to stay on the tree bark.</u> <u>The frogs killed the tree bark.</u> <u>Then a stork came and ate all the frogs.</u>	In a pond, there were many frogs. The frogs realized they had no king and they praised to God for a king. But God wasn't thinking much and dropped a tree bark in the pond. The king didn't move. In a few days, the frogs noticed the king didn't move. They touched the tree bark and it still didn't move. They realized it was inanimate and they complained to God requesting him to send a king again, who would be actually animate and rule over them. God got angry and sent a

alive and actually rule over them. God got a bit angry. He sent a stork to the pond and the stork ate up all the frogs.		stork over to their place. The stork ate all the frogs one by one.

We can see four digressions in both the stories for the RHD participant. He had some major issues in remembering and had many major lapses. The control participant on the other hand had no digressions in both the stories. There were no lapses in the narration of the control participant as well, in both the stories.

5. **Questions answered**

STORY 1				
	Questions	Actual answer	RHD participant	Control participant
1	Which animal(s) were mentioned in the story?	A deer	A deer	A deer
2	What was the deer doing?	Looking at his reflection	Looking at its reflection	Looking at his reflection
3	Why did the deer run?	A hunter shot an arrow but it didn't touch	A hunter followed it	A hunter shot an arrow. The deer ran for its life.
4	Why was he caught?	His big antlers were caught in a bush	Antlers	His big antlers were caught in a bush
5	What was the deer insulting, in the beginning?	His thin legs, that don't match his antlers and body.	The legs	His thin legs, that don't match his antlers and body.

STORY 2				
	Questions	Actual answer	RHD participant	Control participant
1	Which animal(s) were mentioned in the story?	Frogs, stork	Frogs and a stork in the end	Frogs, stork
2	Where did the frogs live?	In a small pond	In a marshy and small pond	In a small pond
3	What did the frogs want the first time?	A king	**A king who would rule them**	A king
4	What did the frogs want the second time?	A king who would actually be alive and rule over them	A king who would actually rule over them	A king who would actually be alive and rule over them
5	Why did all the frogs die?	The stork ate them all	The stork killed them all	The stork ate them all

We can observe the following from fig 3.122: 26AS60MR has been able to answer all 5 questions in the first story but only 4 questions in the second story. The control participant answered all questions, as well as the mean of the control group 58MEANMC and the mean of the RHD group 60MEANFR.

B. **SENTENCES**

Declaratives

Fig 3.124 - 3.126. We can observe the following from the figure displayed previously: In sentence 1, 26AS60MR, 15AK57MC, 50MEANMR and 49MEANMC, have recorded curves belonging to the type C of sentence. In sentence 26AS60MR, 15AK57MC, 50MEANMR and 49MEANMC, have recorded curves belonging to the type D of sentence. 49MEANMC recorded at a pitch range which is much higher than the mean of the RHD group 50MEANMR, but is still lower than the individual control 15AK57MC. In sentence 3, 15AK57MC, 50MEANMR and 49MEANMC a type B sentence in comparison with 26AS60MR, who has used a type D sentence. On an average, the pitch points recorded for 15AK57MC are higher than the others.

Imperatives

Fig 3.127 – 3.129. We can observe the following from the figure displayed previously: In sentence 4, 26AS60MR, 15AK57MC, 50MEANMR and 49MEANMC have all made type D sentences. In sentence 5, 26AS60MR, 15AK57MC, 50MEANMR and 49MEANMC have all made type D sentences. In a type D sentence, the highest pitch point in a sentence is in the middle. In sentence 6, 26AS60MR, 15AK57MC, 50MEANMR and 49MEANMC have all made type C sentences. It can be noted that 26AS60MR operates in a very low pitch range in comparison with 15AK57MC, who has an operating pitch range more than the means of the RHD and control groups.

Interrogatives

Fig 3.130 – 3.132. We can observe the following from the figure displayed previously: In sentence 7, 26AS60MR and 15AK57MC have both made type C sentences in comparison with 50MEANMR and 49MEANMC who have recorded type D sentences. In sentence 8, 26AS60MR has made a type C sentence in comparison with 15AK57MC, who has made a type A sentence. 50MEANMR has a type D sentence and from the chart 49MEANMC has no visible contour, but on checking the figures, 49MEANMC has made a type D sentence as well. In sentence 9, 26AS60MR, 15AK57MC, 50MEANMR and 49MEANMC have all made type D sentences. In all the sentences 26AS60MR has an operating pitch range which is lower than all the other sentence curves.

C. VOWELS

VOWELS RHD					
RHD PARTICIPANT	**Area**	**Control**	**Area**	**% of ind control**	**% of rhd mean**
26AS60MR	331661.5	15AK57MC	278398.5	19.1	-1.5
27BD57MR	352108	15AK57MC	278398.5	26.5	4.5
28DM35MR	344954.5	13AS36MC	198261.5	74.0	2.4
29DS55MR	338952	10AP56MC	353753.5	-4.2	0.6
30HD50MR	207043	16AP52MC	430473.5	-51.9	-38.5
31KM80MR	265859.5	21SD82MC	295629.5	-10.1	-21.1
32KD72MR	229269	12AD75MC	366966	-37.5	-31.9
33NB42MR	302259.5	20SD48MC	387032	-21.9	-10.3
34SR36MR	586667.5	13AS36MC	198261.5	195.9	74.1
35SA58MR	290021.5	15AK57MC	278398.5	4.2	-13.9
36SB47MR	372567	20SD48MC	387032	-3.7	10.6
37SH31MR	371417	17SB30MC	358350	3.6	10.3
38SB74MR	262374.5	12AD75MC	366966	-28.5	-22.1
39SR34MR	273457	13AS36MC	198261.5	37.9	-18.8
40SB82MR	519492	21SD82MC	295629.5	75.7	54.2
41SK55MR	322039	10AP56MC	353753.5	-9.0	-4.4
42SR44MR	363945	20SD48MC	387032	-6.0	8.0
43SK55MR	344865.5	14AK56MC	306181.5	12.6	2.4
44ZS64MR	321792.5	18SB64MC	252738.5	27.3	-4.5
97MEANMR	**336881.342**				

Fig 3.123 compares female RHD participant 26AS60MR with the individual age and gender matched male, that is 15AK57MC. We can observe the following from the figure displayed previously: The vowel /i/ (f1=-320, f2-f1=-2081) in 26AS60MR is slightly higher but a lot more fronted than vowel /i/ (f1=-387, f2-f1=-1734) in 15AK57MC. The vowel /e/ (f1=-437, f2-f1=-1597) in 26AS60MR is slightly fronted than vowel /e/ (f1=-464, f2-f1=-1479) in 15AK57MC. The vowel /æ/ (f1=-563, f2-f1=-1442) in 26AS60MR a lot more fronted and slightly higher in comparison vowel with vowel /æ/ (f1=-693, f2-f1=-970) in 15AK57MC. The vowel /ɑ/ (f1=-792, f2-f1=-805) in 26AS60MR is lower and fronted than vowel /ɑ/ (f1=-758, f2-f1=-649) in 15AK57MC. The vowel /ɔ/ (f1=-533, f2-f1=-503) in 26AS60MR is higher and slightly fronted than vowel /ɔ/ (f1=-695, f2-f1=-363) in 15AK57MC. The vowel /o/ (f1=-381, f2-f1=-717) in 26AS60MR is slightly fronted and higher than vowel /o/ (f1=-450, f2-f1=-592) in 15AK57MC. The vowel /u/ (f1=-374, f2-f1=-375) in 26AS60MR is slightly higher and fronted than vowel /u/ (f1=-390, f2-f1=-289) in 15AK57MC. The area of the acoustic space chart for 26AS60MR is 331661.5 and for 15AK57MC is 278398.5, and 96MEANMR is 336881. The area of 26AS60MR is 19% bigger than that of the individual control but 2 % smaller than the mean of RHD participants. It can be seen that the control participant 15AK57MC has a smaller acoustic space than the RHD participant 26AS60MR.

3.5.6. CASE STUDY 6

PRIMARY INFO

Codified Name: 27BD57MR.

Male, 57 years of age, at the time of recording and case study.

Age and gender matched control: 15AK57MC

Time since incidence: approximately 4 months back, at the time of recording.

PARTICIPANT INFORMATION

Condition of participant: The participant was fully conscious, having scored 14 on the GCS. He also scored 26 on the MMSE. The participant can walk without problems.

The doctor asked him to do some actions with his hands, involving muscle coordination and he could do it with ease. The participant could also perform actions based on instructions, which involved complicated and elaborate instructions. The speech of the participant was not slurred and was easily to understand. The participant did not display any left hemisphere neglect.

The family members stated that he was diagnosed very late and the doctor added to it stating that, the late diagnostic caused him the initial one month of complete hemiplegia in the left hemisphere. The doctor also performed a test in which he held both of the participant's hands in his hands and then asked the participant to keep holding them where he is holding them, after he lets them go. He could maintain the position of both the hands. The participant had issues with remembering earlier, as found in the doctor's case history of the participant when he came earlier. The doctor stated that the participant could remember things in the visit the researcher met him. Late diagnostic of the stroke had caused him vision loss in the first month but now, his vision is back to normal. He is undergoing no physiotherapy.

Observations made by doctor: The doctor mentions that he has no agraphia, no dementia, and no alexia. Participant is highly hypertensive and has a high blood pressure, which is supposedly the cause of the stroke. Participant is not an alcoholic or a smoker. Participant has no problems in planning and judgement. **Diagnosis made by doctor:** The doctor mentions that the participant has chances of suffering another stroke, if his blood pressure rises again. He was asked to continue medicines for blood pressure and to follow up in one month. **Region of damage:** Complete blockage of the **<u>right internal carotid artery</u>**.

COMPREHENSIVE STUDY OF PARTICIPANT AT THE 3 LEVELS OF COMMUNICATION

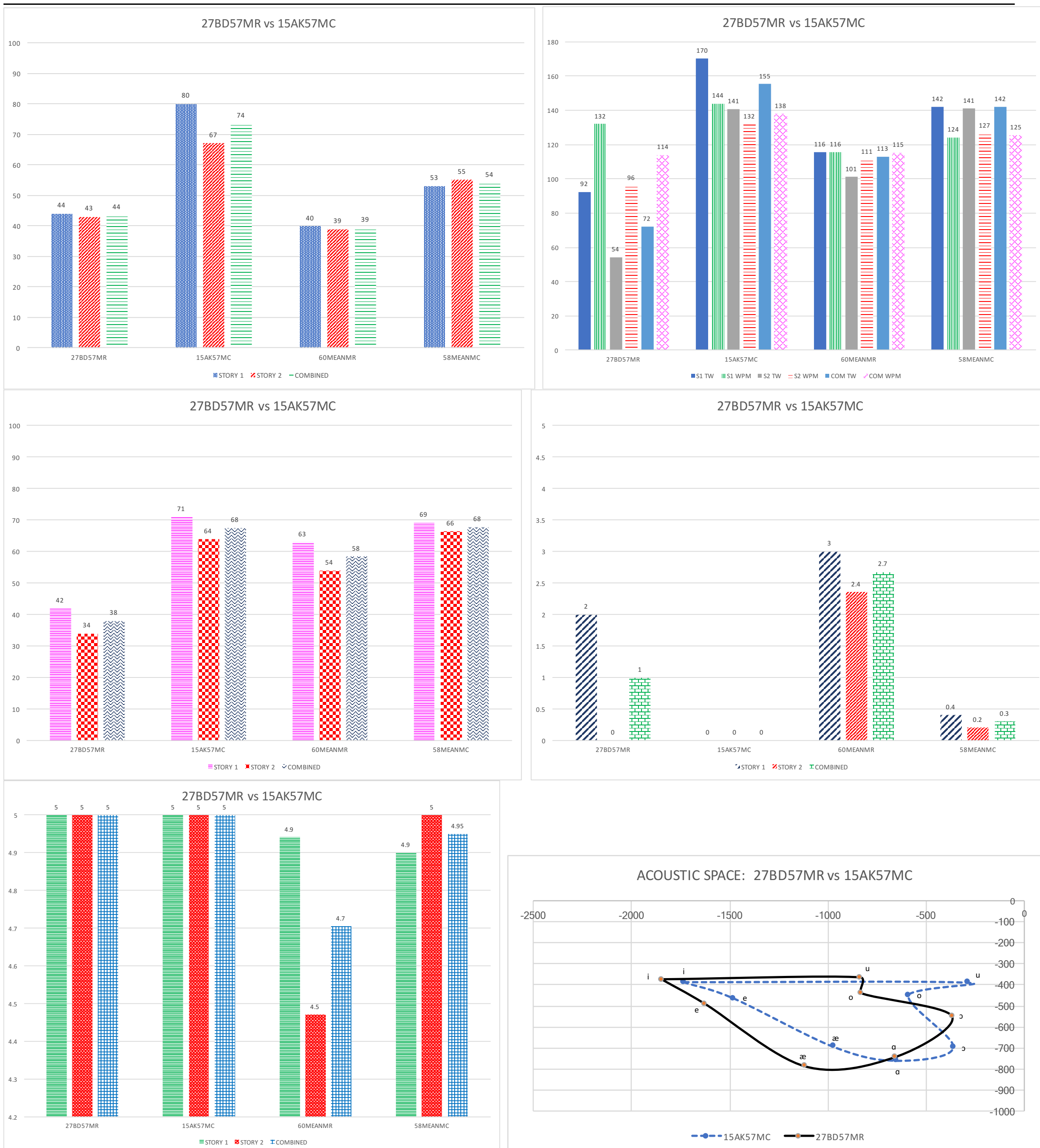
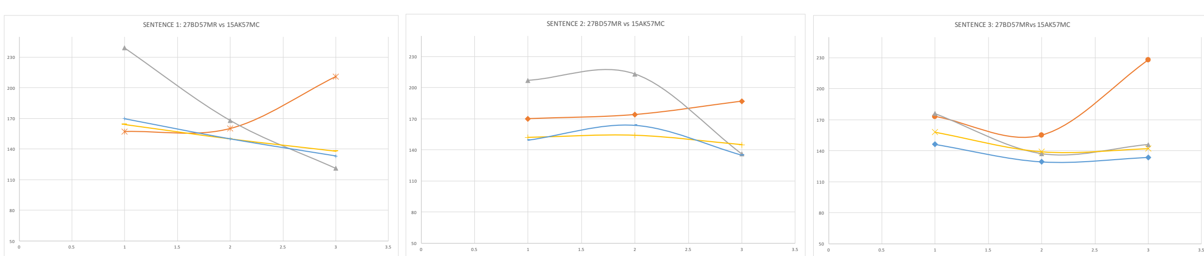


Fig 3.132 to 3.137: 27BD57MR - The bar graphs are comparisons at the level of discourse. The last diagram is an acoustic space.



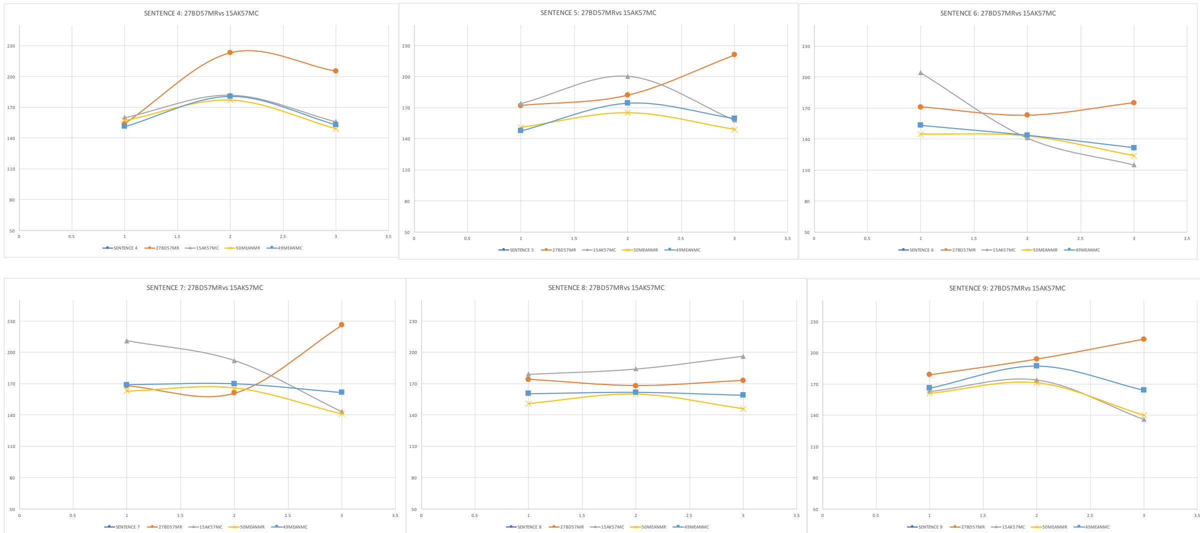


Fig 3.138 to 3.146: 27BD57MR - First three diagrams in first line are declarative sentences. The next line is composed of 3 imperative sentences and the third line has three interrogative sentences

A. Discourse

1. Pitch range

We can observe the following from fig 3.132: 27BD57MR has a pitch range of 44 Hz in the first story in comparison with 15AK57MC, who has a pitch range of 80 Hz; and this is a significant difference in pitch range. 60MEANMR has a pitch range of 40 Hz in the first story while 58MEANMC has a pitch range of 53 Hz in the first story. 27BD57MR has a pitch range of 43 Hz in the second story in comparison with 15AK57MC, who has a pitch range of 67 Hz. This again is a significant difference in pitch range. 60MEANMR has a pitch range of 39 Hz in the second story while 58MEANMC has a pitch range of 55 Hz in the second story. 27BD57MR has a pitch range of 44 Hz in the mean of the stories in comparison with 15AK57MC, who has a pitch range of 74 Hz. 60MEANMR has a pitch range of 39 Hz in the mean of the two stories while 58MEANMC has a pitch range of 54 Hz in the same.

2. Fluency

We can observe the following from fig 3.133: 27BD57MR has 92 words in story 1 in comparison with 15AK57MC, who has 170 words, which is a huge difference. 27BD57MR has a word rate of 132 wpm in story 1 in comparison with 15AK57MC, who has 144 wpm. 27BD57MR has 54 words in story 2 in comparison with 15AK57MC, who has 141 words. 27BD57MR has a word rate of 96 wpm in story 2 in comparison with 15AK57MC, who has 132 wpm. 27BD57MR has 72 words in the combined mean of the two stories in comparison with 15AK57MC, who has 155 words. 27BD57MR has a word rate of 114 wpm in the combined mean of the two stories in comparison with 15AK57MC, who has 138 wpm. The RHD participant has much lower number of both total words and words per minute than the mean of the RHD group as well as the mean of the control group. The only exception is the high fluency rate in the first story.

3. **Duration**

We can observe the following from fig 3.134: 27BD57MR took 42 seconds (fluency – 132 words per minute) to complete narrating the first story in comparison with 15AK57MC, who took 71 seconds (fluency – 144 words per minute). 27BD57MR took 71 seconds (fluency – 96 words per minute) to complete narrating the second story in comparison with 15AK57MC, who took 64 seconds (fluency – 132 words per minute). 27BD57MR has a mean duration of 38 seconds (fluency – 114 words per minute) whereas, 15AK57MC has a mean of 68 seconds (fluency – 138 words per minute). We can see that 27BD57MR has taken lesser time than 15AK57MC in both the stories. This adds to the observation that the participant was speaking in a hurry. 27BD57MR also completed the stories faster than 58MEANMC with a duration of 68 seconds (fluency – 125 words per minute) and 60MEANMR with a duration of 58 seconds (fluency – 113 words per minute), in the mean of the two stories.

4. **Digressions and lapses**

Story 1 (Narrator)	RHD participant	Control participant
There was a deer. It was standing at the edge of the river. It saw its majestic antlers in the river, as a reflection. It kept praising it. Next it saw its feet and started to demean it because it was thin and did not match the overall beauty of the whole body. In the meantime, a hunter shot an arrow but missed. The deer started running in fear but ultimately got caught by the antlers in a bushy area. He exclaimed that the antlers he was praising put him in utter danger but his legs he was demeaning, tried to help him run that far.	<u>A deer was at a pond</u> and looked at its reflection while drinking water. It praised its antlers while it was feeling bad about its legs, which were thin. A hunter shot an arrow towards the deer and the deer started running. Then it got caught by the antlers in a bush. <u>The hunter then came and caught it by the antler and took the deer away.</u>	A deer, on being thirsty, went to a river side and saw its reflection. At first it saw its antlers and felt proud about it. Then it saw its legs and felt bad about the thin legs. A hunter shot an arrow in the meantime. The deer fled for its life and got caught in a bush or hedge. The hunter was catching up. The deer realized that although he was abusing and demeaning the legs did try to help him run but the antlers which he was praising and feeling good about, got him caught.

Story 2 (Narrator)	RHD participant	Control participant

Thousands of frogs lived in a small pond. They were happy but they wanted a king. So, they prayed to God for a king. God sent a big tree trunk to them. At first, they were intimidated by its size but soon they discovered, their new king did not move and did not talk. One brave frog climbed to the top of the trunk and after that many others gathered the courage and climbed to the top. They were unhappy and they prayed to God again stating that the king they were sent was inanimate and they want a new king who would be alive and actually rule over them. God got a bit angry. He sent a stork to the pond and the stork ate up all the frogs.	Frogs stayed in a small pond. They wanted a king to rule over them. A king was sent to them. But the king didn't move or rule. So, they wanted a king again who would rule over them truly. So, a stork was sent and the stork started eating them one by one.	In a pond, there were many frogs. The frogs realized they had no king and they praised to God for a king. But God wasn't thinking much and dropped a tree bark in the pond. The king didn't move. In a few days, the frogs noticed the king didn't move. They touched the tree bark and it still didn't move. They realized it was inanimate and they complained to God requesting him to send a king again, who would be actually animate and rule over them. God got angry and sent a stork over to their place. The stork ate all the frogs one by one.

We can see 2 digressions in story 1 for the RHD participant but not in story 2. From the table above, which contain the stories, we can discern that the RHD participant had some major issues in remembering and also had lapses in both the stories as well. The control participant on the other hand had no digressions in both the stories. There were no lapses in the narration of the control participant as well, in both the stories.

5. Questions answered

STORY 1				
	Questions	Actual answer	RHD participant	Control participant
1	Which animal(s) were mentioned in the story?	A deer	A deer	A deer
2	What was the deer doing?	Looking at his reflection	Looking at its reflection	Looking at his reflection
3	Why did the deer run?	A hunter shot an arrow but it didn't touch	A hunter followed it	A hunter shot an arrow. The deer ran for its life.
4	Why was he caught?	His big antlers were caught in a bush	Antlers	His big antlers were caught in a bush
5	What was the deer insulting, in the beginning?	His thin legs, that don't match his antlers and body.	The legs	His thin legs, that don't match his antlers and body.

STORY 2				
	Questions	Actual answer	RHD participant	Control participant
1	Which animal(s) were mentioned in the story?	Frogs, stork	Frogs and a stork in the end	Frogs, stork
2	Where did the frogs live?	In a small pond	In a marshy and small pond	In a small pond
3	What did the frogs want the first time?	A king	A king	A king
4	What did the frogs want the second time?	A king who would actually be alive and rule over them	A king who would actually rule over them	A king who would actually be alive and rule over them

5	Why did all the frogs die?	The stork ate them all	The stork killed them all	The stork ate them all

We can observe the following from fig 3.136: 27BD57MR has been able to answer all 5 questions in the first story and the second story. The control participant answered all questions, as well as the mean of the control group 58MEANMC and the mean of the RHD group 60MEANFR.

B. **SENTENCES**

Declaratives

Fig 3.138 – 3.140. We can observe the following from the figure displayed previously: In sentence 1, 27BD57MR has a type A curve, which is in complete contrast of that of 15AK57MC, 50MEANMR and 49MEANMC, who have recorded curves belonging to the type C of sentence. In sentence 2 27BD57MR has recorded a type A curve again, in comparison with 15AK57MC, 50MEANMR and 49MEANMC, who have recorded curves belonging to the type D. 49MEANMC recorded at a pitch range which is much higher than the mean of the RHD group 50MEANMR, but is still lower than the individual control 15AK57MC. In sentence 3, 27BD57MR, 15AK57MC, 50MEANMR and 49MEANMC have all recorded type B sentences. But 27BS57MR, still has an operating pitch range which is more than all.

Imperatives

Fig 3.141 - 3.143. We can observe the following from the figure displayed previously: In sentence 4, 27BD57MR, 15AK57MC, 50MEANMR and 49MEANMC have all made type D sentences. In sentence 5, 27BD57MR has made a type A sentence in comparison with 15AK57MC, 50MEANMR and 49MEANMC who show type D sentences. In sentence 6, 27BD57MR conforms to a type B sentence while 15AK57MC, 50MEANMR and 49MEANMC have made type C sentences. It can be noted that 27BD57MR operates in a higher pitch range in comparison with 15AK57MC, who has an operating pitch range more than the means of the RHD and control groups.

Interrogatives

Fig 3.144 – 3.146. We can observe the following from the figure displayed previously: In sentence 7, 27BD57MR has a B type sentence in comparison with 15AK57MC, who has a type C sentences. This is in contrast with 50MEANMR and 49MEANMC who have recorded type D sentences. In sentence 8, 27BD57MR has made a type B sentence in comparison with

15AK57MC, who has made a type A sentence. 50MEANMR has a type D sentence and from the chart 49MEANMC has no visible contour, but on checking the figures, 49MEANMC has made a type D sentence as well. In sentence 9, 27BD57MR has a type A curve in comparison with 15AK57MC, 50MEANMR and 49MEANMC who have type D sentences.

C. VOWELS

Fig 3.137 compares female RHD participant 27BD57MR with the individual age and gender matched male, that is 15AK57MC. We can observe the following from the figure displayed previously: The vowel /i/ (f1=-375, f2-f1=-1847) in 27BD57MR is slightly fronted than vowel /i/ (f1=-387, f2-f1=-1734) in 15AK57MC. The vowel /e/ (f1=-490, f2-f1=-1627) in 27BD57MR is slightly fronted than vowel /e/ (f1=-464, f2-f1=-1479) in 15AK57MC. The vowel /æ/ (f1=-785, f2-f1=-1116) in 27BD57MR is more fronted and slightly lower in comparison vowel with vowel /æ/ (f1=-693, f2-f1=-970) in 15AK57MC. The vowel /ɑ/ (f1=-741, f2-f1=-656) in 27BD57MR is almost at the same place as vowel /ɑ/ (f1=-758, f2-f1=-649) in 15AK57MC. The vowel /ɔ/ (f1=-549, f2-f1=-368) in 27BD57MR is higher than vowel /ɔ/ (f1=-695, f2-f1=-363) in 15AK57MC. The vowel /o/ (f1=-440, f2-f1=-831) in 27BD57MR is more fronted than vowel /o/ (f1=-450, f2-f1=-592) in 15AK57MC. The vowel /u/ (f1=-366, f2-f1=-836) in 27BD57MR is highly fronted in comparison with vowel /u/ (f1=-390, f2-f1=-289) in 15AK57MC. The area of the acoustic space chart for 27BD57MR is 352108 and for 15AK57MC is 278398.5, and 96MEANMR is 336881. The area of 27BD57MR is 26% bigger than that of the individual control and 5% larger than the mean of RHD participants.

3.5.7. CASE STUDY 7

PRIMARY INFO

Codified Name: 28DM35MR.

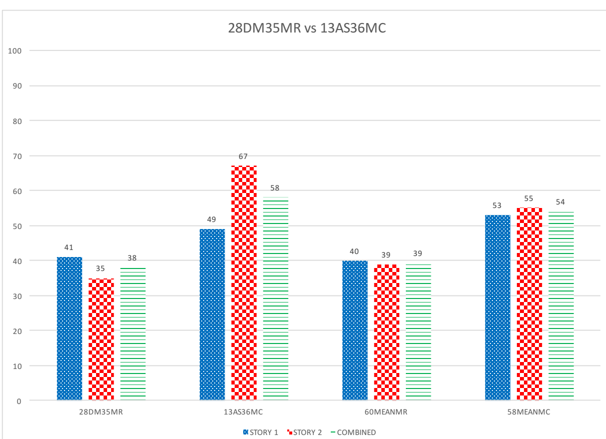
Male, 35 years of age, at the time of recording and case study.

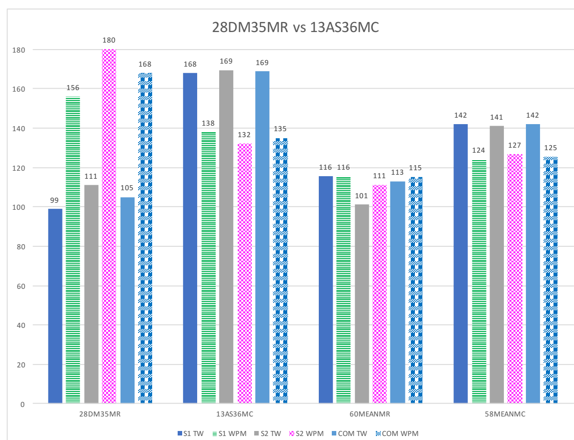
Age and gender matched control: 13AS36MC
Time since incidence: approximately 6 months back, at the time of recording.

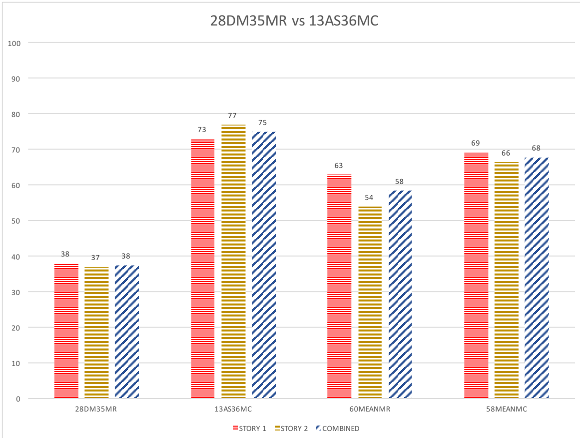
PARTICIPANT INFORMATION

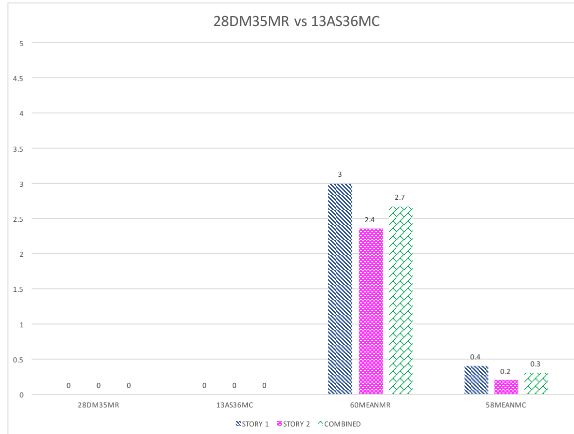
Condition of participant: The participant was fully conscious, having scored 15 on the GCS. He also scored 29 on the MMSE. The participant can walk without problems, but initially after the stroke happened, he lost all control of his left leg. The stroke, as told by the doctor, happened while he was at a morning walk. The doctor asked him to do some actions with his hands, involving muscle coordination and he could do it with ease. The participant could also perform actions based on instructions, which involved complicated and elaborate instructions. The speech of the participant was not slurred and was easily to understand. The participant did not display any left hemisphere neglect and his color recognition was perfect. The doctor also performed a test in which he held both of the participant's hands in his hands and then asked the participant to keep holding them where he is holding them, after he lets them go. He could maintain the position of both the hands. The participant had no issues in remembering things. He is undergoing no physiotherapy. **Observations made by doctor:** The doctor mentions that he has no agraphia, no dementia, and no alexia. Participant is highly hypertensive. Participant is not an alcoholic or a smoker. Participant has no problems in planning and judgement. **Diagnosis made by doctor:** The doctor mentions that the participant has almost no chances of suffering another stroke. He was asked to continue medicines for blood pressure and to follow up in three months. **Region of damage: Right vertebral artery blockage**, at the time of stroke. Infarct in **right internal capsule** and old infarctions in **right basal ganglia**. **M carotid artery blockage**. Lesions in T2

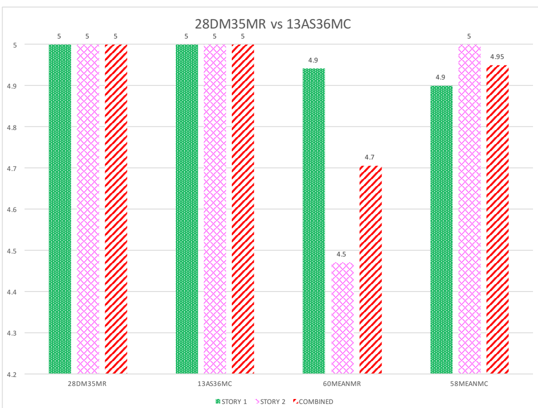
COMPREHENSIVE STUDY OF PARTICIPANT AT THE 3 LEVELS OF COMMUNICATION











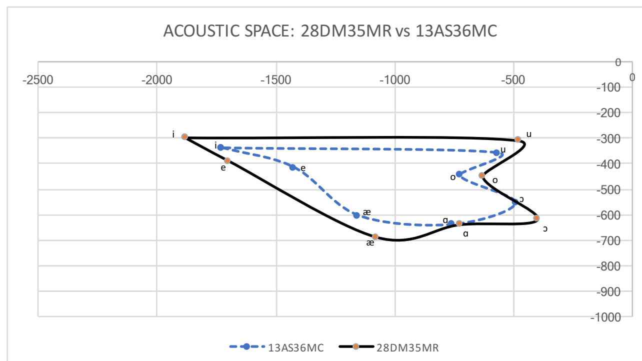
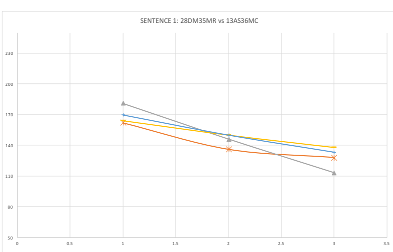
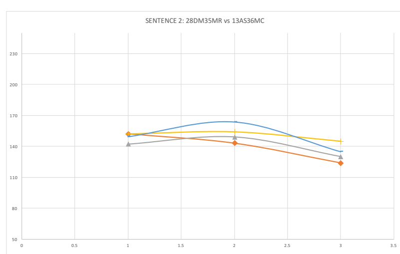
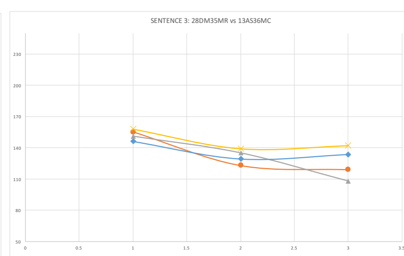
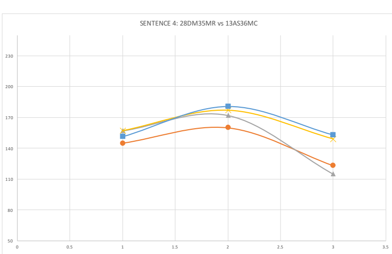


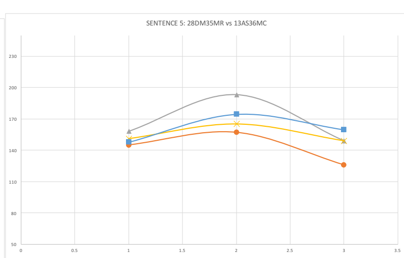
Fig 3.146 to 3.151: 28DM35MR - The bar graphs are comparisons at the level of discourse. The last diagram is an acoustic space.

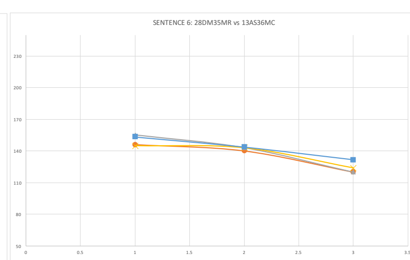












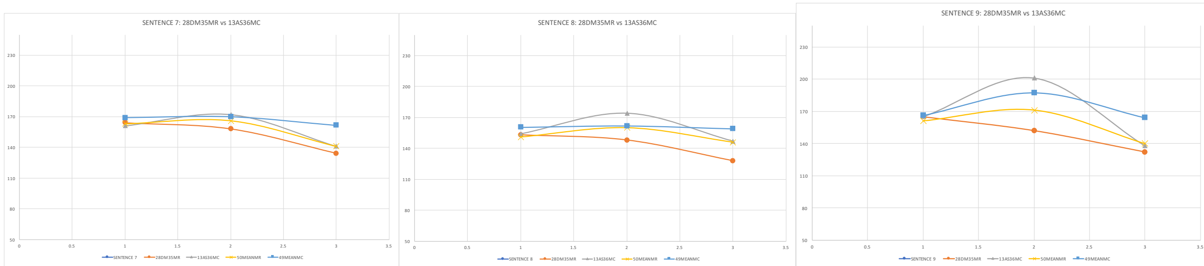


Fig 3.152 to 3.160: 28DM35MR - First three diagrams in first line are declarative sentences. The next line is composed of 3 imperative sentences and the third line has three interrogative sentences.

A. Discourse

1. Pitch range

We can observe the following from fig 3.146: 28DM35MR has a pitch range of 41 Hz in the first story in comparison with 13AS36MC, who has a pitch range of 49 Hz. 60MEANMR has a pitch range of 40 Hz in the first story while 58MEANMC has a pitch range of 53 Hz in the first story. 28DM35MR has a pitch range of 35 Hz in the second story in comparison with 13AS36MC, who has a pitch range of 67 Hz. 60MEANMR has a pitch range of 39 Hz in the first story while 58MEANMC has a pitch range of 55 Hz in the second story. 28DM35MR has a pitch range of 38 Hz in the mean of the stories in comparison with 13AS36MC, who has a pitch range of 58 Hz, which is significant. The difference in pitch range is significant. 60MEANMR has a pitch range of 39 Hz in the mean of the two stories while 58MEANMC has a pitch range of 54 Hz in the same.

2. **Fluency**

We can observe the following from fig 3.147: 28DM35MR has 99 words in story 1 in comparison with 13AS36MC, who has 168 words, which is a huge difference. 28DM35MR has a word rate of 156 wpm in story 1 in comparison with 13AS36MC, who has 138 wpm. 28DM35MR has 111 words in story 2 in comparison with 13AS36MC, who has 169 words. 28DM35MR has a word rate of 180 wpm in story 2 in comparison with 13AS36MC, who has 132 wpm. 28DM35MR has 105 words in the combined mean of the two stories in comparison with 13AS36MC, who has 169 words. 28DM35MR has a word rate of 168 wpm in the combined mean of the two stories in comparison with 13AS36MC, who has 135 wpm. The RHD participant has a higher fluency rate than the control participant but has much lesser total word count in both the stories, because he spoke for a much shorter amount of time.

3. **Duration**

We can observe the following from fig 3.148: 28DM35MR took 42 seconds (fluency – 156 words per minute) to complete narrating the first story in comparison with 13AS36MC, who took 71 seconds (fluency – 138 words per minute). 28DM35MR took 71 seconds (fluency – 180 words per minute) to complete narrating the second story in comparison with 13AS36MC, who took 64 seconds (fluency – 132 words per minute). 28DM35MR has a mean duration of 38 seconds (fluency – 168 words per minute) whereas, 13AS36MC has a mean of 68 seconds (fluency – 135 words per minute). We can see that 28DM35MR has taken lesser time than 13AS36MC in both the stories. The participant was speaking in a hurry. 28DM35MR also completed the stories faster than 58MEANMC with a duration of 68 seconds (fluency – 125 words per minute) and 60MEANMR with a duration of 58 seconds (fluency – 113 words per minute), in the mean of the two stories.

4. Digressions and lapses

Story 1 (Narrator)	RHD participant	Control participant
There was a deer. It was standing at the edge of the river. It saw its majestic antlers in the river, as a reflection. It kept praising it. Next it saw its feet and started to demean it because it was thin and did not match the overall beauty of the whole body. In the meantime, a hunter shot an arrow but missed. The deer started running in fear but ultimately got caught by the antlers in a bushy area. He exclaimed that the antlers he was praising put him in utter danger but his legs he was demeaning, tried to help him run that far.	There was a deer at the river bank. It was drinking water and looking at its reflection. It praised its antlers and then suddenly spotted its thin legs and insulted them. In the meantime, a hunter noticed the deer and shot an arrow. The arrow didn't touch but the deer started to run in fear. Unfortunately, the antlers got stuck in a bush and the deer was caught. The deer understood that the antlers didn't deserve the praise, but the legs did.	A deer went to drink water at a river side. It noticed its reflection and saw its antlers first. It praised its antlers and felt good. After that it saw its thin legs and felt bad, demeaned it. In the meantime, a hunter shot an arrow which missed but the deer started to run. Unfortunately, the deer got stuck in a hedge. Then it realized that the antler which it was praising, got it caught but the legs it was demeaning actually tried to run, to help it.

Story 2 (Narrator)	RHD participant	Control participant
Thousands of frogs lived in a small pond. They were happy but they wanted a king. So, they prayed to God for a king. God sent a big tree trunk to them. At first, they were intimidated by its size but soon they discovered, their new king did not move and did not	There was a small pond and there were many frogs in it. The frogs were sad and they wanted a king. They prayed to God asking for a king. God sent a big tree bark to the small pond. The frogs at first didn't realize this but as time passed, they realized that the	Many frogs lived in a small pond an they were happy. Suddenly they thought that they needed a king and prayed to God for a king. God sent them a big bark of tree. At first the frogs touched it and then realized the king didn't move. Eventually a brave frog

talk. One brave frog climbed to the top of the trunk and after that many others gathered the courage and climbed to the top. They were unhappy and they prayed to God again stating that the king they were sent was inanimate and they want a new king who would be alive and actually rule over them. God got a bit angry. He sent a stork to the pond and the stork ate up all the frogs.	king didn't move at all. Eventually a brave frog climbed on the king and others followed him. They prayed to God again for a new king, who would actually rule over them. God was angry at this and sent a stork. The stork then started eating all the frogs one by one.	climbed the king and others followed. They realized it was not a proper king and they prayed to God again for a king who would actually rule them. God was angry and sent a stork to their place. The stork started to eat all the frogs one by one.

We can see no digressions in story 1 for the RHD participant or in story 2. The control participant on the other hand had no digressions in both the stories. There were no lapses in the narration of the control participant as well, in both the stories.

5. **Questions answered**

STORY 1				
	Questions	Actual answer	RHD participant	Control participant
1	Which animal(s) were mentioned in the story?	A deer	A deer	A deer
2	What was the deer doing?	Looking at his reflection	Looking at its reflection	Looking at his reflection
3	Why did the deer run?	A hunter shot an arrow but it didn't touch	A hunter followed it	A hunter shot an arrow. The deer ran for its life.
4	Why was he caught?	His big antlers were caught in a bush	Antlers	His big antlers were caught in a bush
5	What was the deer insulting, in the beginning?	His thin legs, that don't match his antlers and body.	The legs	His thin legs, that don't match his antlers and body.

STORY 2				
	Questions	Actual answer	RHD participant	Control participant
1	Which animal(s) were mentioned in the story?	Frogs, stork	Frogs and a stork in the end	Frogs, stork
2	Where did the frogs live?	In a small pond	In a marshy and small pond	In a small pond
3	What did the frogs want the first time?	A king	A king	A king
4	What did the frogs want the second time?	A king who would actually be alive and rule over them	A king who would actually rule over them	A king who would actually be alive and rule over them
5	Why did all the frogs die?	The stork ate them all	The stork killed them all	The stork ate them all

We can observe the following from fig 3.150: 28DM35MR has been able to answer all 5 questions in the first story and the second story. The control participant answered all questions, as well as the mean of the control group 58MEANMC and the mean of the RHD group 60MEANFR.

B. SENTENCES

Declaratives

Fig 3.152 – 3.154. We can observe the following from the figure displayed previously: In sentence 1, 28DM35MR, 13AS36MC, 50MEANMR and 49MEANMC, all have recorded curves belonging to the type C. In sentence 2 28DM35MR has recorded a type C curve again, in comparison with 13AS36MC, 50MEANMR and 49MEANMC, who have recorded curves belonging to the type D. 49MEANMC recorded at a pitch range which is much higher than the mean of the RHD group 50MEANMR. In sentence 3, 28DM35MR has a type C curve in comparison with 13AS36MC who has a much steeper gradient for the same type C sentence. 50MEANMR and 49MEANMC have recorded type B sentences.

Imperatives

Fig 3.155 – 3.157. We can observe the following from the figure displayed previously: In sentence 4, 28DM35MR, 13AS36MC, 50MEANMR and 49MEANMC have all made type D sentences. In sentence 5, 28DM35MR, 13AS36MC, 50MEANMR and 49MEANMC all have type D sentences. In a type D sentence, the highest pitch point in a sentence is in the middle. In sentence 6, 28DM35MR, 13AS36MC, 50MEANMR and 49MEANMC all have type C sentences.

Interrogatives

Fig 3.158 – 3.160. We can observe the following from the figure displayed previously: In sentence 7, 28DM35MR has a C type sentence in comparison with 13AS36MC, who has a type D sentences. 50MEANMR and 49MEANMC also have recorded type D sentences. In sentence 8, 28DM35MR has made a type C sentence in comparison with 13AS36MC, who has made a type D sentence. 50MEANMR also has a type D sentence and from the chart 49MEANMC has no visible contour, but on checking the figures, 49MEANMC has made a type D sentence as well. In sentence 9, 28DM35MR has a type C curve in comparison with 13AS36MC, 50MEANMR and 49MEANMC who have type D sentences.

C. Vowels

Fig 3.151 compares female RHD participant 28DM35MR with the individual age and gender matched male, that is 13AS36MC. We can observe the following from the figure displayed previously: The vowel /i/ (f1=-298, f2-f1=-1881) in 28DM35MR is more fronted than vowel /i/ (f1=-340, f2-f1=-1725) in 13AS36MC. The vowel /e/ (f1=-390, f2-f1=-1697) in 28DM35MR is a lot more fronted and slightly higher than vowel /e/ (f1=-416, f2-f1=-1423) in 13AS36MC. The vowel /æ/ (f1=-689, f2-f1=-1077) in 28DM35MR is lower and backed in comparison vowel with vowel /æ/ (f1=-604, f2-f1=-1154) in 13AS36MC. The vowel /ɑ/ (f1=-640, f2-f1=-726) in 28DM35MR is almost at the same place as vowel /ɑ/ (f1=-639, f2-f1=-759) in 13AS36MC. The vowel /ɔ/ (f1=-619, f2-f1=-397) in 28DM35MR is more lower and backed than vowel /ɔ/ (f1=-555, f2-f1=-492) in 13AS36MC. The vowel /o/ (f1=-451, f2-f1=-629) in 28DM35MR is more fronted than vowel /o/ (f1=-447, f2-f1=-727) in 13AS36MC. The vowel /u/ (f1=-310, f2-f1=-478) in 28DM35MR is higher and slightly backed in comparison with vowel /u/ (f1=-359, f2-f1=-567) in 13AS36MC. The area of the acoustic space chart for 28DM35MR is 344954 and for 13AS36MC is 198261.5, and 96MEANMR is 336881. The area of 28DM35MR is 74% bigger than that of the individual control and 2% larger than the mean of RHD participants. The area of the RHD participant is significantly larger than the acoustic space area of the control. The RHD participant has a bigger acoustic space area, hence has more tongue movement in the front and back, as can be discerned from the chart.

3.5.8. Case Study 8

Primary info

Codified Name: 29DS55MR.

Male, 55 years of age, at the time of recording and case study.

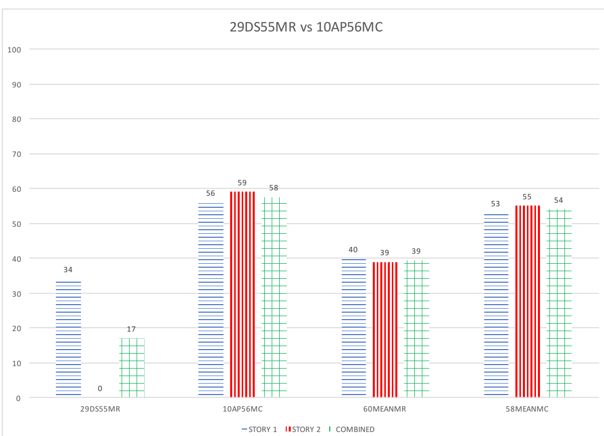
Age and gender matched control: 10AP56MC
Time since incidence: approximately 2 months back, at the time of recording.

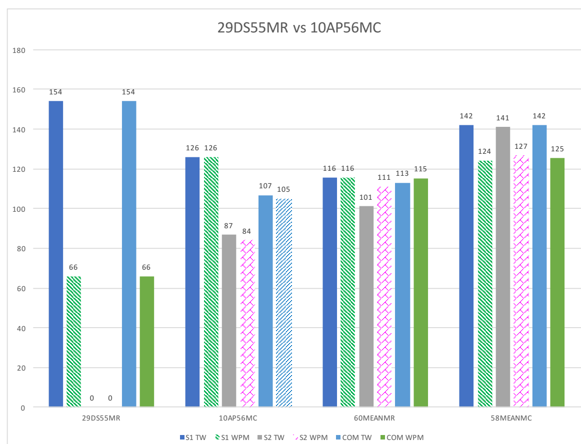
Participant information

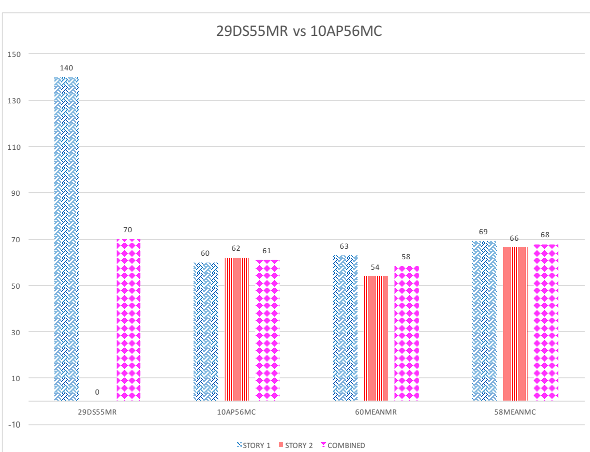
Condition of participant: The participant was fully conscious, having scored 12 on the GCS. He also scored 24 on the MMSE. The participant could walk only with the help of walking aids. The doctor asked him to do some actions with his hands, involving muscle coordination and he could do it but complained of pain in the left hand, while doing it. The participant could also perform actions based on instructions, which involved complicated and elaborate instructions.

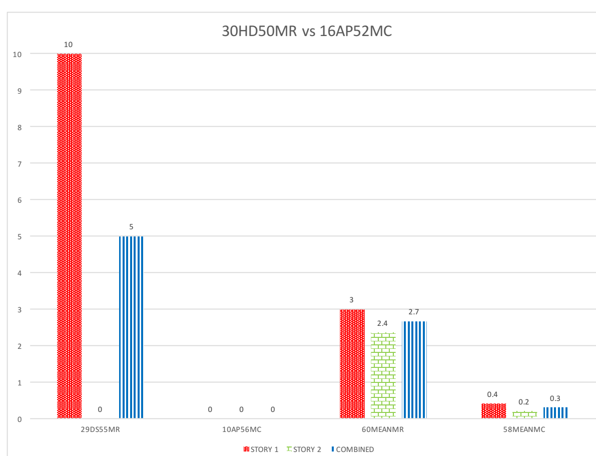
The speech of the participant was slurred and was not easy to understand. It required the help of the family members. The participant displayed left hemisphere neglect. His color recognition was perfect. The doctor also performed a test in which he held both of the participant's hands in his hands and then asked the participant to keep holding them where he is holding them, after he lets them go. He could not maintain the position of the left hand. The participant had issues in remembering things. He is undergoing no physiotherapy due to the poor financial condition of his family. **Observations made by doctor:** The doctor mentions that he has agraphia, mild dementia, and alexia. Participant is highly hypertensive. Participant is an alcoholic and a smoker. Participant has problems in planning and judgement. **Diagnosis made by doctor:** The doctor mentions that even if the participant might suffer another stroke if he cannot bring down his tension levels. He was asked to continue medicines for blood pressure and to follow up in two months. **Region of damage: <u>Right basal ganglia paraventricular</u>**. Acute or early subacute infarct. Cerebral atrophy with focal areas of ischemic gliotic changes.

<u>COMPREHENSIVE STUDY OF PARTICIPANT AT THE 3 LEVELS OF COMMUNICATION</u>









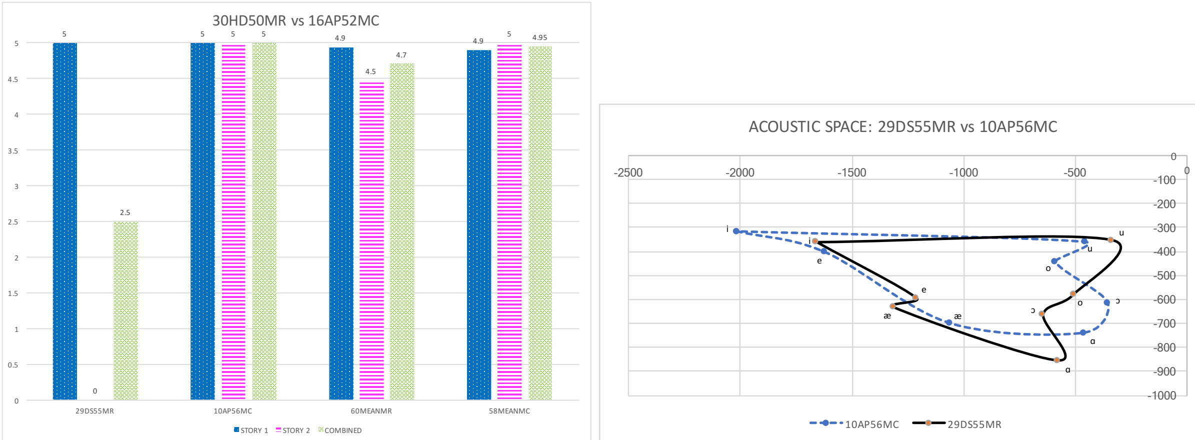


Fig 3.161 to 3.166: 29DS55MR - The bar graphs are comparisons at the level of discourse. The last diagram is an acoustic space.

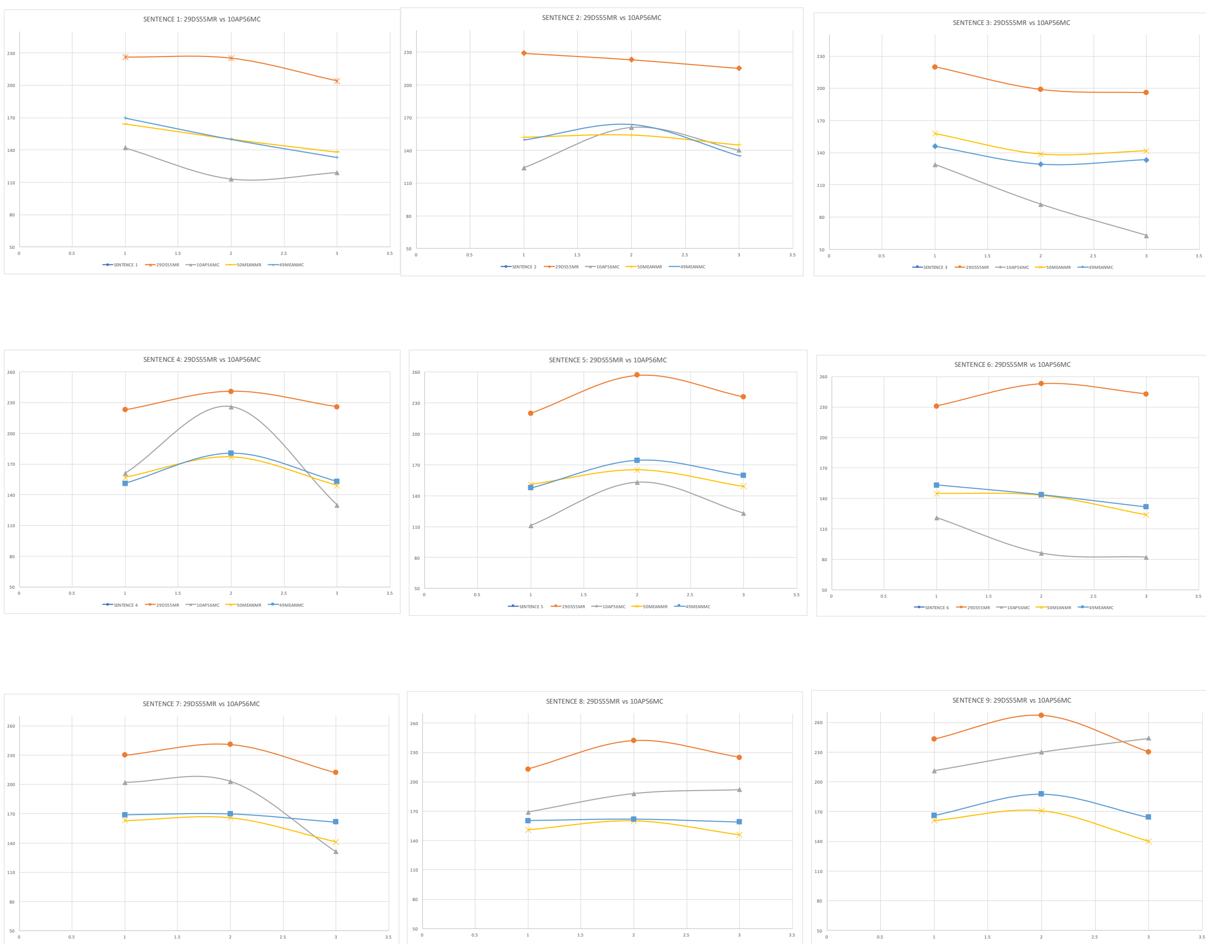


Fig 3.167 to 3.175: 29DS55MR - First three diagrams in first line are declarative sentences. The next line is composed of 3 imperative sentences and the third line has three interrogative sentences.

A. DISCOURSE

1. Pitch range

We can observe the following from fig 3.161: 29DS55MR has a pitch range of 34 Hz in the first story in comparison with 10AP56MC, who has a pitch range of 56 Hz, which is significant. 60MEANMR has a pitch range of 40 Hz in the first story while 58MEANMC has a pitch range of 53 Hz in the first story. 29DS55MR has not recorded the second story in comparison with 10AP56MC, who has a pitch range of 59 Hz. 60MEANMR has a pitch range of 39 Hz in the second story while 58MEANMC has a pitch range of 55 Hz in the second story. 10AP56MC, has a pitch range of 34 Hz (same as story 1, because story 2 was not recorded) in the mean of the two stories and 10AP56MC has a mean of 58 Hz. The difference is significant. 60MEANMR has a pitch range of 39 Hz in the mean of the two stories while 58MEANMC has a pitch range of 54 Hz in the same.

2. Fluency

We can observe the following from fig 3.162: 29DS55MR has 154 words in story 1 in comparison with 10AP56MC, who has 126 words. 29DS55MR has a word rate of 66 wpm in story 1 in comparison with 10AP56MC, who has 126 wpm. The RHD participant has a higher fluency rate than the control participant but has much lesser total word count in both the stories, because he spoke for a much shorter amount of time.

3. Duration

We can observe the following from fig 3.163: 29DS55MR took 140 seconds (fluency – 66 words per minute) to complete narrating the first story in comparison with 10AP56MC, who took 60 seconds (fluency – 126 words per minute). 29DS55MR could not narrate the second story without the help of the narrator, from the very beginning, hence has no time, in comparison with 10AP56MC, who took 62 seconds (fluency – 84 words per minute). 10AP56MC has a mean of 61 seconds (fluency – 105 words per minute). We can see that 29DS55MR took much more time than 10AP56MC in the first story. 58MEANMC took a time of 68 seconds (fluency – 125 words per minute) and 60MEANMR took 58 seconds (fluency – 113 words per minute), in the mean of the two stories.

4. Digressions and lapses

Story 1 (Narrator)	RHD participant	Control participant
There was a deer. It was standing at the edge of the river. It saw its majestic	<u>Deer saw his legs and told they were thin.</u> Deer	One day a deer went to drink water at a river. It saw its

antlers in the river, as a reflection. It kept praising it. Next it saw its feet and started to demean it because it was thin and did not match the overall beauty of the whole body. In the meantime, a hunter shot an arrow but missed. The deer started running in fear but ultimately got caught by the antlers in a bushy area. He exclaimed that the antlers he was praising put him in utter danger but his legs he was demeaning, tried to help him run that far.	looked at water and saw reflection. He looked at his legs first and told they were thin. The deer saw his antlers then in the river. Then an antler came and shot an arrow. The antler fled. The deer sang a song. A hunter came and shot an arrow. Deer fled. An antler came and sang a song.	reflection in the water. It felt ashamed for its legs which were thin and didn't match the beautiful antlers and the body. In the meantime, a hunter shot an arrow at the deer and the deer started to run. Unfortunately, the deer got caught by the antlers in a hedge. It realized that what it was feeling ashamed of, the legs, were what tries to help it; while the beautiful antlers just pushed it towards impending death.

Story 2 (Narrator)	RHD participant	Control participant
Thousands of frogs lived in a small pond. They were happy but they wanted a king. So, they prayed to God for a king. God sent a big tree trunk to them. At first, they were intimidated by its size but soon they discovered, their new king did not move and did not talk. One brave frog climbed to the top of the trunk and after that many others gathered the courage and climbed to the top. They were unhappy and they prayed to God again stating that the king they were sent was inanimate and they want a new king who would be alive and actually rule over them. God got a bit angry. He sent a stork to the pond and the stork ate up all the frogs.	Could not record.	In a small pond, lived innumerous frogs. One day they thought that they wanted a king. They prayed to God for the same and God sent a tree bark to the pond. The frogs looked at it and felt it but the king didn't move. They didn't like it. They prayed to God for another king, who would actually rule over them. God got irritated at this. God sent a stork to the small pond and then started eating all the frogs one by one. The frogs realized it was too late for them and what had happened, could not be avoided.

We can see innumerous digressions in story 1 and 2 for the RHD participant as well as major lapses in the reproduction and chronology of the story. The control participant on the other hand had no digressions in both the stories. There were no lapses in the narration of the control participant as well, in both the stories.

5. **Questions answered**

STORY 1				
	Questions	Actual answer	RHD participant	Control participant
1	Which animal(s) were mentioned in the story?	A deer	A deer	A deer
2	What was the deer doing?	Looking at his reflection	Looking at its reflection	Looking at his reflection

3	Why did the deer run?	A hunter shot an arrow but it didn't touch	A hunter followed it	A hunter shot an arrow. The deer ran for its life.
4	Why was he caught?	His big antlers were caught in a bush	Antlers	His big antlers were caught in a bush
5	What was the deer insulting, in the beginning?	His thin legs, that don't match his antlers and body.	The legs	His thin legs, that don't match his antlers and body.

STORY 2				
	Questions	Actual answer	RHD participant	Control participant
1	Which animal(s) were mentioned in the story?	Frogs, stork		Frogs, stork
2	Where did the frogs live?	In a small pond		In a small pond
3	What did the frogs want the first time?	A king		A king
4	What did the frogs want the second time?	A king who would actually be alive and rule over them		A king who would actually be alive and rule over them
5	Why did all the frogs die?	The stork ate them all		The stork ate them all

We can observe the following from fig 3.165: 29DS55MR has been able to answer all 5 questions in the first story. 29DS55MR couldn't answer any questions from the second story and could not remember any facts from the second story, at all. The control participant answered all questions, as well as the mean of the control group 58MEANMC and the mean of the RHD group 60MEANFR.

B. **SENTENCES**

Declaratives

Fig 3.167 – 3.169. We can observe the following from the figure displayed previously: In sentence 1, 29DS55MR has a type C sentence in comparison with 10AP56MC, who has a type B sentence. 50MEANMR and 49MEANMC have recorded curves belonging to the type C. The type C sentence begins at the highest pitch point, the second point is lower than the starting point and the third point is either equal to or lower than the pitch point in the middle. Type C generally denotes declarative sentences. In sentence 2, 29DS55MR has recorded a type C curve, in comparison with 10AP56MC, who has recorded a type C curve. The RHD participant has an operating range which is higher than the other pitch curves. 50MEANMR and 49MEANMC, have recorded curves belonging to the type D. 49MEANMC recorded at a pitch range which is much higher than the mean of the RHD group 50MEANMR. In sentence 3, 29DS55MR has a type C curve in comparison with 10AP56MC who also has a type C curve. 50MEANMR and 49MEANMC have recorded type B sentences.

Imperatives

Fig 3.170 – 3.172. We can observe the following from the figure displayed previously: In sentence 4, 29DS55MR, 10AP56MC, 50MEANMR and 49MEANMC have all made type D sentences. In sentence 5, 29DS55MR, 10AP56MC, 50MEANMR and 49MEANMC all have type D sentences. In a type D sentence, the highest pitch point in a sentence is in the middle. In sentence 6, 29DS55MR has a type D curve and 10AP56MC, 50MEANMR and 49MEANMC have type C sentences. 29DS55MR has an operating pitch range which is higher than the other pitch curves.

Interrogatives

Fig 3.173 – 3.175. We can observe the following from the figure displayed previously: In sentence 7, 29DS55MR has a D type sentence in comparison with 10AP56MC, who also has a type D sentences. 50MEANMR and 49MEANMC also have recorded type D sentences. In sentence 8, 29DS55MR has made a type D sentence in comparison with 10AP56MC, who has made a type A sentence. 50MEANMR also has a type D sentence and from the chart 49MEANMC has no visible contour, but on checking the figures, 49MEANMC has made a type D sentence as well. In sentence 9, 29DS55MR has a type D curve in comparison with 10AP56MC, who has a type A sentence. 50MEANMR and 49MEANMC have type D sentences. Once again, we notice that 29DS55MR has an operating pitch range which is higher than the other pitch curves.

C. **VOWELS**

Fig 3.166 compares female RHD participant 29DS55MR with the individual age and gender matched male, that is 15AK57MC. We can observe the following from the figure displayed previously: The vowel /i/ (f1=-363, f2-f1=-1659) in 29DS55MR is more fronted than vowel /i/ (f1=-318, f2-f1=-2014) in 10AP56MC. The vowel /e/ (f1=-596, f2-f1=-1212) in 29DS55MR is a lot more fronted and slightly higher than vowel /e/ (f1=-404, f2-f1=-1620) in 10AP56MC. The vowel /æ/ (f1=-634, f2-f1=-1313) in 29DS55MR is lower and slightly fronted in comparison vowel with vowel /æ/ (f1=-699, f2-f1=-1063) in 10AP56MC. The vowel /ɑ/ (f1=-854, f2-f1=-579) in 29DS55MR is lower and more backed in comparison with vowel /ɑ/ (f1=-739, f2-f1=-460) in 10AP56MC. The vowel /ɔ/ (f1=-663, f2-f1=-645) in 29DS55MR is lower and backed than vowel /ɔ/ (f1=-614, f2-f1=-356) in 10AP56MC. The vowel /o/ (f1=-579, f2-

f1=-508) in 29DS55MR is lower and more backed than vowel /o/ (f1=-443, f2-f1=-590) in 10AP56MC. The vowel /u/ (f1=-354, f2-f1=-339) in 29DS55MR is more backed in comparison with vowel /u/ (f1=-362, f2-f1=-458) in 10AP56MC. The area of the acoustic space chart for 29DS55MR is 338952 and for 10AP56MC is 353753.5, and 96MEANMR is 336881, making the area 96% of the individual control and 101 % of the mean, or in other words, the area of 29DS55MR is 4% smaller than that of the individual control and 1% larger than the mean of RHD participants. The area of the RHD participant is significantly smaller than the acoustic space area of the control participant. The RHD participant has lesser front and back movement of the tongue in comparison with the control participant.

3.5.9. CASE STUDY 9

PRIMARY INFO

Codified Name: 30HD50MR.

Male, 50 years of age, at the time of recording and case study.

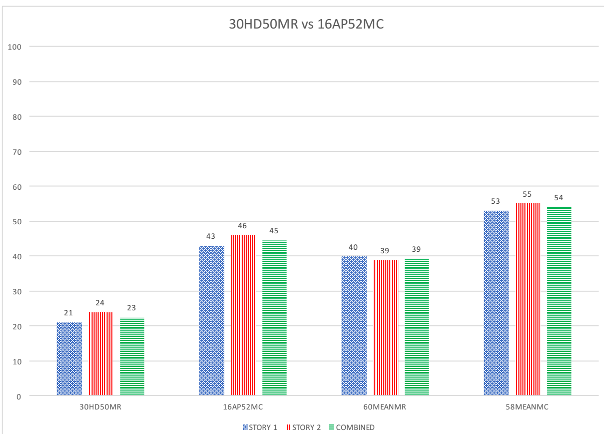
Age and gender matched control: 16AP52MC
Time since incidence: approximately 6 months back, at the time of recording.

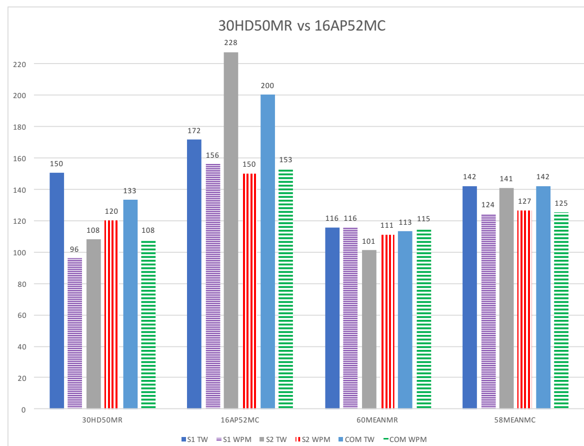
PARTICIPANT INFORMATION

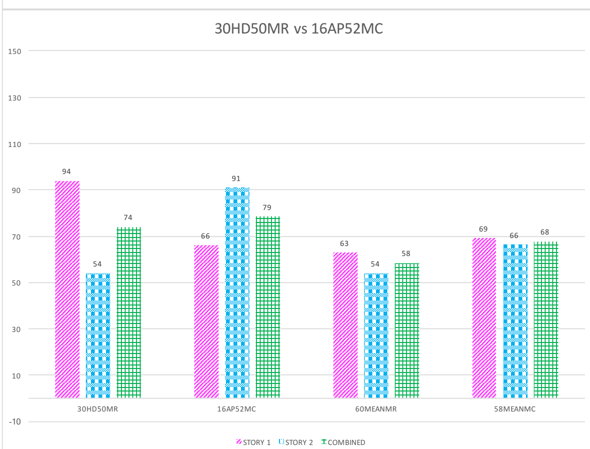
Condition of participant: The participant was fully conscious, having scored 11 on the GCS. He also scored 24 on the MMSE. The participant can walk without problems, but initially after the stroke happened, he had extreme pain in the left side of the body. It was also alleged that the stroke happened to him while he was working on some instruments. The doctor asked him to do some actions with his hands, involving muscle coordination and he could do it with ease. The participant could also perform actions based on instructions, which involved complicated and elaborate instructions. The speech of the participant was not slurred and was easy to understand. The participant did not display any left hemisphere neglect and his color recognition was perfect. The doctor also performed a test in which he held both of the participant's hands in his hands and then asked the participant to keep holding them where he is holding them, after he lets them go. He could maintain the position of both the hands.

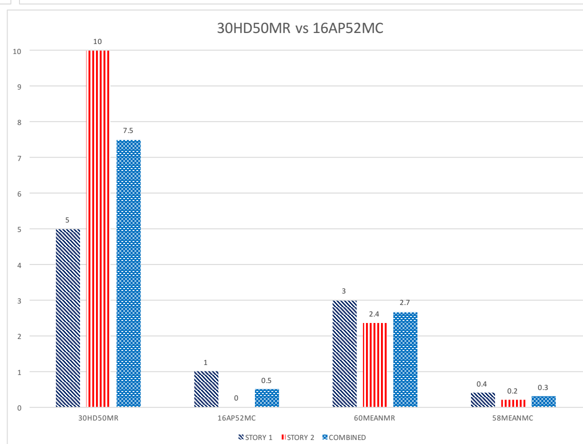
The participant had issues in remembering things. The doctor mentioned that he has problems with the short-term memory, probably due to lack of concentration. He is undergoing no physiotherapy. **Observations made by doctor:** The doctor mentions that he has no agraphia, no dementia, and no alexia. Participant is highly hypertensive and also displayed problems in concentration. The participant has problems in focusing on things. Participant is not an alcoholic or a smoker. Participant has no problems in planning and judgement. **Diagnosis made by doctor:** The doctor mentions that even if the participant is out of the danger zone, he might suffer another stroke if he cannot bring down his hypertension. He was asked to continue medicines for blood pressure and to follow up in six months. **Region of damage:** Infarcts in the **right thalamus**, **right insular cortex** with Fazekas grade 2 white matter lesions in **right centrum semiovale** and **tiny lacunar infarcts in the right**.

COMPREHENSIVE STUDY OF PARTICIPANT AT THE 3 LEVELS OF COMMUNICATION









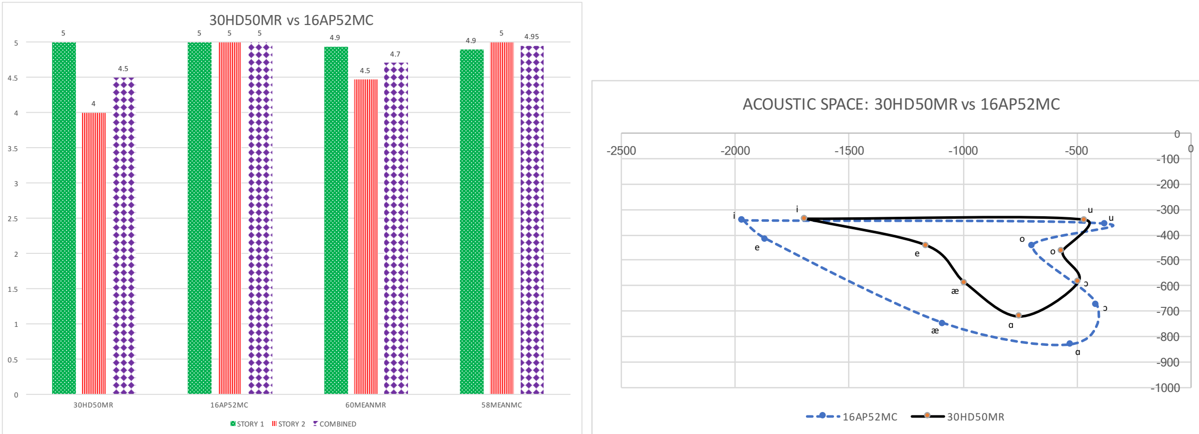


Fig 3.176 to 3.181: 30HD50MR - The bar graphs are comparisons at the level of discourse. The last diagram is an acoustic space.

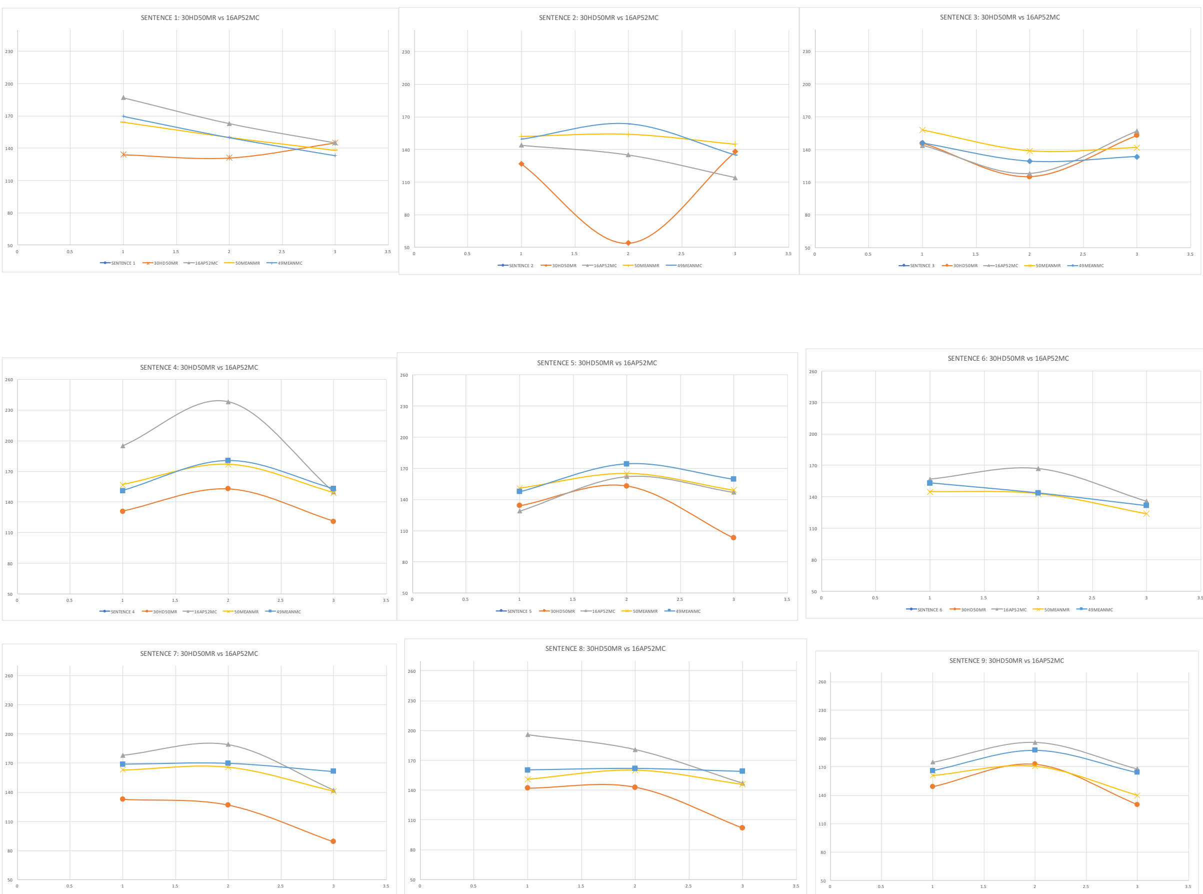


Fig 3.182 to 3.190: 30HD50MR - First three diagrams in first line are declarative sentences. The next line is composed of 3 imperative sentences and the third line has three interrogative sentences.

A. Discourse

1. Pitch range

We can observe the following from fig 4.176: 30HD50MR has a pitch range of 21 Hz in the first story in comparison with 16AP52MC, who has a pitch range of 43 Hz. The difference is significant. 60MEANMR has a pitch range of 40 Hz in the first story while 58MEANMC has a pitch range of 53 Hz in the first story. 30HD50MR has a pitch range of 24 Hz in the second story in comparison with 16AP52MC, who has a pitch range of 46 Hz. The difference here is significant again. 60MEANMR has a pitch range of 39 Hz in the second story while 58MEANMC has a pitch range of 55 Hz in the second story. 30HD50MR has a pitch range of 23 in the mean of both the stories in comparison with 16AP52MC, who has a pitch range of 45 Hz. 60MEANMR has a pitch range of 39 Hz in the mean of the two stories while 58MEANMC has a pitch range of 54 Hz in the same. The RHD participant has much lesser pitch range than the normal control.

2. **Fluency**

We can observe the following from fig 3.177: 30HD50MR has 150 words in story 1 in comparison with 16AP52MC, who has 172 words, which is a small difference. 30HD50MR has a word rate of 96 wpm in story 1 in comparison with 16AP52MC, who has 156 wpm. 30HD50MR has 108 words in story 2 in comparison with 16AP52MC, who has 228 words. 30HD50MR has a word rate of 120 wpm in story 2 in comparison with 16AP52MC, who has 150 wpm. 30HD50MR has 133 words in the combined mean of the two stories in comparison with 16AP52MC, who has 200 words. 30HD50MR has a word rate of 108 wpm in the combined mean of the two stories in comparison with 16AP52MC, who has 153 wpm. The RHD participant has a total word count in the first story but has low fluency figures, even lower than the RHD mean. In the second story and the combined mean, the RHD participant compares up to the RHD mean.

3. **Duration**

We can observe the following from fig 3.178: 30HD50MR took 94 seconds (fluency – 66 words per minute) to complete narrating the first story in comparison with 16AP52MC, who took 66 seconds (fluency – 126 words per minute). 30HD50MR could not narrate the second story without the help of the narrator, from the very beginning, and took 54 seconds, in comparison with 16AP52MC, who took 91 seconds (fluency – 84 words per minute). 30HD50MR has a mean duration of 74 seconds in comparison with 16AP52MC, who has a mean of 79 seconds (fluency – 105 words per minute). We can see that 30HD50MR has much more time than 16AP52MC in the first story. The participant was speaking in a hurry. 58MEANMC took a time of 68 seconds (fluency – 125 words per minute) and 60MEANMR took 58 seconds (fluency – 113 words per minute), in the mean of the two stories.

4. Digressions and lapses

Story 1 (Narrator)	RHD participant	Control participant
There was a deer. It was standing at the edge of the river. It saw its majestic antlers in the river, as a reflection. It kept praising it. Next it saw its feet and started to demean it because it was thin and did not match the overall beauty of the whole body. In the meantime, a hunter shot an arrow but missed. The deer started running in fear but ultimately got caught by the antlers in a bushy area. He exclaimed that the antlers he was praising put him in utter danger but his legs he was demeaning, tried to help him run that far.	The deer came in front. The deer showed the antler and then showed the legs which were thin. Then the deer looked in the river. A hunter shot an arrow which went past the deer. The deer ran and the antlers got caught. The hunter came and caught it. The deer thought that the legs were bad but they helped. The body was good but the legs were better. The antlers got caught.	One day a deer went to drink water at a river. It saw its reflection in the water. It felt ashamed for its legs which were thin and didn't match the beautiful antlers and the body. In the meantime, a hunter shot an arrow at the deer and the deer started to run. Unfortunately, the deer got caught by the antlers in a hedge. It realized that what it was feeling ashamed of, the legs, were what tries to help it; while the beautiful antlers just pushed it towards impending death.

Story 2 (Narrator)	RHD participant	Control participant
Thousands of frogs lived in a small pond. They were happy but they wanted a king. So, they prayed to God for a king. God sent a big tree trunk to them. At first, they were intimidated by its size but soon they discovered, their new king did not move and did not talk. One brave frog climbed to the top of the trunk and after that many others gathered the courage and climbed to the top. They were unhappy and they prayed to God again stating that the king they were sent was inanimate and they want a new king who would be alive and actually rule over them. God got a bit angry. He sent a stork to the pond and the stork ate up all the frogs.	The frogs lived. The wanted a king. They looked for a king. God sent a stork. Stork ate the king and the frogs.	In a small pond, lived innumerous frogs. One day they thought that they wanted a king. They prayed to God for the same and God sent a tree bark to the pond. The frogs looked at it and felt it but the king didn't move. They didn't like it. They prayed to God for another king, who would actually rule over them. God got irritated at this. God sent a stork to the small pond and then started eating all the frogs one by one. The frogs realized it was too late for them and what had happened, could not be avoided.

We can see innumerous digressions in story 1 and 2 for the RHD participant as well as major lapses in the reproduction and chronology of the story. The control participant on the other hand had no digressions in both the stories. There were no lapses in the narration of the control participant as well, in both the stories.

5. **Questions answered**

	STORY 1			
	Questions	Actual answer	RHD participant	Control participant
1	Which animal(s) were mentioned in the story?	A deer	A deer	A deer
2	What was the deer doing?	Looking at his reflection	Looking at its reflection	Looking at his reflection
3	Why did the deer run?	A hunter shot an arrow but it didn't touch	A hunter followed it	A hunter shot an arrow. The deer ran for its life.
4	Why was he caught?	His big antlers were caught in a bush	Antlers	His big antlers were caught in a bush
5	What was the deer insulting, in the beginning?	His thin legs, that don't match his antlers and body.	The legs	His thin legs, that don't match his antlers and body.

	STORY 2			
	Questions	Actual answer	RHD participant	Control participant
1	Which animal(s) were mentioned in the story?	Frogs, stork	Frogs	Frogs, stork
2	Where did the frogs live?	In a small pond	In a marsh	In a small pond
3	What did the frogs want the first time?	A king	A king	A king
4	What did the frogs want the second time?	A king who would actually be alive and rule over them	<u>**A stork who would eat them**</u>	A king who would actually be alive and rule over them
5	Why did all the frogs die?	The stork ate them all	The stork ate them	The stork ate them all

We can observe the following from fig 3.180: 30HD50MR has been able to answer all 5 questions in the first story. 30HD50MR couldn't answer all questions from the second story as he could not remember the facts. The control participant answered all questions, as well as the mean of the control group 58MEANMC and the mean of the RHD group 60MEANFR.

B. SENTENCES

<u>Declaratives</u>

Fig 3.182 – 3.184. We can observe the following from the figure displayed previously: In sentence 1, 30HD50MR has a type A sentence in comparison with 16AP52MC, 50MEANMR and 49MEANMC, who have recorded curves belonging to the type C. In sentence 2, 30HD50MR has recorded a type B curve, in comparison with 16AP52MC, who has recorded a type C curve. The RHD participant has an operating range which is lower than the other pitch

curves. 50MEANMR and 49MEANMC, have recorded curves belonging to the type D. 49MEANMC recorded at a pitch range which is much higher than the mean of the RHD group 50MEANMR. In sentence 3, 30HD50MR has a type B curve in comparison with 16AP52MC who also has a type B curve. 50MEANMR and 49MEANMC have recorded type B sentences.

Imperatives

Fig 3.185 – 3.187. We can observe the following from the figure displayed previously: In sentence 4, 30HD50MR, 16AP52MC, 50MEANMR and 49MEANMC have all made type D sentences. In sentence 5, 30HD50MR, 16AP52MC, 50MEANMR and 49MEANMC all have type D sentences. In a type D sentence, the highest pitch point in a sentence is in the middle. In sentence 6, 30HD50MR has no pitch curve, as the participant skipped the sentence due to personal reasons and 16AP52MC, 50MEANMR and 49MEANMC have type C sentences. 30HD50MR has an operating pitch range which is lower than the other pitch curves.

Interrogatives

Fig 3.188 – 3.190. We can observe the following from the figure displayed previously: In sentence 7, 30HD50MR has a C type sentence in comparison with 16AP52MC, who has a type D sentences. 50MEANMR and 49MEANMC also have recorded type D sentences. In sentence 8, 30HD50MR has made a type B sentence in comparison with 16AP52MC, who has made a type C sentence. 50MEANMR also has a type D sentence and from the chart 49MEANMC has no visible contour, but on checking the figures, 49MEANMC has made a type D sentence as well. In sentence 9, 30HD50MR has a type D curve in comparison with 16AP52MC, 50MEANMR and 49MEANMC who also have type D sentences. Once again, we notice that 30HD50MR has an operating pitch range which is lower than the other pitch curves.

C. **VOWELS**

Fig 3.181 compares female RHD participant 30HD50MR with the individual age and gender matched male, that is 15AK57MC. We can observe the following from the figure: The vowel /i/ (f1=-298, f2-f1=-1881) in 30HD50MR is more backed than vowel /i/ (f1=-344, f2-f1=-1967) in 16AP52MC. The vowel /e/ (f1=-441, f2-f1=-1161) in 30HD50MR is a lot more backed and slightly lower than vowel /e/ (f1=-416, f2-f1=-1868) in 16AP52MC. The vowel /æ/ (f1=-589, f2-f1=-991) in 30HD50MR is higher and slightly backed in comparison vowel with vowel /æ/ (f1=-747, f2-f1=-1085) in 16AP52MC. The vowel /ɑ/ (f1=-721, f2-f1=-751) in 30HD50MR is higher and more fronted in comparison with vowel /ɑ/ (f1=-829, f2-f1=-525) in 16AP52MC.

The vowel /ɔ/ (f1=-585, f2-f1=-494) in 30HD50MR is higher and fronted than vowel /ɔ/ (f1=-674, f2-f1=-413) in 16AP52MC. The vowel /o/ (f1=-464, f2-f1=-564) in 30HD50MR is lower and more backed than vowel /o/ (f1=-443, f2-f1=-697) in 16AP52MC. The vowel /u/ (f1=-340, f2-f1=-467) in 30HD50MR is more fronted and higher in comparison with vowel /u/ (f1=-357, f2-f1=-377) in 16AP52MC. The area of the acoustic space chart for 30HD50MR is 207043 and for 16AP52MC is 430473.5, and 96MEANMR is 336881. The area of 30HD50MR is 52% smaller than that of the individual control and 39% smaller than the mean of RHD participants. The area of the RHD participant is significantly smaller than the acoustic space area of the control participant. The RHD participant has a much smaller acoustic space area in comparison with the control participant. From the chart, we can discern that the RHD participant has much smaller movement in the high low range and front back range.

3.5.10.CASE STUDY 10

PRIMARY INFO

Codified Name: 31KM80MR.

Male, 80 years of age, at the time of recording and case study.

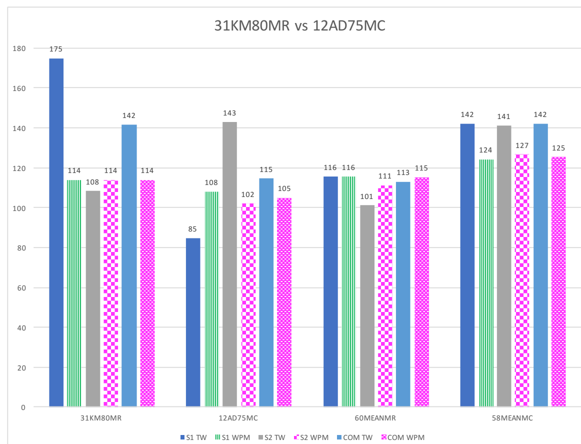
Age and gender matched control: 12AD75MC for the discourse level. 21SD82MC for sentences and vowels.

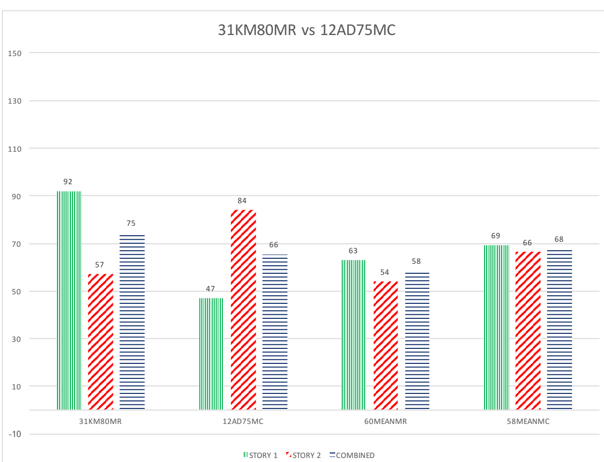
Time since incidence: approximately 4 months back, at the time of recording.

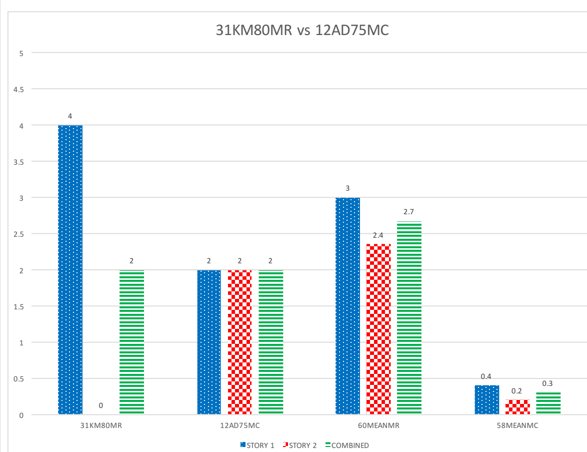
PARTICIPANT INFORMATION

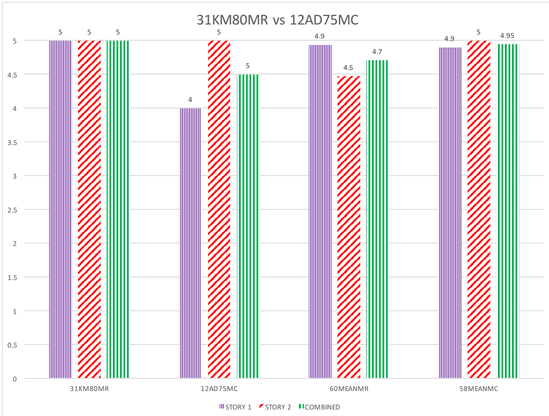
Condition of participant: The participant was fully conscious, having scored 12 on the GCS. He also scored 27 on the MMSE. The participant can walk without problems. The doctor asked him to do some actions with his hands, involving muscle coordination and he could do it with ease. The participant could also perform actions based on instructions, which involved complicated and elaborate instructions. The speech of the participant was slightly slurred and was easily to understand. The participant did not display any left hemisphere neglect. His sense of color recognition is also intact. The doctor also performed a test in which he held both of the participant's hands in his hands and then asked the participant to keep holding them where he is holding them, after he lets them go. He could maintain the position of both the hands. The participant had no issues in remembering things. He is undergoing no physiotherapy. **Observations made by doctor:** The doctor mentions that he has no agraphia, no dementia, and no alexia. Participant is not hypertensive. Participant is not an alcoholic or a smoker. Participant has no problems in planning and judgement. **Diagnosis made by doctor:** The doctor mentions that the participant has chances of suffering another stroke, if his blood pressure rises again. He was asked to continue medicines for blood pressure and to follow up in two months. **Region of damage:** An irregular area with signal characteristics of central encephalomalacia and peripheral gliosis is seen in lateral lobe involving anterior right frontal sylvian region with hemosilisin staining. Associated focal atrophy is noted with widened cortical sulci and frontal horn of right lateral ventricle. Chronic infarction in the territory of superior division of the right middle cerebral artery involving lateral frontal lobe.

COMPREHENSIVE STUDY OF PARTICIPANT AT THE 3 LEVELS OF COMMUNICATION









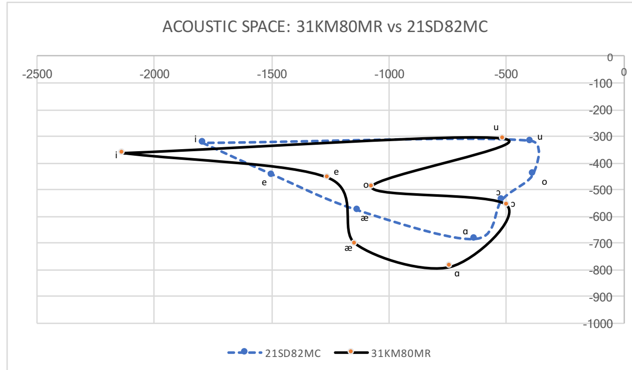


Fig 3.191 to 3.196: 31KM80MR - The bar graphs are comparisons at the level of discourse. The last diagram is an acoustic space.

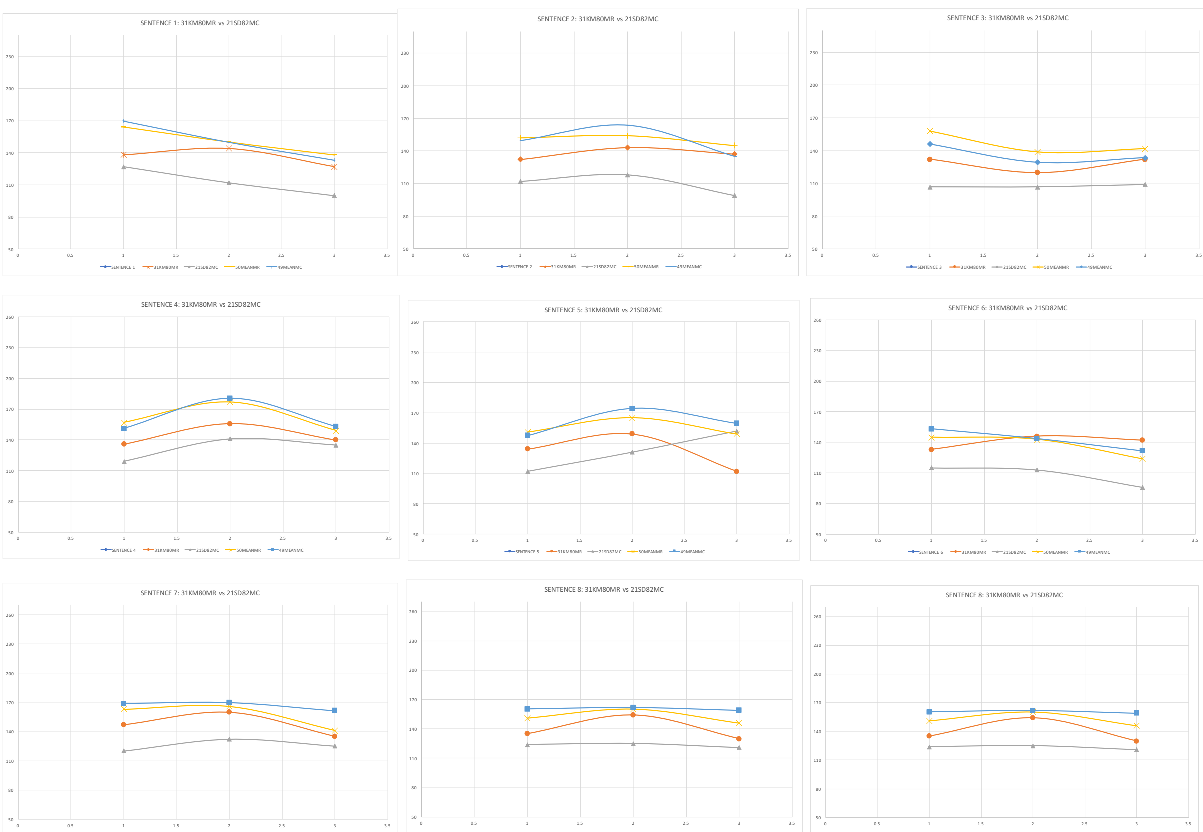


Fig 3.197 to 3.205: 31KM80MR- First three diagrams in first line are declarative sentences. The next line is composed of 3 imperative sentences and the third line has three interrogative sentences.

A. Discourse

1. Pitch range

We can observe the following from fig 3.191: 31KM80MR has a pitch range of 33 Hz in the first story in comparison with 12AD75MC, who has a pitch range of 37 Hz; and the difference is insignificant. 60MEANMR has a pitch range of 40 Hz in the first story while 58MEANMC has a pitch range of 53 Hz in the first story. 31KM80MR has a pitch range of 30 Hz in the second story in comparison with 12AD75MC, who has a pitch range of 48 Hz. The difference is not huge, but still significant. 60MEANMR has a pitch range of 39 Hz in the second story while 58MEANMC has a pitch range of 55 Hz in the second story. 31KM80MR has a pitch range of 32 Hz in the mean of the stories in comparison with 12AD75MC, who has a pitch range of 43 Hz. 60MEANMR has a pitch range of 39 Hz in the mean of the two stories while 58MEANMC has a pitch range of 54 Hz in the same.

2. **Fluency**

We can observe the following from fig 3.192: 31KM80MR has 175 words in story 1 in comparison with 12AD75MC, who has 85 words, which is a huge difference. 31KM80MR has a word rate of 114 wpm in story 1 in comparison with 12AD75MC, who has 108 wpm. 31KM80MR has 108 words in story 2 in comparison with 12AD75MC, who has 143 words. 31KM80MR has a word rate of 114 wpm in story 2 in comparison with 12AD75MC, who has 102 wpm. 31KM80MR has 142 words in the combined mean of the two stories in comparison with 12AD75MC, who has 115 words. 31KM80MR has a word rate of 114 wpm in the combined mean of the two stories in comparison with 12AD75MC, who has 105 wpm. The RHD participant has a higher total word count and fluency rate than the control participant except for story two total words, where the control participant has a better total word count.

3. **Duration**

We can observe the following from fig 3.193: 31KM80MR took 92 seconds (fluency – 114 words per minute) to complete narrating the first story in comparison with 12AD75MC, who took 47 seconds (fluency – 108 words per minute). 31KM80MR took 57 seconds (fluency – 114 words per minute) to complete narrating the second story in comparison with 12AD75MC, who took 84 seconds (fluency – 102 words per minute). 31KM80MR has a mean duration of 75 seconds (fluency – 114 words per minute) whereas, 12AD75MC has a mean of 66 seconds (fluency – 105 words per minute). 58MEANMC took a time of 68 seconds (fluency – 125 words per minute) and 60MEANMR took a time of 58 seconds (fluency – 113 words per minute), in the mean of the two stories.

4. Digressions and lapses

Story 1 (Narrator)	RHD participant	Control participant
There was a deer. It was standing at the edge of the river. It saw its majestic antlers in the river, as a reflection. It kept praising it. Next it saw its feet and started to demean it because it was thin and did not match the overall beauty of the whole body. In the meantime, a hunter shot an arrow but missed. The deer started running in fear but ultimately got caught by the antlers in a bushy area. He exclaimed that the antlers he was praising put him in utter danger but his legs he was demeaning, tried to help him run that far.	A deer was passing by a river bank. Then it went into the water to drink water. It found that its antlers were looking good. It went in further into the water. It noticed that the legs were normal. Suddenly a hunter shot an arrow at the deer. The arrow didn't touch the deer but it started running in fear. Then the deer got caught in a hedge. It became easier for the hunter to catch the deer. The deer then said the antler was praised but got the deer caught.	The deer stood by a pond. It saw its reflection in it and praised its antlers and then insulted it. Then saw its body, which was thin and the legs were thin. Then an arrow fell in the water and the deer ran. The deer got caught in the jungle. Then the deer said that the antlers caught the deer.

Story 2 (Narrator)	RHD participant	Control participant
Thousands of frogs lived in a small pond. They were happy but they wanted a king. So, they prayed to God for a king. God sent a big tree trunk to them. At first, they were intimidated by its size but soon they discovered, their new king did not move and did not talk. One brave frog climbed to the top of the trunk and after that many others gathered the courage and climbed to the top. They were unhappy and they prayed to God again stating that the king they were sent was inanimate and they want a new king who would be alive and actually rule over them. God got a bit angry. He sent a stork to the pond and the stork ate up all the frogs.	Many frogs lived in a small pond. They all thought they wanted a king and prayed to God. God sent a tree bark to them and the bark didn't rule over them and was inanimate. They were displeased and prayed to God again for a king who would rule and keep them happy. So, God sent them a stork, who ate all the frogs.	Many frogs lived in a pond. They wanted a king from God. God sent them a tree bark after one day exactly. The frogs realized that the king wasn't moving, even on being touched. One frog climbed the king and yet it didn't move. Then they complained to God, that they wanted a king who would actually rule them and be alive. Then God was displeased and sent a stork to them who came and ate all the frogs.

We can see 4 digressions in story 1 for the RHD participant but not in story 2. From the table above, which contain the stories, we can discern that the RHD participant had some major issues in remembering and also had lapses in both the stories as well. The control participant on the other hand had 2 digressions in the first story and 2 digressions in the second story as well. There were major lapses, even in the narration of the control participant as well, in both the stories.

5. Questions answered

STORY 1				
	Questions	Actual answer	RHD participant	Control participant
1	Which animal(s) were mentioned in the story?	A deer	A deer	A deer

2	What was the deer doing?	Looking at his reflection	Looking at its reflection	Looking at his reflection
3	Why did the deer run?	A hunter shot an arrow but it didn't touch	A hunter followed it	A hunter shot an arrow. The deer ran for its life.
4	Why was he caught?	His big antlers were caught in a bush	Antlers	**The antlers caught the deer**
5	What was the deer insulting, in the beginning?	His thin legs, that don't match his antlers and body.	The legs	His thin legs, that don't match his antlers and body.
		STORY 2		
	Questions	Actual answer	RHD participant	Control participant
1	Which animal(s) were mentioned in the story?	Frogs, stork	Frogs and a stork in the end	Frogs, stork
2	Where did the frogs live?	In a small pond	In a marshy and small pond	In a small pond
3	What did the frogs want the first time?	A king	A king	A king
4	What did the frogs want the second time?	A king who would actually be alive and rule over them	A king who would actually rule over them	A king who would actually be alive and rule over them
5	Why did all the frogs die?	The stork ate them all	The stork killed them all	The stork ate them all

We can observe the following from fig 3.195: 31KM80MR has been able to answer all 5 questions in the first story and the second story. The control participant answered 4 questions in the first story and all questions in the second story.

B. SENTENCES

Declaratives

Fig 3.197 – 3.199. We can observe the following from the figure displayed previously: In sentence 1, 31KM80MR has a type D curve, which is in complete contrast of that of 21SD82MC, 50MEANMR and 49MEANMC, who have recorded curves belonging to the type C of sentence. In sentence 2 31KM80MR has recorded a type B curve, in comparison with 21SD82MC, who has a type A curve. 50MEANMR and 49MEANMC, have recorded curves belonging to the type D. In sentence 3, 31KM80MR, 21SD82MC, 50MEANMR and 49MEANMC have all recorded type B sentences.

Imperatives

Fig 3.200 – 3.202. We can observe the following from the figure displayed previously: In sentence 4, 31KM80MR, 21SD82MC, 50MEANMR and 49MEANMC have all made type D sentences. In sentence 5, 31KM80MR has made a type D sentence in comparison with

21SD82MC, who has a type A sentence. 50MEANMR and 49MEANMC show type D sentences. In a type D sentence, the highest pitch point in a sentence is in the middle. But a type A sentence generally denotes a yes/no question. In sentence 6, 31KM80MR conforms to a type D sentence while 21SD82MC, 50MEANMR and 49MEANMC have made type C sentences.

Interrogatives

Fig 3.203 – 3.205. We can observe the following from the figure displayed previously: In sentence 7, 31KM80MR has a D type sentence in comparison with 21SD82MC, who also has a type D sentences. This is in contrast with 50MEANMR and 49MEANMC who have recorded type D sentences. In sentence 8, 31KM80MR has made a type D sentence in comparison with 21SD82MC, who also has made a type D sentence. 50MEANMR has a type D sentence and from the chart 49MEANMC has no visible contour, but on checking the figures, 49MEANMC has made a type D sentence as well. In sentence 9, 31KM80MR has a type D curve in comparison with 21SD82MC, 50MEANMR and 49MEANMC who also have type D sentences.

C. VOWELS

Fig 3.196 compares female RHD participant 31KM80MR with the individual age and gender matched male, that is 15AK57MC. We can observe the following from the figure displayed previously: The vowel /i/ (f1=-363, f2-f1=-2132) in 31KM80MR is a lot more fronted slightly lower than vowel /i/ (f1=-326, f2-f1=-1793) in 21SD82MC. The vowel /e/ (f1=-455, f2-f1=-1261) in 31KM80MR is backed than vowel /e/ (f1=-444, f2-f1=-1496) in 21SD82MC. The vowel /æ/ (f1=-702, f2-f1=-1143) in 31KM80MR is lower in comparison vowel with vowel /æ/ (f1=-577, f2-f1=-1133) in 21SD82MC. The vowel /ɑ/ (f1=-788, f2-f1=-739) in 31KM80MR is fronted and slightly lower in comparison with vowel /ɑ/ (f1=-758, f2-f1=-649) in 21SD82MC. The vowel /ɔ/ (f1=-558, f2-f1=-498) in 31KM80MR is almost at the same place as vowel /ɔ/ (f1=-537, f2-f1=-519) in 21SD82MC. The vowel /o/ (f1=-442, f2-f1=-387) in 21SD82MC is a mid-vowel and is an exception in comparison with vowel /o/ (f1=-490, f2-f1=-1074) in 31KM80MR. The vowel /o/ in 21SD82MC is closer to vowel /e/ (f1=-444, f2-f1=-1496) in 21SD82MC. The vowel /u/ (f1=-309, f2-f1=-515) in 31KM80MR is slightly more fronted in comparison with vowel /u/ (f1=-318, f2-f1=-399) in 21SD82MC. The area of the acoustic space chart for 31KM80MR is 265859 and for 21SD82MC is 295629.5, and 96MEANMR is 336881. The area of 31KM80MR is 10% smaller than that of the individual control and 21% smaller than the mean of RHD participants. The tongue movement of the RHD participant in capable of making the /i/ vowel more fronted but the back vowels are more fronted as well.

3.5.11.CASE STUDY 11

PRIMARY INFO

Codified Name: 32KD72MR.

Male, 72 years of age, at the time of recording and case study.

Age and gender matched control: 12AD75MC

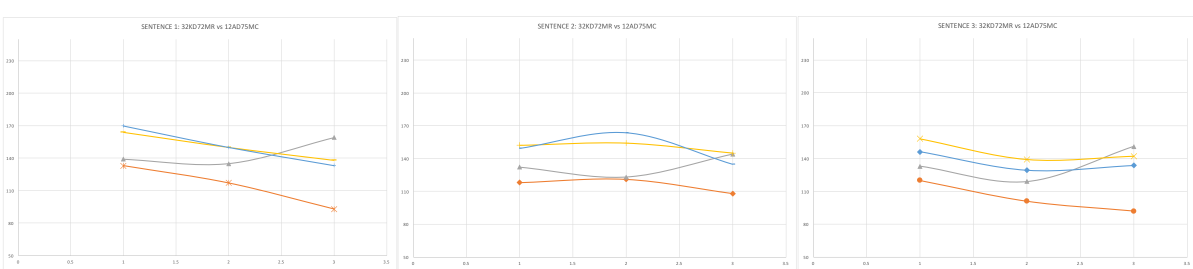
Time since incidence: approximately 1.5 years back, at the time of recording.

PARTICIPANT INFORMATION

Condition of participant: The participant was conscious, and barely scored 11 on the GCS. He scored 20 on the MMSE. The participant can walk but has major problems. The participant complains of severe pain in the left leg and when the pain is severe, he needs someone to help him walk. The doctor asked him to do some actions with his hand, involving muscle coordination and he could do it but it needed him time to complete. The participant faced difficulty in performing actions based on instructions, which involved complicated and elaborate instructions. The speech of the participant was slurred and was difficult to understand. The participant did not display any left hemisphere neglect. His sense of color recognition was also intact, although he had difficulty in remembering the names. The doctor also performed a test in which he held both of the participant's hands in his hands and then asked the participant to keep holding them where he is holding them, after he lets them go. He could maintain the position of the right hand. The left hand fell down a fair bit, before he regained control. The participant had major issues in remembering things. He is undergoing no physiotherapy due to his poor financial condition. **Observations made by doctor:** The doctor mentions that he has agraphia, dementia, and alexia. Participant is hypertensive. Participant is an alcoholic but not a smoker. Participant has some problems in planning and judgement. Acute psychiatric illness. **Diagnosis made by doctor:** The doctor mentions that the participant is out of danger and would not suffer another stroke. He was asked to follow up in six months. **Region of damage:** Late subacute hematoma in right putamen with mild mass effect and residual chronic hematomas in both putamen anteriorly. At present: residual hypo density in right paraventricular region.

COMPREHENSIVE STUDY OF PARTICIPANT AT THE 3 LEVELS OF COMMUNICATION

Fig 3.206 to 3.211: 32KD72MR - The bar graphs are comparisons at the level of discourse. The last diagram is an acoustic space.



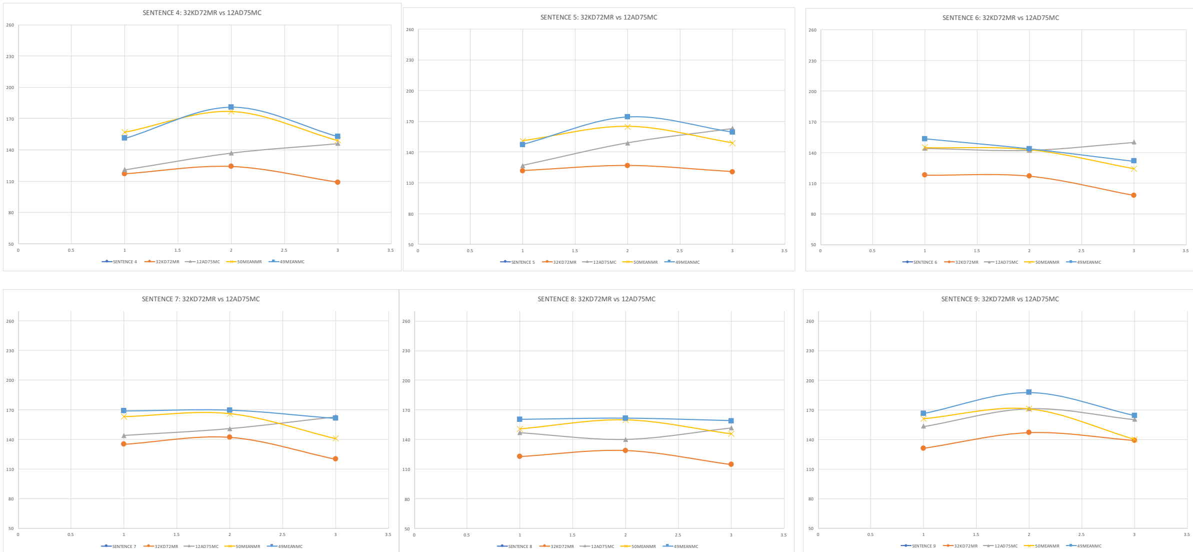


Fig 3.212 to 3.220: 32KD72MR - First three diagrams in first line are declarative sentences. The next line is composed of 3 imperative sentences and the third line has three interrogative sentences.

A. DISCOURSE

1. Pitch range

We can observe the following from fig 3.206: 32KD72MR has a pitch range of 48 Hz in the first story in comparison with 12AD75MC, who has a pitch range 37 Hz. This is the first time an RHD participant has a pitch range, which exceeds that of a control participant. 60MEANMR has a pitch range of 40 Hz in the first story while 58MEANMC has a pitch range of 53 Hz in the first story. 32KD72MR has a pitch range of 28 Hz in the second story in comparison with 12AD75MC, who has a pitch range of 48 Hz. 60MEANMR has a pitch range of 39 Hz in the second story while 58MEANMC has a pitch range of 55 Hz in the second story. 32KD72MR has a pitch range of 38 Hz in the mean of the stories in comparison with 12AD75MC, who has a pitch range of 43 Hz. The pitch ranges in both the RD participant and the control participant are very similar. 60MEANMR has a pitch range of 39 Hz in the mean of the two stories while 58MEANMC has a pitch range of 54 Hz in the same.

2. Fluency

We can observe the following from fig 3.207: 32KD72MR has 110 words in story 1 in comparison with 12AD75MC, who has 85 words, which is a small difference. 32KD72MR has a word rate of 96 wpm in story 1 in comparison with 12AD75MC, who has 108 wpm. 32KD72MR has 75 words in story 2 in comparison with 12AD75MC, who has 143 words.

32KD72MR has a word rate of 54 wpm in story 2 in comparison with 12AD75MC, who has 102 wpm. 32KD72MR has 95 words in the combined mean of the two stories in comparison with 12AD75MC, who has 115 words. 32KD72MR has a word rate of 75 wpm in the combined mean of the two stories in comparison with 12AD75MC, who has 105 wpm.

3. **Duration**

We can observe the following from fig 3.208: 32KD72MR took 69 seconds (fluency – 96 words per minute) to complete narrating the first story in comparison with 12AD75MC, who took 47 seconds (fluency – 108 words per minute). 32KD72MR took 83 seconds (fluency – 54 words per minute) to complete narrating the second story in comparison with 12AD75MC, who took 84 seconds (fluency – 102 words per minute). 32KD72MR has a mean duration of 76 seconds (fluency – 75 words per minute) whereas, 12AD75MC has a mean of 66 seconds (fluency – 105 words per minute). 58MEANMC took a time of 68 seconds (fluency – 125 words per minute) and 60MEANMR took a time of 58 seconds (fluency – 113 words per minute), in the mean of the two stories.

4. Digressions and lapses

Story 1 (Narrator)	RHD participant	Control participant
There was a deer. It was standing at the edge of the river. It saw its majestic antlers in the river, as a reflection. It kept praising it. Next it saw its feet and started to demean it because it was thin and did not match the overall beauty of the whole body. In the meantime, a hunter shot an arrow but missed. The deer started running in fear but ultimately got caught by the antlers in a bushy area. He exclaimed that the antlers he was praising put him in utter danger but his legs he was demeaning, tried to help him run that far.	The deer went to drink water. He said that his legs were thin and asked himself why? He also asked why his antlers were crooked. The deer went into a creeper forest. Why were the legs thin? The deer got stuck in a hedge. The deer ran after spotting a hunter. The hunter caught the deer. Mind is the main culprit. Legs are thin and antlers are crooked and that is why it got caught.	The deer stood by a pond. It saw its reflection in it and praised its antlers and then insulted it. Then saw its body, which was thin and the legs were thin. Then an arrow fell in the water and the deer ran. The deer got caught in the jungle. Then the deer said that the antlers caught the deer.

Story 2 (Narrator)	RHD participant	Control participant
Thousands of frogs lived in a small pond. They were happy but they wanted a king. So, they prayed to God for a king. God sent a big tree trunk to them. At first, they were intimidated by its size but soon they discovered, their new king did not move and did not	Many frogs lived in a small pond. Later, they wanted a king. One frog	Many frogs lived in a pond. They wanted a king from God. God sent them a tree bark after one day exactly. The frogs realized that the king wasn't

talk. One brave frog climbed to the top of the trunk and after that many others gathered the courage and climbed to the top. They were unhappy and they prayed to God again stating that the king they were sent was inanimate and they want a new king who would be alive and actually rule over them. God got a bit angry. He sent a stork to the pond and the stork ate up all the frogs.	<u>climbed a tree. A frog told frogs for a king. A frog a God for a king. That solved the problem. Then a stork came.</u>	moving, even on being touched. One frog climbed the king and yet it didn't move. Then they complained to God, that they wanted a king who would actually rule them and be alive. Then God was displeased and sent a stork to them who came and ate all the frogs.

We can see 10 and more digressions in story 1 for the RHD participant and 8 digressions not in story 2. From the table above, which contain the stories, we can discern that the RHD participant had some major issues in remembering and also had lapses in both the stories as well. The RHD participant remembered the events but could not narrate the story in correct chronology as well. The control participant on the other hand had 2 digressions in the first story and 2 digressions in the second story as well. There were major lapses, even in the narration of the control participant as well, in both the stories.

5. Questions answered

STORY 1				
	Questions	Actual answer	RHD participant	Control participant
1	Which animal(s) were mentioned in the story?	A deer	A deer	A deer
2	What was the deer doing?	Looking at his reflection	Looking at its reflection	Looking at his reflection
3	Why did the deer run?	A hunter shot an arrow but it didn't touch	A hunter followed it	A hunter shot an arrow. The deer ran for its life.
4	Why was he caught?	His big antlers were caught in a bush	Antlers	<u>**The antlers caught the deer**</u>
5	What was the deer insulting, in the beginning?	His thin legs, that don't match his antlers and body.	The legs	His thin legs, that don't match his antlers and body.

STORY 2				
	Questions	Actual answer	RHD participant	Control participant
1	Which animal(s) were mentioned in the story?	Frogs, stork	Frogs and a stork in the end	Frogs, stork
2	Where did the frogs live?	In a small pond	In a marshy and small pond	In a small pond
3	What did the frogs want the first time?	A king	A king	A king
4	What did the frogs want the second time?	A king who would actually be alive and rule over them	<u>**A stork**</u>	A king who would actually be alive and rule over them

5	Why did all the frogs die?	The stork ate them all	The stork killed them all	The stork ate them all

We can observe the following from fig 3.210: 32KD72MR has been able to answer all 5 questions in the first story and 4 in the second story. The control participant answered 4 questions in the first story and all questions in the second story.

B. SENTENCES

Declaratives

Fig 3.212 – 3.214. We can observe the following from the figure displayed previously: In sentence 1, 32KD72MR has a type C curve, which is in complete contrast of that of 12AD75MC, who has a type B curve. 50MEANMR and 49MEANMC, have recorded curves belonging to the type C of sentence. The type C sentence begins at the highest pitch point, the second point is lower than the starting point and the third point is either equal to or lower than the pitch point in the middle. In sentence 2, 32KD72MR has recorded a type D curve, in comparison with 12AD75MC, who has a type B curve. 50MEANMR and 49MEANMC, have recorded curves belonging to the type D. In sentence 3, 32KD72MR, 50MEANMR and 49MEANMC have recorded type C sentences, in comparison with 12AD75MC, who has a type B sentence.

Imperatives

Fig 3.215 – 3.217. We can observe the following from the figure displayed previously: In sentence 4, 32KD72MR, 50MEANMR and 49MEANMC have type D sentences, in comparison with 12AD75MC, who has a type A sentence. In sentence 5, 32KD72MR, 50MEANMR and 49MEANMC have type D sentences, in comparison with 12AD75MC, who has a type A sentence. In a type D sentence, the highest pitch point in a sentence is in the middle. In sentence 6, 32KD72MR conforms to a type D sentence while 12AD75MC conforms to a type A sentence. 50MEANMR and 49MEANMC have type C sentences.

Interrogatives

Fig 3.218 – 3.220. We can observe the following from the figure displayed previously: In sentence 7, 32KD72MR has a D type sentence in comparison with 12AD75MC, who has a type A sentences. This is in contrast with 50MEANMR and 49MEANMC who have recorded type D sentences. In sentence 8, 32KD72MR has made a type D sentence in comparison with 12AD75MC, who has made a type B sentence. 50MEANMR has a type D sentence and from the chart 49MEANMC has no visible contour, but on checking the figures, 49MEANMC has made a type D sentence as well. In sentence 9, 32KD72MR has a type D curve in comparison with 12AD75MC, 50MEANMR and 49MEANMC who also have type D sentences.

C. VOWELS

Fig 3.211 compares female RHD participant 32KD72MR with the individual age and gender matched male, that is 15AK57MC. We can observe the following from the figure displayed previously: The vowel /i/ (f1=-319, f2-f1=-1784) in 32KD72MR is almost at the same place as vowel /i/ (f1=-305, f2-f1=-1793) in 12AD75MC. The vowel /e/ (f1=-369, f2-f1=-1235) in 32KD72MR is more backed and slightly higher than vowel /e/ (f1=-419, f2-f1=-1476) in 12AD75MC. The vowel /æ/ (f1=-644, f2-f1=-1003) in 32KD72MR is slightly backed and higher comparison than vowel /æ/ (f1=-714, f2-f1=-1095) in 12AD75MC. The vowel /ɑ/ (f1=-701, f2-f1=-697) in 32KD72MR is higher and fronted in comparison with vowel /ɑ/ (f1=-748, f2-f1=-557) in 12AD75MC. The vowel /ɔ/ (f1=-497, f2-f1=-513) in 32KD72MR is slightly higher and fronted in comparison with vowel /ɔ/ (f1=-533, f2-f1=-400) in 12AD75MC. The vowel /o/ (f1=-415, f2-f1=-536) in 32KD72MR is slightly lower and fronted in comparison with vowel /o/ (f1=-390, f2-f1=-451) in 12AD75MC. The vowel /u/ (f1=-296, f2-f1=-512) in 32KD72MR is slightly higher and fronted in comparison with vowel /u/ (f1=-342, f2-f1=-446) in 12AD75MC. The area of the acoustic space chart for 32KD72MR is 229269 and for 12AD75MC is 366966, and 96MEANMR is 336881. The area of 32KD72MR is 38% smaller than that of the individual control and 32% smaller than the mean of RHD participants. The acoustic space of the RHD participant is significantly smaller.

3.5.12. CASE STUDY 12

PRIMARY INFO

Codified Name: 33NB42MR.

Male, 42 years of age, at the time of recording and case study.

Age and gender matched control: 20SD48MC

Time since incidence: approximately 3 months back, at the time of recording.

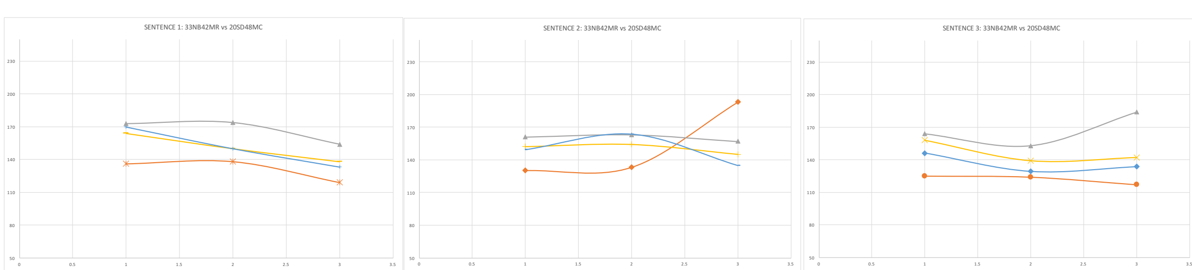
PARTICIPANT INFORMATION

Condition of participant: The participant was conscious, and scored 12 on the GCS. He scored 26 on the MMSE. The participant can without any problems. The participant could not walk, just after the stroke but he could walk again, within one month from the date of the stroke. The doctor asked him to do some actions with his hand, involving muscle coordination and he could do it but it needed him time to complete. The participant did not face any difficulty in performing actions based on instructions, which involved complicated and elaborate instructions. The speech of the participant was not slurred or difficult to understand.

The participant displays massive left hemisphere neglect. The doctor drew six straight lines on a piece of paper and asked him to divide every line at the half mark. He could not divide any of the lines in half. Every line had a bigger left segment than the segment on the right, showing left hemisphere neglect. His sense of color recognition was intact. The doctor also performed a test in which he held both of the participant's hands in his hands and then asked the participant to keep holding them where he is holding them, after he lets them go. He could maintain the position of the right hand. The left hand fell down a fair bit, before he regained control. The participant had major issues in remembering things. He is undergoing no physiotherapy due to his poor financial condition. **Observations made by doctor:** The doctor mentions that he has no agraphia, no dementia, and no alexia. Participant is not hypertensive. Participant is not an alcoholic and not a smoker. Participant has some minor problems in planning and judgement. **Diagnosis made by doctor:** The doctor mentions that the participant needs to be start physiotherapy for the hands and legs. He was asked to follow up in six months. **Region of damage:** Subacute infarct in the territory of right MCA involving in the lateral front parietal temporal lobes with a smaller one in right corpus striatum; diminished flow signal in superior and inferior right MCA and distal branches. Pulling towards left, first a TIX, then an ischemic infarct to the above-mentioned area.

COMPREHENSIVE STUDY OF PARTICIPANT AT THE 3 LEVELS OF COMMUNICATION

Fig 3.221 to 3.226: 33NB42MR - The bar graphs are comparisons at the level of discourse. The last diagram is an acoustic space.



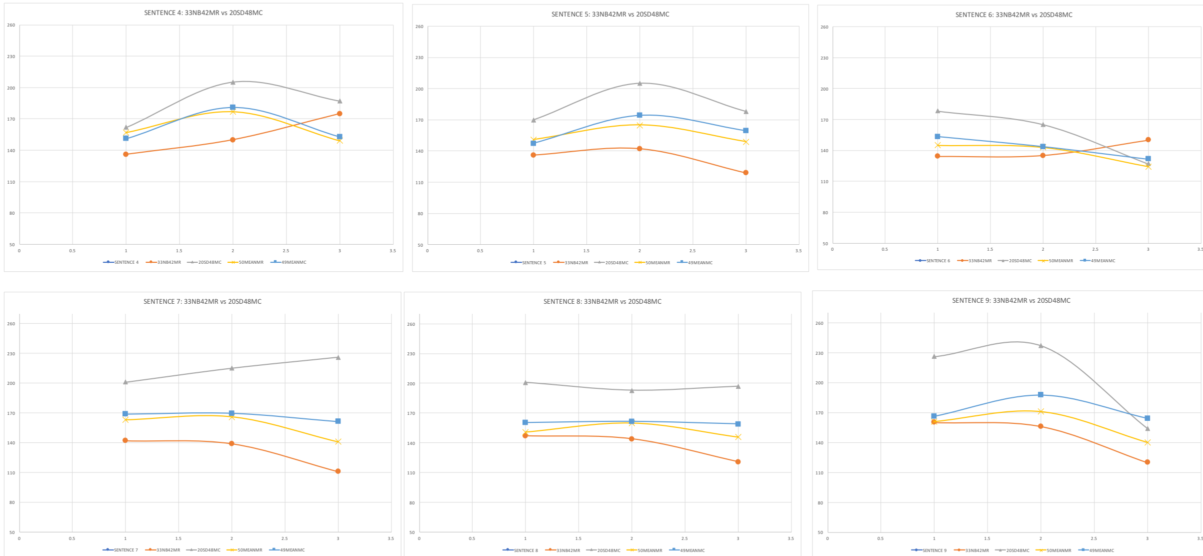


Fig 3.227 to 3.235: 33NB42MR - First three diagrams in first line are declarative sentences. The next line is composed of 3 imperative sentences and the third line has three interrogative sentences.

A. DISCOURSE

1. Pitch range

We can observe the following from fig 3.221: 33NB42MR has a pitch range of 68 Hz in the first story in comparison with 20SD48MC, who has a pitch range of 55 Hz. The RHD participant has a pitch range which is more than that of the control participant. 60MEANMR has a pitch range of 40 Hz in the first story while 58MEANMC has a pitch range of 53 Hz in the first story. 33NB42MR has a pitch range of 47 Hz in the second story in comparison with 20SD48MC, who has a pitch range of 46 Hz. 60MEANMR has a pitch range of 39 Hz in the second story while 58MEANMC has a pitch range of 55 Hz in the second story. 33NB42MR has a pitch range of 58 Hz in the mean of the stories in comparison with 20SD48MC, who has a pitch range of 51 Hz. 60MEANMR has a pitch range of 39 Hz in the mean of the two stories while 58MEANMC has a pitch range of 54 Hz in the same. The RHD participant has a pitch range which is more than the control participant, which proves that this RHD participant has almost no damage in terms of pitch information.

2. Fluency

We can observe the following from fig 3.222: 33NB42MR has 148 words in story 1 in comparison with 20SD48MC, who has 179 words, which is a small difference. 33NB42MR has a word rate of 156 wpm in story 1 in comparison with 20SD48MC, who has 156 wpm.

33NB42MR has 165 words in story 2 in comparison with 20SD48MC, who has 86 words. 33NB42MR has a word rate of 168 wpm in story 2 in comparison with 20SD48MC, who has 114 wpm. 33NB42MR has 157 words in the combined mean of the two stories in comparison with 20SD48MC, who has 128 words. 33NB42MR has a word rate of 162 wpm in the combined mean of the two stories in comparison with 20SD48MC, who has 135 wpm. The RHD participant has a better performance, overall than the control participant and the control group mean.

3. **Duration**

We can observe the following from fig 3.223: 33NB42MR took 57 seconds (fluency – 156 words per minute) to complete narrating the first story in comparison with 20SD48MC, who took 69 seconds (fluency – 156 words per minute). 33NB42MR took 59 seconds (fluency – 168 words per minute) to complete narrating the second story in comparison with 20SD48MC, who took 45 seconds (fluency – 114 words per minute). 33NB42MR has a mean duration of 58 seconds (fluency – 162 words per minute) whereas, 20SD48MC has a mean of 57 seconds (fluency – 135 words per minute). 58MEANMC took a time of 68 seconds (fluency – 125 words per minute) and 60MEANMR took a time of 58 seconds (fluency – 113 words per minute), in the mean of the two stories.

4. Digressions and lapses

Story 1 (Narrator)	RHD participant	Control participant
There was a deer. It was standing at the edge of the river. It saw its majestic antlers in the river, as a reflection. It kept praising it. Next it saw its feet and started to demean it because it was thin and did not match the overall beauty of the whole body. In the meantime, a hunter shot an arrow but missed. The deer started running in fear but ultimately got caught by the antlers in a bushy area. He exclaimed that the antlers he was praising put him in utter danger but his legs he was demeaning, tried to help him run that far.	A deer was standing by a river to drink water and saw its reflection. It saw its antlers in the water and praised it. It then saw its thin legs and didn't like them, felt ashamed of them. In the meantime, a hunter shot an arrow at the deer and missed. The deer started running for life and unfortunately got stuck by the antlers in a hedge. Then it realized that what it was praising, got it stuck but what it was feeling ashamed, at least helped it run.	In a forest lived a deer. It went to drink water and noticed its reflection in the water. It praised it beautiful antlers and then suddenly noticed the thin legs and felt ashamed of having such thin legs. In the meantime, a hunter shot an arrow at the deer and missed. The deer started running and then got caught by the antlers in a bush. The deer then realized that what it was praising got it caught but what it was ashamed of helped it escape, although the antlers got it caught finally.

Story 2 (Narrator)	RHD participant	Control participant
Thousands of frogs lived in a small pond. They were happy but they wanted a king. So, they prayed to God for a king. God sent a big tree trunk to them. At first, they were intimidated by its size but soon they discovered, their new king did not move and did not talk. One brave frog climbed to the top of the trunk and after that many others gathered the courage and climbed to the top. They were unhappy and they prayed to God again stating that the king they were sent was inanimate and they want a new king who would be alive and actually rule over them. God got a bit angry. He sent a stork to the pond and the stork ate up all the frogs.	Many frogs lived in a small pond. They decided that they needed a king and prayed to God for the same. God sent a tree bark to the pond. The frogs saw it and touched it. But the king didn't move. The frogs were dissatisfied with the new king because they realized it was inanimate. They prayed to God again requesting for a king who would actually rule over them. God got irritated at this and sent a stork to their home. The stork ate all the frogs one by one and it was too late for them to correct their mistake.	Many frogs lived in a small pond. One day they prayed to God for a king. God put a tree bark in the pond. But the frogs noticed that the king didn't move or budge. They touched it and it was inanimate to touch. The frogs felt bad and prayed to God again for another king, a second king, who would actually be animate and rule over them. God got angry at this and sent a stork to their home. The stork then started eating all the frogs one by one.

We can see 0 digressions in story 1 for the RHD participant and 0 digressions in story 2 as well. From the table above, which contain the stories, we can discern that the RHD participant had no major issues in remembering and had no lapses in both the stories as well. The control participant had 0 digressions in the first story and 0 digressions in the second story as well. There were no major lapses, even in the narration of the control participant as well, in both the stories.

5. **Questions answered**

STORY 1				
	Questions	Actual answer	RHD participant	Control participant
1	Which animal(s) were mentioned in the story?	A deer	A deer	A deer
2	What was the deer doing?	Looking at his reflection	Looking at its reflection	Looking at his reflection
3	Why did the deer run?	A hunter shot an arrow but it didn't touch	A hunter followed it	A hunter shot an arrow. The deer ran for its life.
4	Why was he caught?	His big antlers were caught in a bush	Antlers got caught in creepers.	The antlers got caught in a hedge.
5	What was the deer insulting, in the beginning?	His thin legs, that don't match his antlers and body.	The legs	His thin legs, that don't match his antlers and body.
STORY 2				
	Questions	Actual answer	RHD participant	Control participant
1	Which animal(s) were mentioned in the story?	Frogs, stork	Frogs and a stork in the end	Frogs, stork
2	Where did the frogs live?	In a small pond	In a marshy and small pond	In a small pond

3	What did the frogs want the first time?	A king	A king	A king
4	What did the frogs want the second time?	A king who would actually be alive and rule over them	A king who would rule	A king who would actually be alive and rule over them
5	Why did all the frogs die?	The stork ate them all	The stork killed them all	The stork ate them all

We can observe the following from fig 3.225: 33NB42MR has been able to answer all 5 questions in the both stories. The control participant answered all questions in both the stories.

B. SENTENCES

Declaratives

Fig 3.227 – 3.229. We can observe the following from the figure displayed previously: In sentence 1, 33NB42MR has a type D curve, and 20SD48MC, has a type D curve as well. 50MEANMR and 49MEANMC, have recorded curves belonging to the type C of sentence. The type C sentence begins at the highest pitch point, the second point is lower than the starting point and the third point is either equal to or lower than the pitch point in the middle. In sentence 2, 33NB42MR has recorded a type A curve, in comparison with 20SD48MC, who has a type D curve. 50MEANMR and 49MEANMC, have recorded curves belonging to the type D. In sentence 3, 20SD48MC, 50MEANMR and 49MEANMC have type B sentences while 33NB42MR has a type D sentence.

Imperatives

Fig 3.230 – 3.232. We can observe the following from the figure displayed previously: In sentence 4, 33NB42MR has a type A sentence while, 20SD48MC, 50MEANMR and 49MEANMC have type D sentences. In sentence 5, 33NB42MR, 20SD48MC, 50MEANMR and 49MEANMC have type D sentences. In a type D sentence, the highest pitch point in a sentence is in the middle. In sentence 6, 33NB42MR conforms to a type A sentence while 20SD48MC conforms to a type C sentence. 50MEANMR and 49MEANMC have type C sentences.

Interrogatives

Fig 3.233 – 3.235. We can observe the following from the figure displayed previously: In sentence 7, 33NB42MR has a C type sentence in comparison with 20SD48MC, who has a type A sentences. This is in contrast with 50MEANMR and 49MEANMC who have recorded type D sentences. In sentence 8, 33NB42MR has made a type C sentence in comparison with 20SD48MC, who has made a type B sentence. 50MEANMR has a type D sentence and from the chart 49MEANMC has no visible contour, but on checking the figures, 49MEANMC has made a type D sentence as well. In sentence 9, 33NB42MR has a type C curve in comparison with 20SD48MC, 50MEANMR and 49MEANMC who also have type D sentences.

C. **VOWELS**

D. Fig 3.226 compares female RHD participant 33NB42MR with the individual age and gender matched male, that is 15AK57MC. We can observe the following from the figure displayed previously: The vowel /i/ (f1=-316, f2-f1=-2019) in 33NB42MR is almost at the same place as vowel /i/ (f1=-368, f2-f1=-2011) in 20SD48MC. The vowel /e/ (f1=-435, f2-f1=-1650) in 33NB42MR is backed and slightly lower than vowel /e/ (f1=-412, f2-f1=-1732) in 20SD48MC. The vowel /æ/ (f1=-672, f2-f1=-1136) in 33NB42MR is slightly fronted and higher in comparison with vowel /æ/ (f1=-726, f2-f1=-998) in 20SD48MC. The vowel /ɑ/ (f1=-721, f2-f1=-819) in 33NB42MR is much more fronted and higher in comparison with vowel /ɑ/ (f1=-831, f2-f1=-506) in 20SD48MC. The vowel /ɔ/ (f1=-623, f2-f1=-516) in 33NB42MR is slightly higher and fronted in comparison with vowel /ɔ/ (f1=-670, f2-f1=-361) in 20SD48MC. The vowel /o/ (f1=-434, f2-f1=-623) in 33NB42MR is more fronted in comparison with vowel /o/ (f1=-432, f2-f1=-402) in 20SD48MC. The vowel /u/ (f1=-402, f2-f1=-411 in 33NB42MR is almost at the same place in comparison with vowel /u/ (f1=-387, f2-f1=-442) in 20SD48MC. The area of the acoustic space chart for 33NB42MR is 302259.5 and for 20SD48MC is 387032, and 96MEANMR is 336881, making the area 78% of the individual control and 68% of the mean, or in other words, the area of 33NB42MR is 22% smaller than that of the individual control and 32% smaller than the mean of RHD participants. The acoustic space of the RHD participant is significantly smaller.

3.5.13.CASE STUDY 13

PRIMARY INFO

Codified Name: 34SR36MR

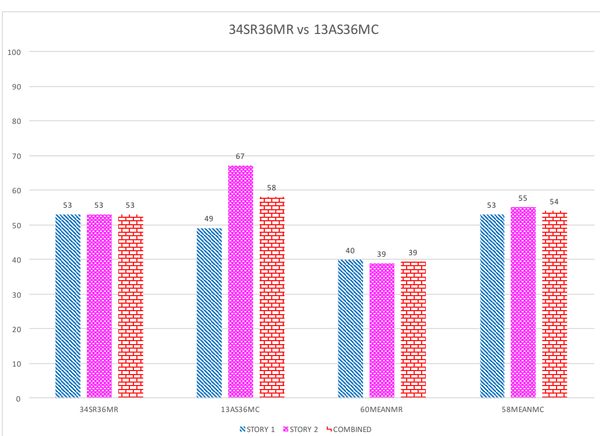
Male, 36 years of age, at the time of recording and case study.

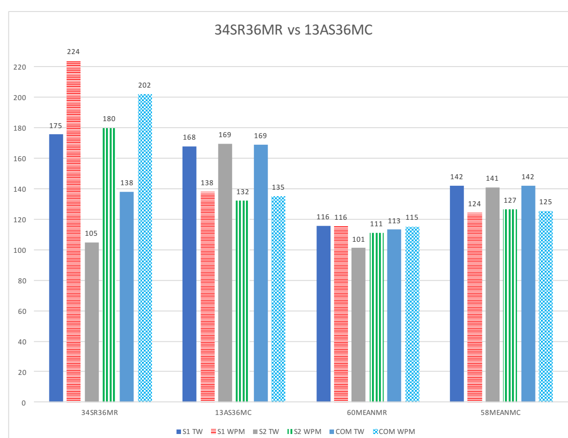
Age and gender matched control: 13AS36MC
Time since incidence: approximately 1 year back, at the time of recording.

PARTICIPANT INFORMATION

Condition of participant: The participant was fully conscious, having scored 15 on the GCS. He also scored 27 on the MMSE. The participant cannot walk without walking aids. The doctor asked him to do some actions with his hands, involving muscle coordination and he could do it with ease. The participant could also perform actions based on instructions, which involved complicated and elaborate instructions. The speech of the participant was slightly slurred but could be understood. The participant displayed slight left hemisphere neglect and his color recognition was perfect. The doctor also performed a test in which he held both of the participant's hands in his hands and then asked the participant to keep holding them where he is holding them, after he lets them go. He could maintain the position of the right hand but the left hand fell to some extent before he could regain control back. The participant had no issues in remembering things. He is undergoing no physiotherapy. **Observations made by doctor:** The doctor mentions that he has no agraphia, no dementia, and no alexia. Participant is very highly hypertensive. Participant is not an alcoholic or a smoker. Participant has no problems in planning and judgement. Hypersensitivity reaction in the left hemisphere. Spastic hemiparesis. **Diagnosis made by doctor:** The doctor mentions that the participant has almost no chances of suffering another stroke. He was asked to follow up in six months. **Region of damage: Right MCA** blockage.

COMPREHENSIVE STUDY OF PARTICIPANT AT THE 3 LEVELS OF COMMUNICATION





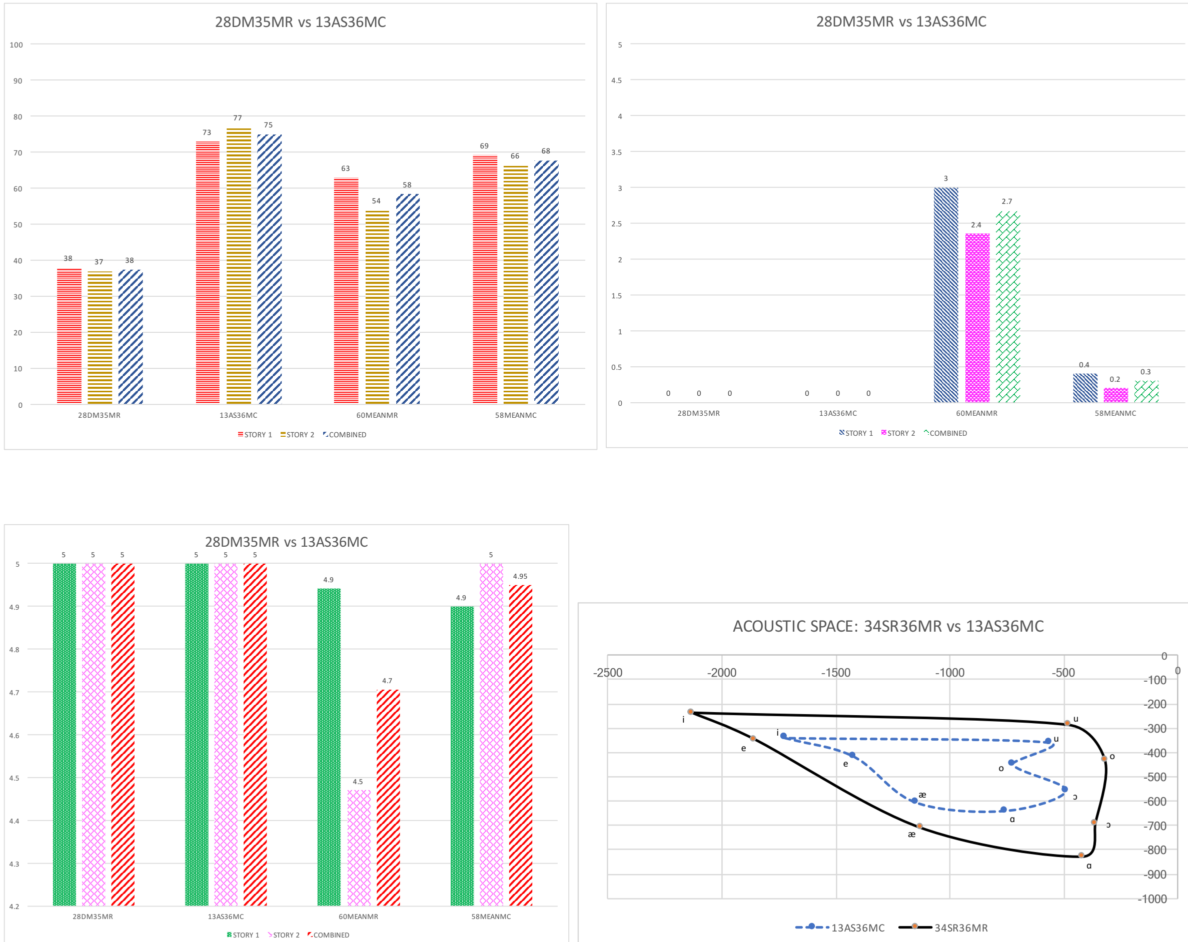
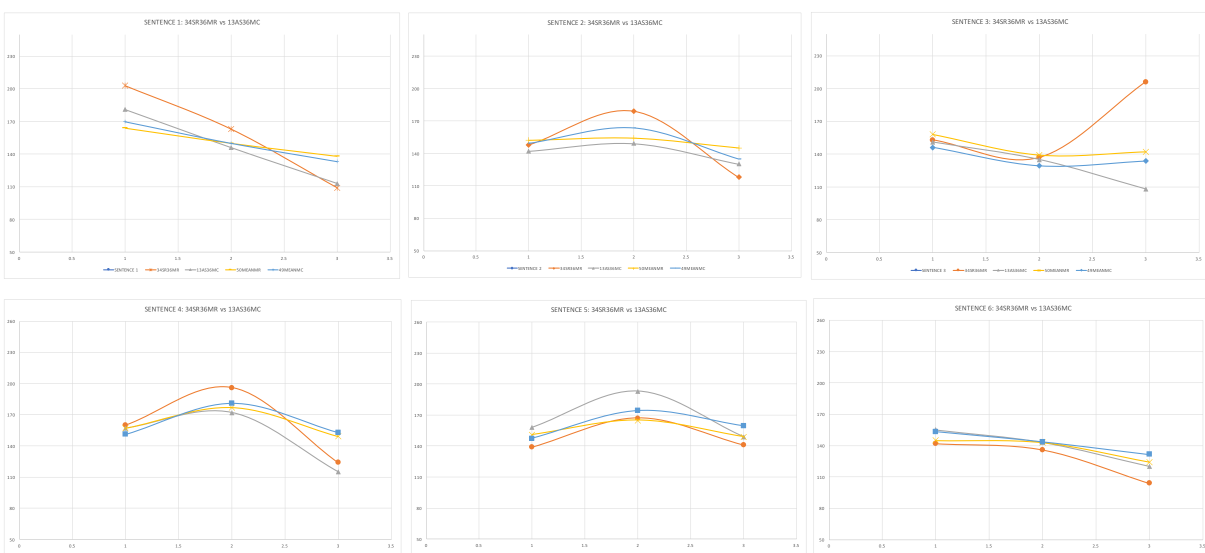


Fig 3.236 to 3.241: 34SR36MR - The bar graphs are comparisons at the level of discourse. The last diagram is an acoustic space.



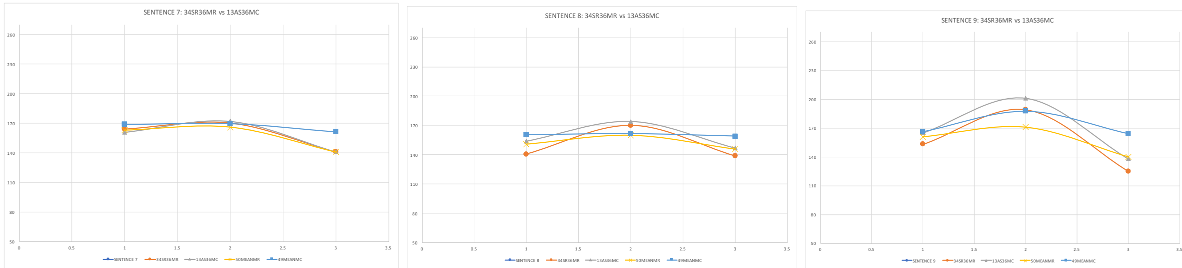


Fig 3.242 to 3.250: 34SR36MR - First three diagrams in first line are declarative sentences. The next line is composed of 3 imperative sentences and the third line has three interrogative sentences.

A. DISCOURSE

1. Pitch range

We can observe the following from fig 3.236: 34SR36MR has a pitch range of 53 Hz in the first story in comparison with 13AS36MC, who has a pitch range of 49 Hz. 60MEANMR has a pitch range of 40 Hz in the first story while 58MEANMC has a pitch range of 53 Hz in the first story. 34SR36MR has a pitch range of 53 Hz in the second story in comparison with 13AS36MC, who has a pitch range of 67 Hz. 60MEANMR has a pitch range of 39 Hz in the first story while 58MEANMC has a pitch range of 55 Hz in the second story. 34SR36MR has a pitch range of 53 Hz in the mean of the stories in comparison with 13AS36MC, who has a pitch range of 58 Hz. The difference in pitch range is insignificant and throughout the recordings, the pitch range of the RHD participant is very close to the pitch range of the control participant. 60MEANMR has a pitch range of 39 Hz in the mean of the two stories while 58MEANMC has a pitch range of 54 Hz in the same.

2. Fluency

We can observe the following from fig 3.237: 34SR36MR has 175 words in story 1 in comparison with 13AS36MC, who has 168 words, which is a small difference. 34SR36MR has a word rate of 224 wpm in story 1 in comparison with 13AS36MC, who has 138 wpm. 34SR36MR has 105 words in story 2 in comparison with 13AS36MC, who has 169 words. 34SR36MR has a word rate of 180 wpm in story 2 in comparison with 13AS36MC, who has 132 wpm. 34SR36MR has 138 words in the combined mean of the two stories in comparison with 13AS36MC, who has 169 words. 34SR36MR has a word rate of 202 wpm in the combined mean of the two stories in comparison with 13AS36MC, who has 135 wpm. The RHD participant has a better performance, overall than the control participant and the control group mean.

3. Duration

We can observe the following from fig 3.238: 34SR36MR took 38 seconds (fluency – 224 words per minute) to complete narrating the first story in comparison with 13AS36MC, who took 71 seconds (fluency – 138 words per minute). 34SR36MR took 37 seconds (fluency – 180 words per minute) to complete narrating the second story in comparison with 13AS36MC, who took 64 seconds (fluency – 132 words per minute). 34SR36MR has a mean duration of 38 seconds (fluency – 202 words per minute) whereas, 13AS36MC has a mean of 68 seconds (fluency – 135 words per minute). We can see that 34SR36MR has taken lesser time than 13AS36MC in both the stories. The participant was speaking in a hurry. 34SR36MR also completed the stories faster than 58MEANMC with a duration of 68 seconds (fluency – 125 words per minute) and 60MEANMR with a duration of 58 seconds (fluency – 113 words per minute), in the mean of the two stories.

4. Digressions and lapses

Story 1 (Narrator)	RHD participant	Control participant
There was a deer. It was standing at the edge of the river. It saw its majestic antlers in the river, as a reflection. It kept praising it. Next it saw its feet and started to demean it because it was thin and did not match the overall beauty of the whole body. In the meantime, a hunter shot an arrow but missed. The deer started running in fear but ultimately got caught by the antlers in a bushy area. He exclaimed that the antlers he was praising put him in utter danger but his legs he was demeaning, tried to help him run that far.	There is a deer standing at a river side. It looked into the water and saw its reflection. It praised its antlers but felt bad and ashamed of its thin legs which didn't match the body. In the meantime, an arrow was shot by a hunter but it missed. The deer started to run in fear, and then its antlers got stuck in a hedge. The deer then realized that its antlers, even if they were beautiful and majestic, got him caught, while the legs, it was so ashamed about tried to let it escape.	A deer went to drink water at a river side. It noticed its reflection and saw its antlers first. It praised its antlers and felt good. After that it saw its thin legs and felt bad, demeaned it. In the meantime, a hunter shot an arrow which missed but the deer started to run. Unfortunately, the deer got stuck in a hedge. Then it realized that the antler which it was praising, got it caught but the legs it was demeaning actually tried to run, to help it.

Story 2 (Narrator)	RHD participant	Control participant
Thousands of frogs lived in a small pond. They were happy but they wanted a king. So, they prayed to God for a king. God sent a big tree trunk to them. At first, they were intimidated by its	Many frogs lived in a small pond. They one day wanted a king and requested God for it. God dropped a tree bark into the pond. The	Many frogs lived in a small pond and they were happy. Suddenly they thought that they needed a king and prayed to God for a king. God sent them a big bark

size but soon they discovered, their new king did not move and did not talk. One brave frog climbed to the top of the trunk and after that many others gathered the courage and climbed to the top. They were unhappy and they prayed to God again stating that the king they were sent was inanimate and they want a new king who would be alive and actually rule over them. God got a bit angry. He sent a stork to the pond and the stork ate up all the frogs.	frogs at first were happy but soon realized that the king didn't move or rule. They started to climb the king and soon they were dissatisfied. They prayed to God for another king who would actually rule over them. This time God sent a stork to them, because God got pissed. The stork ate all the frogs.	of tree. At first the frogs touched it and then realized the king didn't move. Eventually a brave frog climbed the king and others followed. They realized it was not a proper king and they prayed to God again for a king who would actually rule them. God was angry and sent a stork to their place. The stork started to eat all the frogs one by one.

We can see no digressions in story 1 or in story 2 for the RHD participant. The control participant on the other hand also had no digressions in both the stories. There were no lapses in the narration of the control participant as well, in both the stories.

5. **Questions answered**

STORY 1				
	Questions	Actual answer	RHD participant	Control participant
1	Which animal(s) were mentioned in the story?	A deer	A deer	A deer
2	What was the deer doing?	Looking at his reflection	Looking at its reflection	Looking at his reflection
3	Why did the deer run?	A hunter shot an arrow but it didn't touch	A hunter followed it	A hunter shot an arrow. The deer ran for its life.
4	Why was he caught?	His big antlers were caught in a bush	Antlers	His big antlers were caught in a bush
5	What was the deer insulting, in the beginning?	His thin legs, that don't match his antlers and body.	The legs	His thin legs, that don't match his antlers and body.

STORY 2				
	Questions	Actual answer	RHD participant	Control participant
1	Which animal(s) were mentioned in the story?	Frogs, stork	Frogs and a stork in the end	Frogs, stork
2	Where did the frogs live?	In a small pond	In a marshy and small pond	In a small pond
3	What did the frogs want the first time?	A king	A king	A king
4	What did the frogs want the second time?	A king who would actually be alive and rule over them	A king who would actually rule over them	A king who would actually be alive and rule over them
5	Why did all the frogs die?	The stork ate them all	The stork killed them all	The stork ate them all

We can observe the following from fig 4.240: 34SR36MR has been able to answer all 5 questions in the first story and the second story. The control participant answered all questions, as well as the mean of the control group 58MEANMC and the mean of the RHD group 60MEANFR.

B. SENTENCES

Declaratives

Fig 3.242 – 3.244. We can observe the following from the figure displayed previously: In sentence 1, 34SR36MR, 13AS36MC, 50MEANMR and 49MEANMC, all have recorded curves belonging to the type C. The type C sentence begins at the highest pitch point, the second point is lower than the starting point and the third point is either equal to or lower than the pitch point in the middle. Type C generally denotes declarative sentences. In sentence 2 34SR36MR has recorded a type D curve again, in comparison with 13AS36MC, 50MEANMR and 49MEANMC, who have also recorded curves belonging to the type D. 49MEANMC recorded at a pitch range which is much higher than the mean of the RHD group 50MEANMR. In sentence 3, 34SR36MR has a type B curve in comparison with 13AS36MC who has recorded a type C sentence. 50MEANMR and 49MEANMC have recorded type B sentences.

Imperatives

Fig 3.245 – 3.247. We can observe the following from the figure displayed previously: In sentence 4, 34SR36MR, 13AS36MC, 50MEANMR and 49MEANMC have all made type D sentences. In sentence 5, 34SR36MR, 13AS36MC, 50MEANMR and 49MEANMC all have type D sentences. In a type D sentence, the highest pitch point in a sentence is in the middle. In sentence 6, 34SR36MR, 13AS36MC, 50MEANMR and 49MEANMC all have type C sentences.

Interrogatives

Fig 3.248 – 3.250. We can observe the following from the figure displayed previously: In sentence 7, 34SR36MR has a D type sentence in comparison with 13AS36MC, who also has a type D sentences. 50MEANMR and 49MEANMC also have recorded type D sentences. In sentence 8, 34SR36MR has made a type D sentence in comparison with 13AS36MC, who also has made a type D sentence. 50MEANMR also has a type D sentence and from the chart 49MEANMC has no visible contour, but on checking the figures, 49MEANMC has made a type D sentence as well. In sentence 9, 34SR36MR has a type D curve in comparison with 13AS36MC, 50MEANMR and 49MEANMC who also have type D sentences.

C. VOWELS

Fig 3.241 compares female RHD participant 34SR36MR with the individual age and gender matched male, that is 13AS36MC. We can observe the following from the figure displayed previously: The vowel /i/ (f1=-238, f2-f1=-2132) in 34SR36MR is more fronted than vowel /i/ (f1=-340, f2-f1=-1725) in 13AS36MC. The vowel /e/ (f1=-347, f2-f1=-1859) in 34SR36MR is a lot more fronted and slightly higher than vowel /e/ (f1=-416, f2-f1=-1423) in 13AS36MC. The vowel /æ/ (f1=-711, f2-f1=-1131) in 34SR36MR is lower and backed in comparison vowel with vowel /æ/ (f1=-604, f2-f1=-1154) in 13AS36MC. The vowel /ɑ/ (f1=-830, f2-f1=-423) in 34SR36MR is lower and backed in comparison with vowel /ɑ/ (f1=-639, f2-f1=-759) in 13AS36MC. The vowel /ɔ/ (f1=-691, f2-f1=-365) in 34SR36MR is more lower and backed than vowel /ɔ/ (f1=-555, f2-f1=-492) in 13AS36MC. The vowel /o/ (f1=-434, f2-f1=-323) in 34SR36MR is higher and more backed than vowel /o/ (f1=-447, f2-f1=-727) in 13AS36MC. The vowel /u/ (f1=-288, f2-f1=-484) in 34SR36MR is higher and more backed in comparison with vowel /u/ (f1=-359, f2-f1=-567) in 13AS36MC. The area of the acoustic space chart for 34SR36MR is 586667.5 and for 13AS36MC is 198261.5, and 96MEANMR is 336881. The area of 34SR36MR is 195% bigger than that of the individual control and 74% larger than the mean of RHD participants. The area of the RHD participant is significantly larger than the acoustic space area of the control. The RHD participant has much more tongue movement in terms of both front and back and high or low, in comparison with the control participant. The RHD acoustic space engulfs the whole control participant acoustic space.

3.5.14. CASE STUDY 14

PRIMARY INFO

Codified Name: 35SA58MR.

Male, 58 years of age, at the time of recording and case study.

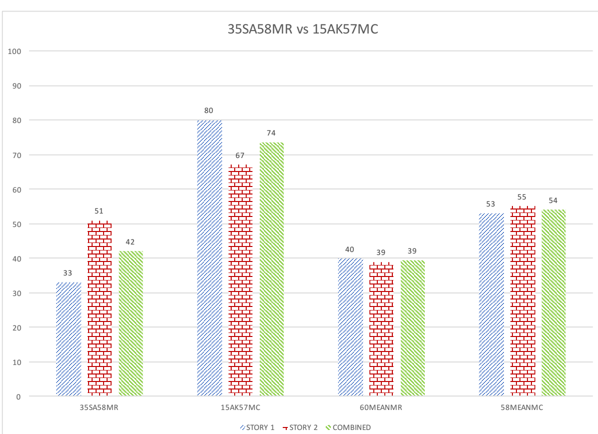
Age and gender matched control: 15AK57MC

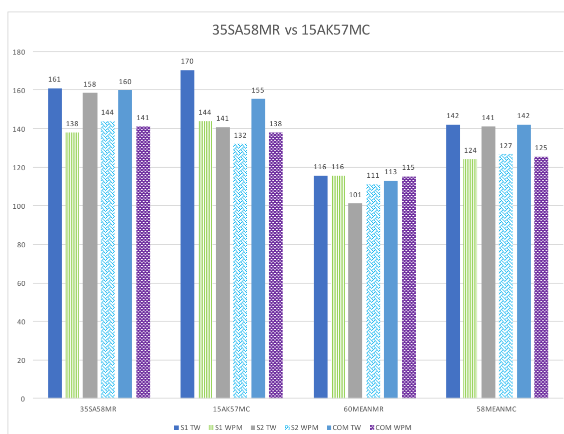
Time since incidence: approximately 2 months back, at the time of recording.

PARTICIPANT INFORMATION

Condition of participant: The participant was fully conscious, having scored 15 on the GCS. He also scored 29 on the MMSE. The participant can walk but is still weak in the left hemisphere and at times needs help from family members. It cannot be termed as hemiparesis, because he can control all his left hemisphere functions, but the doctor noticed a significant lack of strength in the left hemisphere. The doctor asked him to do some actions with his hands, involving muscle coordination and he could do it but it took him time to do the actions. The participant could also perform actions based on instructions, which involved complicated and elaborate instructions, but again, it took time. The speech of the participant was slurred, and was difficult to understand. The participant displayed no left hemisphere neglect. The doctor also performed a test in which he held both of the participant's hands in his hands and then asked the participant to keep holding them where he is holding them, after he lets them go. He could maintain the position of the right hand but the left hand fell down to some extent before he could gain back control. The participant has no problems in remembering things. He remembers old facts and memories completely as well. He is undergoing no physiotherapy. **Observations made by doctor:** The doctor mentions that he has no agraphia, no dementia, but has alexia (he cannot read). Participant is highly hypertensive. Participant is not an alcoholic but was a smoker. Participant has no problems in planning and judgement. **Diagnosis made by doctor:** The doctor mentions that the participant has chances of suffering another stroke, if he does not refrain from strenuous situations. He was also advised to keep away from alcohol and smoking. He was asked to continue medicines for blood pressure and to follow up in two months. **Region of damage:** Blockage of the **right MCA** causing ischemic stroke to the **right parietal lobe**.

COMPREHENSIVE STUDY OF PARTICIPANT AT THE 3 LEVELS OF COMMUNICATION





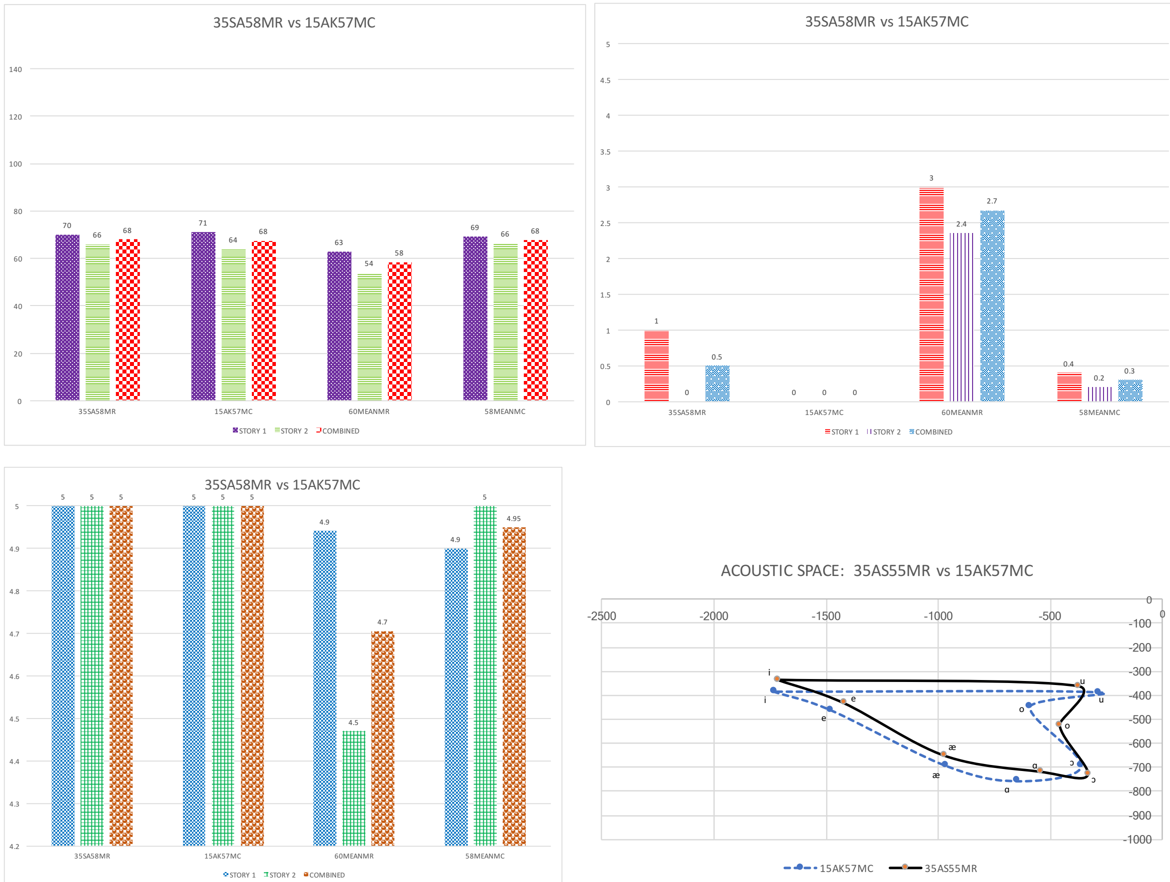
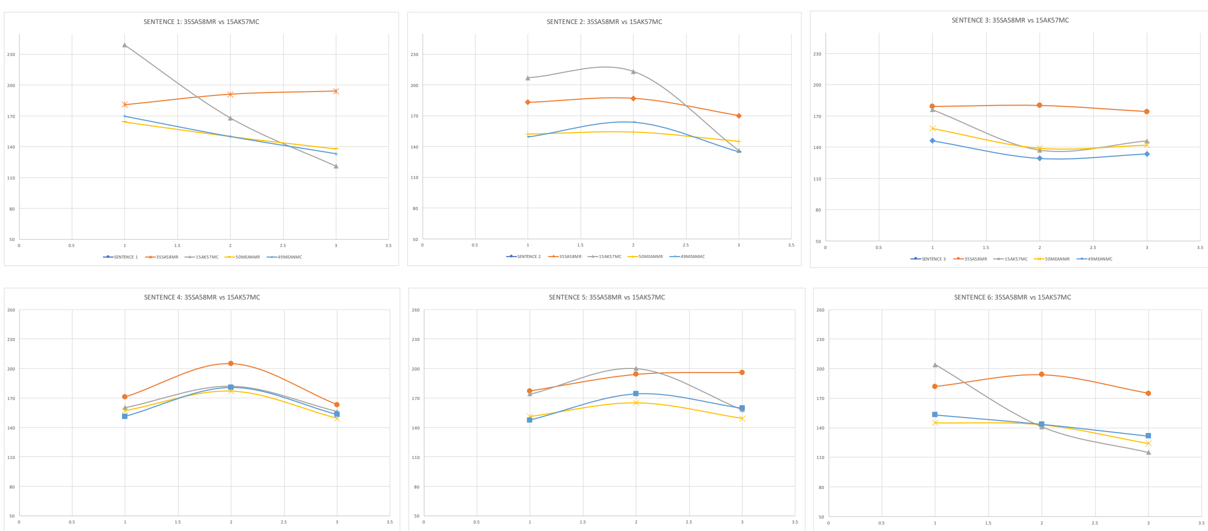
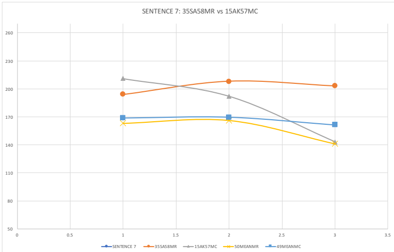
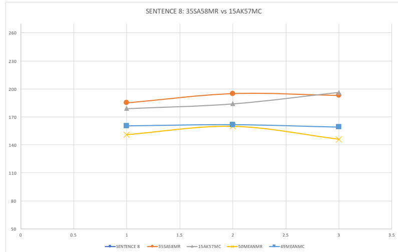


Fig 3.251 to 3.256: 35SA58MR - The bar graphs are comparisons at the level of discourse. The last diagram is an acoustic space.







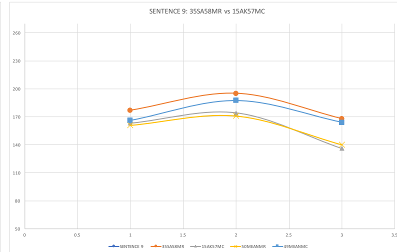


Fig 3.257 to 3.265: 35SA58MR - First three diagrams in first line are declarative sentences. The next line is composed of 3 imperative sentences and the third line has three interrogative sentences.

A. Discourse

1. Pitch range

We can observe the following from fig 3.251: 35SA58MR has a pitch range of 33 Hz in the first story in comparison with 15AK57MC, who has a pitch range of 80 Hz. 60MEANMR has a pitch range of 40 Hz in the first story while 58MEANMC has a pitch range of 53 Hz in the first story. 35SA58MR has a pitch range of 51 Hz in the second story in comparison with 15AK57MC, who has a pitch range of 67 Hz. 60MEANMR has a pitch range of 39 Hz in the first story while 58MEANMC has a pitch range of 55 Hz in the second story. 35SA58MR has a pitch range of 42 Hz in the mean of the stories in comparison with 15AK57MC, who has a pitch range of 74 Hz. The difference is huge and shows the diminished pitch range in the speech of the RHD participant. 60MEANMR has a pitch range of 39 Hz in the mean of the two stories while 58MEANMC has a pitch range of 54 Hz in the same.

2. Fluency

We can observe the following from fig 3.252: 35SA58MR has 161 words in story 1 in comparison with 15AK57MC, who has 170 words, which is a small difference. 35SA58MR has a word rate of 138 wpm in story 1 in comparison with 15AK57MC, who has 144 wpm. 35SA58MR has 158 words in story 2 in comparison with 15AK57MC, who has 141 words. 35SA58MR has a word rate of 144 wpm in story 2 in comparison with 15AK57MC, who has 132 wpm. 35SA58MR has 160 words in the combined mean of the two stories in comparison with 15AK57MC, who has 155 words. 35SA58MR has a word rate of 141 wpm in the combined mean of the two stories in comparison with 15AK57MC, who has 138 wpm. The RHD participant has a performance, which is very similar to that of the control participant and is definitely better than the RHD group mean.

3. **Duration**

We can observe the following from fig 3.253: 35SA58MR took 70 seconds (fluency – 138 words per minute) to complete narrating the first story in comparison with 15AK57MC, who took 71 seconds (fluency – 144 words per minute). 35SA58MR took 66 seconds (fluency – 144 words per minute) to complete narrating the second story in comparison with 15AK57MC, who took 64 seconds (fluency – 132 words per minute). 35SA58MR has a mean duration of 68 seconds (fluency – 141 words per minute) whereas, 15AK57MC has a mean of 68 seconds (fluency – 138 words per minute). 35SA58MR also completed the stories at the same time as 58MEANMC with a duration of 68 seconds (fluency – 125 words per minute) and slower than 60MEANMR with a duration of 58 seconds (fluency – 113 words per minute), in the mean of the two stories.

4. Digressions and lapses

Story 1 (Narrator)	RHD participant	Control participant
There was a deer. It was standing at the edge of the river. It saw its majestic antlers in the river, as a reflection. It kept praising it. Next it saw its feet and started to demean it because it was thin and did not match the overall beauty of the whole body. In the meantime, a hunter shot an arrow but missed. The deer started running in fear but ultimately got caught by the antlers in a bushy area. He exclaimed that the antlers he was praising put him in utter danger but his legs he was demeaning, tried to help him run that far.	A deer was at a river side and could look at its reflection. First it saw its antlers and the body <u>and the color</u>. It praised its antlers and then felt ashamed of the thin legs. A hunter, in the meantime shot the deer but missed. The deer started to run and then while running the antlers got caught in a creeper bush. The deer then realized that the antlers weren't worth praising and the legs deserved more praise.	A deer, on being thirsty, went to a river side and saw its reflection. At first it saw its antlers and felt proud about it. Then it saw its legs and felt bad about the thin legs. A hunter shot an arrow in the meantime. The deer fled for its life and got caught in a bush or hedge. The hunter was catching up. The deer realized that although he was abusing and demeaning the legs did try to help him run but the antlers which he was praising and feeling good about, got him caught.

Story 2 (Narrator)	RHD participant	Control participant
Thousands of frogs lived in a small pond. They were happy but they wanted a king. So, they prayed to God for a king. God sent a big tree trunk to them. At first, they were intimidated by its size but soon they discovered, their new king did not move and did not talk. One brave frog climbed to the top of the trunk and after that many others gathered the courage and climbed to the top. They were unhappy and they prayed to God again stating	There was a small pond and many frogs lived in it. They wanted a king and requested to God for the same. God sent them a tree bark. They were afraid at first but then they noticed that the king didn't move for long. Then they started to climb the king. Soon they prayed to God again for another king, who would actually rule	In a pond, there were many frogs. The frogs realized they had no king and they praised to God for a king. But God wasn't thinking much and dropped a tree bark in the pond. The king didn't move. In a few days, the frogs noticed the king didn't move. They touched the tree bark and it still didn't move. They realized it was inanimate and they complained to God requesting him to send a

that the king they were sent was inanimate and they want a new king who would be alive and actually rule over them. God got a bit angry. He sent a stork to the pond and the stork ate up all the frogs.	over them. God got irritated at this and sent them a stork, who came to their place and started to eat all the frogs. They realized it was too late.	king again, who would be actually animate and rule over them. God got angry and sent a stork over to their place. The stork ate all the frogs one by one.

We can see one digression in story 1 for the RHD participant but none in story 2. The control participant on the other hand had no digressions in both the stories. There were no lapses in the narration of the control participant as well, in both the stories.

5. **Questions answered**

STORY 1				
	Questions	Actual answer	RHD participant	Control participant
1	Which animal(s) were mentioned in the story?	A deer	A deer	A deer
2	What was the deer doing?	Looking at his reflection	Looking at its reflection	Looking at his reflection
3	Why did the deer run?	A hunter shot an arrow but it didn't touch	A hunter followed it	A hunter shot an arrow. The deer ran for its life.
4	Why was he caught?	His big antlers were caught in a bush	Antlers	His big antlers were caught in a bush
5	What was the deer insulting, in the beginning?	His thin legs, that don't match his antlers and body.	The legs	His thin legs, that don't match his antlers and body.

STORY 2				
	Questions	Actual answer	RHD participant	Control participant
1	Which animal(s) were mentioned in the story?	Frogs, stork	Frogs and a stork in the end	Frogs, stork
2	Where did the frogs live?	In a small pond	In a marshy and small pond	In a small pond
3	What did the frogs want the first time?	A king	**A king who would rule them**	A king
4	What did the frogs want the second time?	A king who would actually be alive and rule over them	A king who would actually rule over them	A king who would actually be alive and rule over them
5	Why did all the frogs die?	The stork ate them all	The stork killed them all	The stork ate them all

We can observe the following from fig 3.255: 35SA58MR has been able to answer all 5 questions in the first story but only 4 questions in the second story. The control participant answered all questions, as well as the mean of the control group 58MEANMC and the mean of the RHD group 60MEANFR.

B. SENTENCES

Declaratives

Fig 3.257 – 3.259. We can observe the following from the figure displayed previously: In sentence 1, 35SA58MR has a type A sentence while 15AK57MC, 50MEANMR and 49MEANMC, have recorded curves belonging to the type C of sentence. The type C sentence begins at the highest pitch point, the second point is lower than the starting point and the third point is either equal to or lower than the pitch point in the middle. In sentence 35SA58MR, 15AK57MC, 50MEANMR and 49MEANMC, have recorded curves belonging to the type D of sentence. In sentence 3, 15AK57MC, 50MEANMR and 49MEANMC a type B sentence in comparison with 35SA58MR, who has used a type D sentence. On an average, the pitch points recorded for 15AK57MC are higher than the others.

Imperatives

Fig 3.260 – 3.262. We can observe the following from the figure displayed previously: In sentence 4, 35SA58MR, 15AK57MC, 50MEANMR and 49MEANMC have all made type D sentences. In sentence 5, 35SA58MR has a type A sentence, while 15AK57MC, 50MEANMR and 49MEANMC have made type D sentences. In a type D sentence, the highest pitch point in a sentence is in the middle. In sentence 6, 35SA58MR has a type D sentence, while 15AK57MC, 50MEANMR and 49MEANMC have made type C sentences.

Interrogatives

Fig 3.263 – 3.265. We can observe the following from the figure displayed previously: In sentence 7, 35SA58MR has a type D sentence while 15AK57MC has a type C sentence in comparison with 50MEANMR and 49MEANMC who have recorded type D sentences. In sentence 8, 35SA58MR has made a type D sentence in comparison with 15AK57MC, who has made a type A sentence. 50MEANMR has a type D sentence and from the chart 49MEANMC has no visible contour, but on checking the figures, 49MEANMC has made a type D sentence as well. In sentence 9, 35SA58MR, 15AK57MC, 50MEANMR and 49MEANMC have all made type D sentences.

C. VOWELS

Fig 3.256 compares female RHD participant 35SA58MR with the individual age and gender matched male, that is 15AK57MC. We can observe the following from the figure displayed previously: The vowel /i/ (f1=-338, f2-f1=-1716) in 35SA58MR is slightly higher than vowel /i/ (f1=-387, f2-f1=-1734) in 15AK57MC. The vowel /e/ (f1=-434, f2-f1=-1420) in 35SA58MR is slightly backed and higher than vowel /e/ (f1=-464, f2-f1=-1479) in 15AK57MC. The vowel

/æ/ (f1=-651, f2-f1=-971) in 35SA58MR a slightly higher in comparison vowel with vowel /æ/ (f1=-693, f2-f1=-970) in 15AK57MC. The vowel /ɑ/ (f1=-717, f2-f1=-545) in 35SA58MR is higher and slightly backed than vowel /ɑ/ (f1=-758, f2-f1=-649) in 15AK57MC. The vowel /ɔ/ (f1=-730, f2-f1=-333) in 35SA58MR is lower and slightly backed than vowel /ɔ/ (f1=-695, f2-f1=-363) in 15AK57MC. The vowel /o/ (f1=-524, f2-f1=-459) in 35SA58MR is slightly backed and lower than vowel /o/ (f1=-450, f2-f1=-592) in 15AK57MC. The vowel /u/ (f1=-364, f2-f1=-337) in 35SA58MR is slightly higher and fronted than vowel /u/ (f1=-390, f2-f1=-289) in 15AK57MC. The area of the acoustic space chart for 35SA58MR is 290021.5 and for 15AK57MC is 278398.5, and 96MEANMR is 336881. The area of 35SA58MR is 4.2% bigger than that of the individual control but 13.9% smaller than the mean of RHD participants. It can be seen that the control participant 15AK57MC has a smaller acoustic space than the RHD participant 35SA58MR. The RHD participant and the control participant have similar front and back ranges, as well as high and low, in the acoustic space.

3.5.15.CASE STUDY 15

PRIMARY INFO

Codified Name: 36SB47MR

Male, 47 years of age, at the time of recording and case study.

Age and gender matched control: 20SD48MC

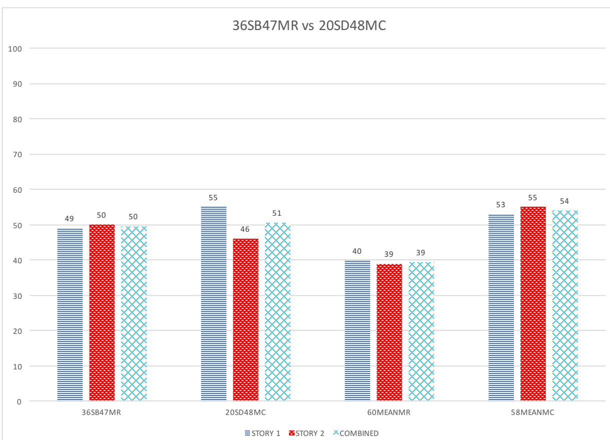
Time since incidence: approximately 1 year and 10 months back, at the time of recording.

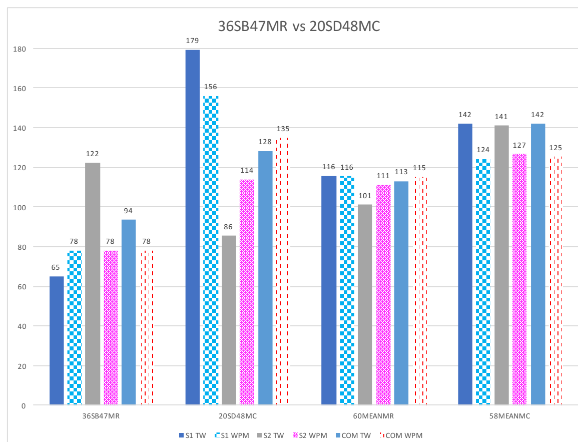
PARTICIPANT INFORMATION

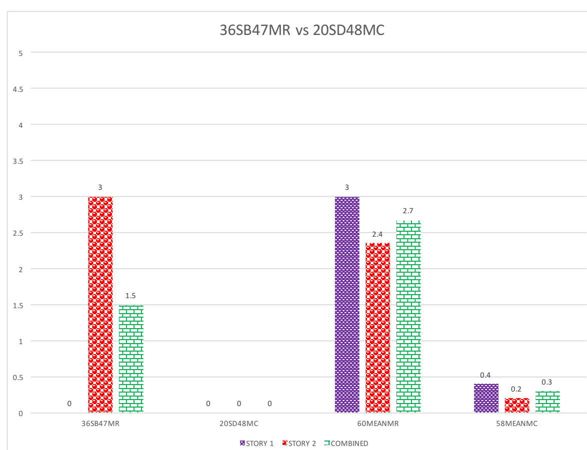
Condition of participant: The participant was conscious, and scored 14 on the GCS. He scored 26 on the MMSE. The participant can walk without any problems but still has weakness in the left side of the body. The doctor has advised the participant to not do strenuous activities.

The doctor asked him to do some actions with his hand, involving muscle coordination and he could do them with ease. The participant did not face any difficulty in performing actions based on instructions, which involved complicated and elaborate instructions. The speech of the participant was not slurred or difficult to understand. The participant displays no left hemisphere neglect. His sense of color recognition was intact. The doctor also performed a test in which he held both of the participant's hands in his hands and then asked the participant to keep holding them where he is holding them, after he lets them go. He could maintain the position of both the hands. The participant had some issues in remembering things. The doctor asked him to mention what he had last night and he could remember but he forgot some key details about the phase before he was hospitalized for stroke. He is undergoing no physiotherapy. **Observations made by doctor:** The doctor mentions that he has no agraphia, no dementia, and no alexia. Participant is not hypertensive. Participant is not an alcoholic and not a smoker. Participant has no problems in planning and judgement. **Diagnosis made by doctor:** The doctor mentions that the participant needs to be start physiotherapy for the left side of the body. He was asked to follow up in six months. **Region of damage:** Subacute non-hemorrhagic infarction at the **right medial temporal lobe, post limb of right internal capsule and adjacent putamen.**

COMPREHENSIVE STUDY OF PARTICIPANT AT THE 3 LEVELS OF COMMUNICATION







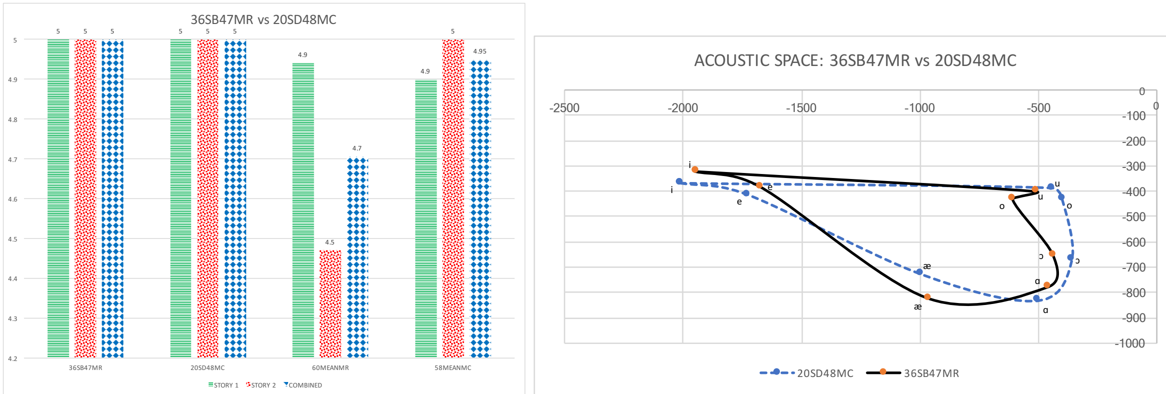


Fig 3.266 to 3.271: 36SB47MR - The bar graphs are comparisons at the level of discourse. The last diagram is an acoustic space.

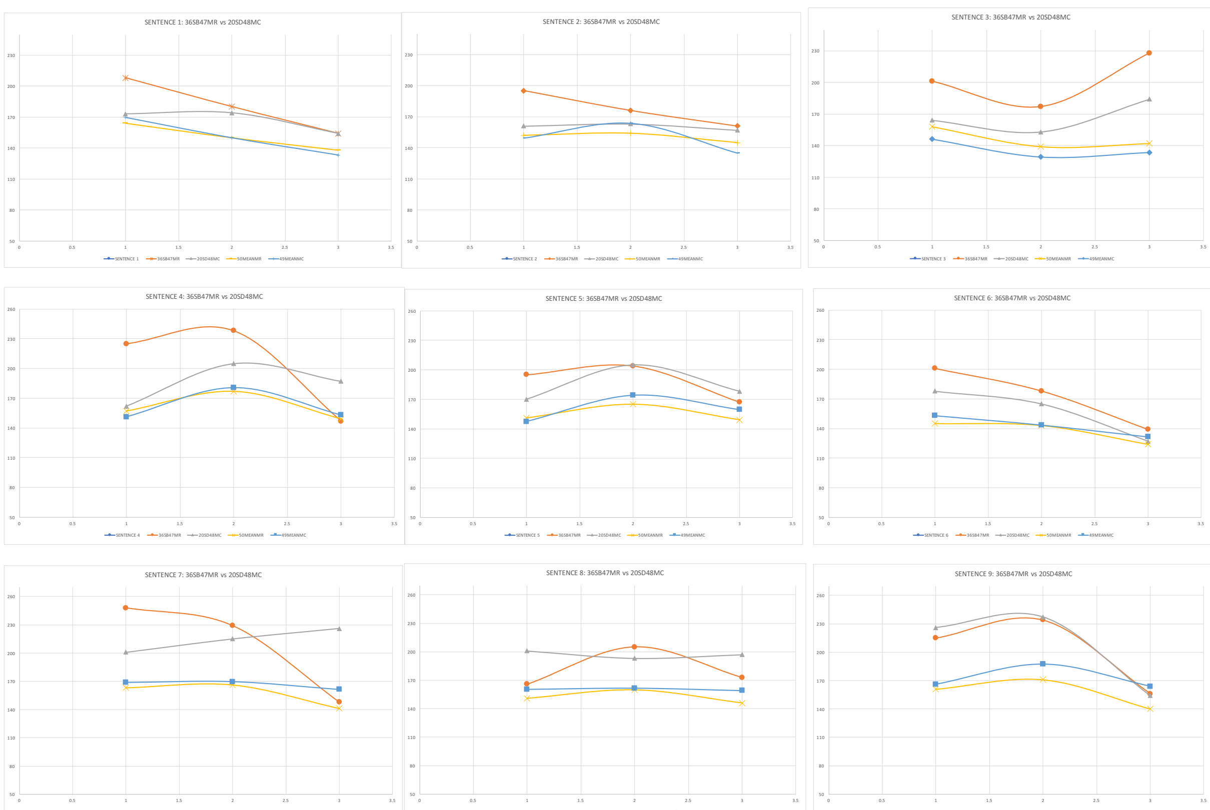


Fig 3.272 to 3.280: 36SB47MR - First three diagrams in first line are declarative sentences. The next line is composed of 3 imperative sentences and the third line has three interrogative sentences.

A. Discourse

1. Pitch range

We can observe the following from fig 3.266: 36SB47MR has a pitch range of 49 Hz in the first story in comparison with 20SD48MC, who has a pitch range of 55 Hz. 60MEANMR has a pitch range of 40 Hz in the first story while 58MEANMC has a pitch range of 53 Hz in the first story. 36SB47MR has a pitch range of 50 Hz in the second story in comparison with 20SD48MC, who has a pitch range of 46 Hz. 60MEANMR has a pitch range of 39 Hz in the second story while 58MEANMC has a pitch range of 55 Hz in the second story. 36SB47MR has a pitch range of 50 Hz in the mean of the stories in comparison with 20SD48MC, who has a pitch range of 51 Hz. 60MEANMR has a pitch range of 39 Hz in the mean of the two stories while 58MEANMC has a pitch range of 54 Hz in the same. The RHD participant has a similar pitch range, in comparison with that of the control participant.

2. **Fluency**

We can observe the following from fig 3.267: 36SB47MR has 65 words in story 1 in comparison with 20SD48MC, who has 179 words, which is a huge difference. 36SB47MR has a word rate of 78 wpm in story 1 in comparison with 20SD48MC, who has 156 wpm. 36SB47MR has 122 words in story 2 in comparison with 20SD48MC, who has 86 words. 36SB47MR has a word rate of 78 wpm in story 2 in comparison with 20SD48MC, who has 114 wpm. 36SB47MR has 94 words in the combined mean of the two stories in comparison with 20SD48MC, who has 128 words. 36SB47MR has a word rate of 78 wpm in the combined mean of the two stories in comparison with 20SD48MC, who has 135 wpm. The RHD participant has a poor total word count and fluency figure, in comparison to the control and control group, although, it is surprising to see the RHD participant have 122 total words in the second story

3. **Duration**

We can observe the following from fig 3.268: 36SB47MR took 50 seconds (fluency – 156 words per minute) to complete narrating the first story in comparison with 20SD48MC, who took 69 seconds (fluency – 156 words per minute). 36SB47MR took 94 seconds (fluency – 168 words per minute) to complete narrating the second story in comparison with 20SD48MC, who took 45 seconds (fluency – 114 words per minute). 36SB47MR has a mean duration of 58 seconds (fluency – 162 words per minute) whereas, 20SD48MC has a mean of 57 seconds (fluency – 135 words per minute). 58MEANMC took a time of 72 seconds (fluency – 125 words per minute) and 60MEANMR took a time of 58 seconds (fluency – 113 words per minute), in the mean of the two stories.

4. Digressions and lapses

Story 1 (Narrator)	RHD participant	Control participant
There was a deer. It was standing at the edge of the river. It saw its majestic antlers in the river, as a reflection. It kept praising it. Next it saw its feet and started to demean it because it was thin and did not match the overall beauty of the whole body. In the meantime, a hunter shot an arrow but missed. The deer started running in fear but ultimately got caught by the antlers in a bushy area. He exclaimed that the antlers he was praising put him in utter danger but his legs he was demeaning, tried to help him run that far.	A male deer went to drink water at a river and saw its reflection. It saw its antlers and loved it but saw its thin legs and was ashamed of them. Then it ran after a hunter shot an arrow at it, but missed. The deer got stuck in a bush with the antlers and then the deer realized that the antlers didn't deserve so much praise which the thin legs actually did deserve praise.	In a forest lived a deer. It went to drink water and noticed its reflection in the water. It praised it beautiful antlers and then suddenly noticed the thin legs and felt ashamed of having such thin legs. In the meantime, a hunter shot an arrow at the deer and missed. The deer started running and then got caught by the antlers in a bush. The deer then realized that what it was praising got it caught but what it was ashamed of helped it escape, although the antlers got it caught finally.

Story 2 (Narrator)	RHD participant	Control participant
Thousands of frogs lived in a small pond. They were happy but they wanted a king. So, they prayed to God for a king. God sent a big tree trunk to them. At first, they were intimidated by its size but soon they discovered, their new king did not move and did not talk. One brave frog climbed to the top of the trunk and after that many others gathered the courage and climbed to the top. They were unhappy and they prayed to God again stating that the king they were sent was inanimate and they want a new king who would be alive and actually rule over them. God got a bit angry. He sent a stork to the pond and the stork ate up all the frogs.	There was a small pond. Many frogs lived in it. One day they decided to pray to God. They asked God for someone to protect them. They asked for a <u>king to rule</u>. No, they wanted a king. God dropped a tree bark and <u>they started to climb on the tree regularly</u>. They found out the king was of no use. <u>They then wanted God to send a stork</u>, no, a king. Then God sent a stork who ate all the frogs.	Many frogs lived in a small pond. One day they prayed to God for a king. God put a tree bark in the pond. But the frogs noticed that the king didn't move or budge. They touched it and it was inanimate to touch. The frogs felt bad and prayed to God again for another king, a second king, who would actually be animate and rule over them. God got angry at this and sent a stork to their home. The stork then started eating all the frogs one by one.

We can see 0 digressions in story 1 for the RHD participant but 3 digressions in story 2. From the table above, which contain the stories, we can discern that the RHD participant had some issues in remembering the second story but no issues in remembering the first story. The control participant had 0 digressions in the first story and 0 digressions in the second story as well. There were no major lapses, even in the narration of the control participant as well, in both the stories.

5. **Questions answered**

STORY 1				
	Questions	Actual answer	RHD participant	Control participant

1	Which animal(s) were mentioned in the story?	A deer	A deer	A deer
2	What was the deer doing?	Looking at his reflection	Looking at its reflection	Looking at his reflection
3	Why did the deer run?	A hunter shot an arrow but it didn't touch	A hunter followed it	A hunter shot an arrow. The deer ran for its life.
4	Why was he caught?	His big antlers were caught in a bush	Antlers got caught in creepers.	The antlers got caught in a hedge.
5	What was the deer insulting, in the beginning?	His thin legs, that don't match his antlers and body.	The legs	His thin legs, that don't match his antlers and body.

STORY 2				
	Questions	Actual answer	RHD participant	Control participant
1	Which animal(s) were mentioned in the story?	Frogs, stork	Frogs and a stork in the end	Frogs, stork
2	Where did the frogs live?	In a small pond	In a marshy and small pond	In a small pond
3	What did the frogs want the first time?	A king	A king	A king
4	What did the frogs want the second time?	A king who would actually be alive and rule over them	A king who would rule	A king who would actually be alive and rule over them
5	Why did all the frogs die?	The stork ate them all	The stork killed them all	The stork ate them all

We can observe the following from fig 3.270: 36SB47MR has been able to answer all 5 questions in the both stories. The control participant answered all questions in both the stories.

B. Sentences

Declaratives

Fig 3.272 – 3.274. We can observe the following from the figure displayed previously: In sentence 1, 36SB47MR has a type C curve, and 20SD48MC, has a type D curve as well. 50MEANMR and 49MEANMC, have recorded curves belonging to the type C of sentence. The type C sentence begins at the highest pitch point, the second point is lower than the starting point and the third point is either equal to or lower than the pitch point in the middle. In sentence 2, 36SB47MR has recorded a type C curve, in comparison with 20SD48MC, who has a type D curve. 50MEANMR and 49MEANMC, have recorded curves belonging to the type D. In sentence 3, 36SB47MR, 20SD48MC, 50MEANMR and 49MEANMC have type B sentences.

Imperatives

Fig 3.275 – 3.277. We can observe the following from the figure displayed previously:_In sentence 4, 36SB47MR, 20SD48MC, 50MEANMR and 49MEANMC have type D sentences.

In sentence 5, 36SB47MR, 20SD48MC, 50MEANMR and 49MEANMC have type D sentences. In a type D sentence, the highest pitch point in a sentence is in the middle. In sentence 6, 36SB47MR conforms to a type C sentence while 20SD48MC also conforms to a type C sentence. 50MEANMR and 49MEANMC have type C sentences.

Interrogatives

Fig 3.278 – 3.280. We can observe the following from the figure displayed previously: In sentence 7, 36SB47MR has a C type sentence in comparison with 20SD48MC, who has a type A sentences. This is in contrast with 50MEANMR and 49MEANMC who have recorded type D sentences. In sentence 8, 36SB47MR has made a type D sentence in comparison with 20SD48MC, who has made a type B sentence. 50MEANMR has a type D sentence and from the chart 49MEANMC has no visible contour, but on checking the figures, 49MEANMC has made a type D sentence as well. In sentence 9, 36SB47MR has a type D curve in comparison with 20SD48MC, 50MEANMR and 49MEANMC who also have type D sentences.

C. VOWELS

Fig 3.271 compares female RHD participant 36SB47MR with the individual age and gender matched male, that is 15AK57MC. We can observe the following from the figure displayed previously: The vowel /i/ (f1=-322, f2-f1=-1948) in 36SB47MR is higher and slightly backed in comparison with as vowel /i/ (f1=-368, f2-f1=-2011) in 20SD48MC. The vowel /e/ (f1=-381, f2-f1=-1677) in 36SB47MR is backed and slightly higher than vowel /e/ (f1=-412, f2-f1=-1732) in 20SD48MC. The vowel /æ/ (f1=-823, f2-f1=-967) in 36SB47MR is lower comparison than vowel /æ/ (f1=-726, f2-f1=-998) in 20SD48MC. The vowel /ɑ/ (f1=-779, f2-f1=-462) in 36SB47MR is higher and backed in comparison with vowel /ɑ/ (f1=-831, f2-f1=-506) in 20SD48MC. The vowel /ɔ/ (f1=-653, f2-f1=-439) in 36SB47MR is more fronted in comparison with vowel /ɔ/ (f1=-670, f2-f1=-361) in 20SD48MC. The vowel /o/ (f1=-431, f2-f1=-610) in 36SB47MR is more fronted and slightly higher in comparison with vowel /o/ (f1=-432, f2-f1=-402) in 20SD48MC. The vowel /u/ (f1=-401, f2-f1=-513) in 36SB47MR is slightly lower and fronted in comparison with vowel /u/ (f1=-387, f2-f1=-442) in 20SD48MC. The area of the acoustic space chart for 36SB47MR is 372567 and for 20SD48MC is 387032, and 96MEANMR is 336881. The area of 36SB47MR is 3.7% smaller than that of the individual control and 10.6% larger than the mean of RHD participants.

3.5.16. CASE STUDY 16

PRIMARY INFO

Codified Name: 37SH31MR

Male, 31 years of age, at the time of recording and case study.

Age and gender matched control: 17SB30MC

Time since incidence: approximately 1 year and 10 months back, at the time of recording.

PARTICIPANT INFORMATION

Condition of participant: The participant was conscious, and scored 15 on the GCS. He scored 28 on the MMSE. The participant can walk without any problems. The doctor asked him to do some actions with his hand, involving muscle coordination and he could do them with ease. The participant did not face any difficulty in performing actions based on instructions, which involved complicated and elaborate instructions. The speech of the participant was not slurred or difficult to understand. The participant displays no left hemisphere neglect. His sense of color recognition was intact. The doctor also performed a test in which he held both of the participant's hands in his hands and then asked the participant to keep holding them where he is holding them, after he lets them go. He could maintain the position of both the hands. The participant had some issues in remembering things. The doctor asked him to mention what he had last night and he could remember but he forgot some key details about the phase before he was hospitalized for stroke. He is undergoing no physiotherapy due to his financial condition. **Observations made by doctor:** The doctor mentions that he has no agraphia, no dementia, and no alexia. Participant is not hypertensive. Participant is not an alcoholic and not a smoker. Participant has no problems in planning and judgement. Participant has difficulty in controlling the hands, while doing intricate activities like threading a needle. It is important to know here, that the participant was a weaver and he lost his business after the stroke because of his inability to weave anymore. **Diagnosis made by doctor:** The doctor mentions that the participant needs to be start physiotherapy for him to regain his skills in weaving, which can be regained to some extent. He was asked to follow up in three months. **Region of damage:** Hyper acute infarction in **right ganglio-capsular region**.

COMPREHENSIVE STUDY OF PARTICIPANT AT THE 3 LEVELS OF COMMUNICATION

Fig 3.281 to 3.286: 37SH31MR - The bar graphs are comparisons at the level of discourse. The last diagram is an acoustic space.

Fig 3.287 to 3.295: 37SH31MR - First three diagrams in first line are declarative sentences. The next line is composed of 3 imperative sentences and the third line has three interrogative sentences.

A. DISCOURSE

1. Pitch range

We can observe the following from 3.281: 37SH31MR has a pitch range of 31 Hz in the first story in comparison with 17SB30MC, who has a pitch range of 72 Hz. 60MEANMR has a pitch range of 40 Hz in the first story while 58MEANMC has a pitch range of 53 Hz in the first story. 37SH31MR has a pitch range of 48 Hz in the second story in comparison with 17SB30MC, who has a pitch range of 64 Hz. 60MEANMR has a pitch range of 39 Hz in the second story while 58MEANMC has a pitch range of 55 Hz in the second story. 37SH31MR has a pitch range of 40 Hz in the mean of the stories in comparison with 17SB30MC, who has a pitch range of 68 Hz. 60MEANMR has a pitch range of 39 Hz in the mean of the two stories while 58MEANMC has a pitch range of 54 Hz in the same. The RHD participant has a much smaller pitch range than the control participant.

2. Fluency

We can observe the following from fig 3.282: 37SH31MR has 116 words in story 1 in comparison with 17SB30MC, who has 171 words, which is a huge difference. 37SH31MR has a word rate of 126 wpm in story 1 in comparison with 17SB30MC, who has 108 wpm. 37SH31MR has 136 words in story 2 in comparison with 17SB30MC, who has 116 words. 37SH31MR has a word rate of 132 wpm in story 2 in comparison with 17SB30MC, who has 120 wpm. 37SH31MR has 126 words in the combined mean of the two stories in comparison with 17SB30MC, who has 145 words. 37SH31MR has a word rate of 129 wpm in the combined mean of the two stories in comparison with 17SB30MC, who has 114 wpm. The RHD participant has a performance, similar to that of the control participant.

3. **Duration**

We can observe the following from fig 3.283: 37SH31MR took 55 seconds (fluency – 126 words per minute) to complete narrating the first story in comparison with 17SB30MC, who took 95 seconds (fluency – 108 words per minute). 37SH31MR took 62 seconds (fluency – 132 words per minute) to complete narrating the second story in comparison with 17SB30MC, who took 58 seconds (fluency – 120 words per minute). 37SH31MR has a mean duration of 59 seconds (fluency – 129 words per minute) whereas, 17SB30MC has a mean of 77 seconds (fluency – 114 words per minute). 58MEANMC took a time of 72 seconds (fluency – 125 words per minute) and 60MEANMR took a time of 58 seconds (fluency – 113 words per minute), in the mean of the two stories. The participant was speaking very fast and that is evident from his duration and rate of speech or fluency.

4. Digressions and lapses

Story 1 (Narrator)	RHD participant	Control participant
There was a deer. It was standing at the edge of the river. It saw its majestic antlers in the river, as a reflection. It kept praising it. Next it saw its feet and started to demean it because it was thin and did not match the overall beauty of the whole body. In the meantime, a hunter shot an arrow but missed. The deer started running in fear but ultimately got caught by the antlers in a bushy area. He exclaimed that the antlers he was praising put him in utter danger but his legs he was demeaning, tried to help him run that far.	A deer came and was thirsty, so went to drink water. Then it saw the reflection and praised its antlers but felt ashamed of its legs, which were thin. Then a hunter shot an arrow, but it missed. The deer ran in fear. Then it got stuck by its antlers in a hedge. It realized that the legs actually tried to save it but the antlers it was so praising actually got it caught.	There was a deer and it went to drink water from a river one day because it was thirsty. Then it noticed its reflection in the water and praised its antlers. <u>Then it knelt down and noticed its thin legs</u> and because the legs were thin, the deer felt ashamed. In the meantime, a hunter shot an arrow at the deer but missed. The deer began to run in fear and unfortunately the deer got caught in a hedge by its antlers. The deer realized that the antlers it was praising actually got it caught but the legs which were thin, actually helped it run.

Story 2 (Narrator)	RHD participant	Control participant
Thousands of frogs lived in a small pond. They were happy but they wanted a king. So, they prayed to God for a king. God sent a big tree trunk to them. At first, they were intimidated by its size but soon they discovered, their new king did not move and did not talk. One brave frog climbed to the top of the trunk and after that many others gathered the courage and climbed to the top. They were unhappy and they prayed to God again stating that the king they were sent was inanimate and they want a new king who would be alive and actually rule over them. God got a bit angry. He sent a stork to the pond and the stork ate up all the frogs.	There was a small pond and many frogs lived in it. They asked God for a king. God was not paying attention and sent a tree bark to them. But the frogs were disappointed because the king was inanimate and didn't move at all or respond to the frogs. A frog went to touch it but since it didn't move, they climbed it. Then the frogs prayed to God again for another king, who would actually rule over them. God was irritated at this and sent a stork to their pond, which ate all the frogs.	There was a small pond and many frogs lived in it. They wanted a king and they prayed to God for the same. God sent a tree bark to them and the frogs were surprised. Eventually they realized the king didn't move and soon climbed the king. They soon prayed to God dissatisfied and wanted another king who would actually rule and be alive. God was irritated and sent a stork to their place, which ate up all the frogs alive.

We can see 0 digressions in story 1 for the RHD participant but 1 digressions in story 2. From the table above, which contain the stories, we can discern that the RHD participant had some issues in remembering the second story but no issues in remembering the first story. The control participant had 1 digression in the first story and 0 digressions in the second story. There were no major lapses, even in the narration of the control participant as well, in both the stories.

5. **Questions answered**

STORY 1				
	Questions	Actual answer	RHD participant	Control participant
1	Which animal(s) were mentioned in the story?	A deer	A deer	A deer
2	What was the deer doing?	Looking at his reflection	Looking at its reflection	Looking at his reflection
3	Why did the deer run?	A hunter shot an arrow but it didn't touch	A hunter followed it	A hunter shot an arrow. The deer ran for its life.
4	Why was he caught?	His big antlers were caught in a bush	Antlers got caught in creepers.	The antlers got caught in a hedge.
5	What was the deer insulting, in the beginning?	His thin legs, that don't match his antlers and body.	The legs	His thin legs, that don't match his antlers and body.

STORY 2				
	Questions	Actual answer	RHD participant	Control participant
1	Which animal(s) were mentioned in the story?	Frogs, stork	Frogs and a stork in the end	Frogs, stork

2	Where did the frogs live?	In a small pond	In a marshy and small pond	In a small pond
3	What did the frogs want the first time?	A king	A king	A king
4	What did the frogs want the second time?	A king who would actually be alive and rule over them	A king who would rule	A king who would actually be alive and rule over them
5	Why did all the frogs die?	The stork ate them all	The stork killed them all	The stork ate them all

We can observe the following from fig 3.285: 37SH31MR has been able to answer all 5 questions in the both stories. The control participant answered all questions in both the stories.

B. SENTENCES

Declaratives

Fig 3.287 – 3.289. We can observe the following from the figure displayed previously: In sentence 1, 37SH31MR has a type C curve, and 17SB30MC, has a type C curve as well. 50MEANMR and 49MEANMC, have recorded curves belonging to the type C of sentence. The type C sentence begins at the highest pitch point, the second point is lower than the starting point and the third point is either equal to or lower than the pitch point in the middle. In sentence 2, 37SH31MR has recorded a type D curve, in comparison with 17SB30MC, who also has a type D curve. 50MEANMR and 49MEANMC, have recorded curves belonging to the type D. In sentence 3, 37SH31MR and 17SB30MC have type C sentences. 50MEANMR and 49MEANMC have type B sentences.

Imperatives

Fig 3.290 – 3.292. We can observe the following from the figure displayed previously: In sentence 4, 37SH31MR has a type D sentence while 17SB30MC has a type A sentence. 50MEANMR and 49MEANMC have type D sentences. In sentence 5, 37SH31MR has a type A sentence while 17SB30MC, 50MEANMR and 49MEANMC have type D sentences. In a type D sentence, the highest pitch point in a sentence is in the middle. In sentence 6, 37SH31MR conforms to a type C sentence while 17SB30MC conforms to a type B sentence. 50MEANMR and 49MEANMC have type C sentences.

Interrogatives

Fig 3.293 – 3.295. We can observe the following from the figure displayed previously: In sentence 7, 37SH31MR has a D type sentence in comparison with 17SB30MC, who has a type B sentences. This is in contrast with 50MEANMR and 49MEANMC who have recorded type D sentences. In sentence 8, 37SH31MR has made a type D sentence in comparison with

17SB30MC, who has made a type B sentence. 50MEANMR has a type D sentence and from the chart 49MEANMC has no visible contour, but on checking the figures, 49MEANMC has made a type D sentence as well. In sentence 9, 37SH31MR has a type D curve in comparison with 17SB30MC who has a type B sentence. 50MEANMR and 49MEANMC have type D sentences.

C. **VOWELS**

Fig 3.286 compares female RHD participant 37SH31MR with the individual age and gender matched male, that is 15AK57MC. We can observe the following from the figure displayed previously: The vowel /i/ (f1=-386, f2-f1=-1973) in 37SH31MR slightly fronted and lower than vowel /i/ (f1=-299, f2-f1=-1922) in 17SB30MC. The vowel /e/ (f1=-427, f2-f1=-1685) in 37SH31MR is more backed and slightly lower than vowel /e/ (f1=-361, f2-f1=-1756) in 17SB30MC. The vowel /æ/ (f1=-713, f2-f1=-1046) in 37SH31MR is slightly backed and lower comparison than vowel /æ/ (f1=-651, f2-f1=-1078) in 17SB30MC. The vowel /ɑ/ (f1=-867, f2-f1=-543) in 37SH31MR is lower and fronted in comparison with vowel /ɑ/ (f1=-782, f2-f1=-480) in 17SB30MC. The vowel /ɔ/ (f1=-727, f2-f1=-383) in 37SH31MR is more fronted in comparison with vowel /ɔ/ (f1=-723, f2-f1=-296) in 17SB30MC. The vowel /o/ (f1=-455, f2-f1=-498) in 37SH31MR is lower and backed in comparison with vowel /o/ (f1=-411, f2-f1=-805) in 17SB30MC. The vowel /u/ (f1=-387, f2-f1=-403) in 37SH31MR is slightly lower and fronted in comparison with vowel /u/ (f1=-321, f2-f1=-297) in 17SB30MC. The area of the acoustic space chart for 37SH31MR is 371417 and for 17SB30MC is 358350, and 96MEANMR is 336881. The area of 37SH31MR is 3.6% larger than that of the individual control and 10.3% larger than the mean of RHD participants.

3.5.17.CASE STUDY 17

PRIMARY INFO

Codified Name: 38SB74MR.

Male, 74 years of age, at the time of recording and case study.

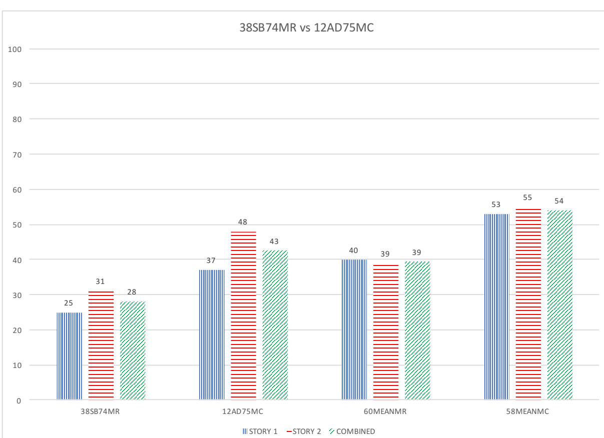
Age and gender matched control: 12AD75MC

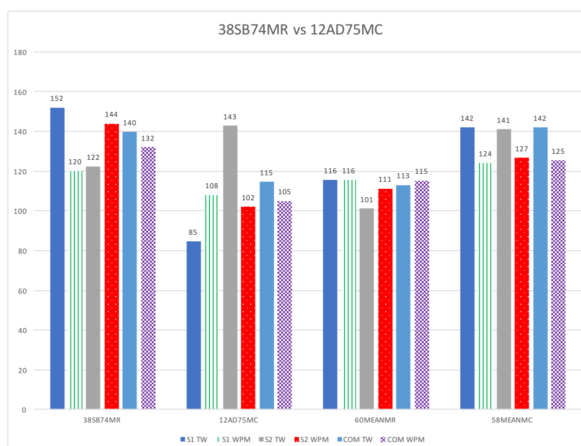
Time since incidence: approximately 7 months back, at the time of recording.

PARTICIPANT INFORMATION

Condition of participant: The participant was conscious, scored 12 on the GCS. He scored 27 on the MMSE. The participant can walk and has no major problems. The doctor asked him to do some actions with his hand, involving muscle coordination and he could do it with ease. The participant faced no difficulty in performing actions based on instructions, which involved complicated and elaborate instructions. The speech of the participant was slurred but was not difficult to understand. The participant did not display any left hemisphere neglect. His sense of color recognition was also intact, although he had difficulty in remembering the names. The doctor also performed a test in which he held both of the participant's hands in his hands and then asked the participant to keep holding them where he is holding them, after he lets them go. He could maintain the position of the both the hands. The participant had no major issues in remembering things. He is undergoing no physiotherapy. **Observations made by doctor:** The doctor mentions that he has no agraphia, dementia, and alexia. Participant is hypertensive. Participant is not an alcoholic or a smoker.Participant has no problems in planning and judgement. **Diagnosis made by doctor:** The doctor mentions that the participant is out of danger and would not suffer another stroke. He was asked to follow up in six months. **Region of damage:** Acute infarction in posterior limb of **<u>right internal capsule</u>** with foci of ischemic gliosis in white matter of both cerebral hemispheres and **<u>right basal ganglia.</u>**

<u>Comprehensive study of participant at the 3 levels of communication</u>





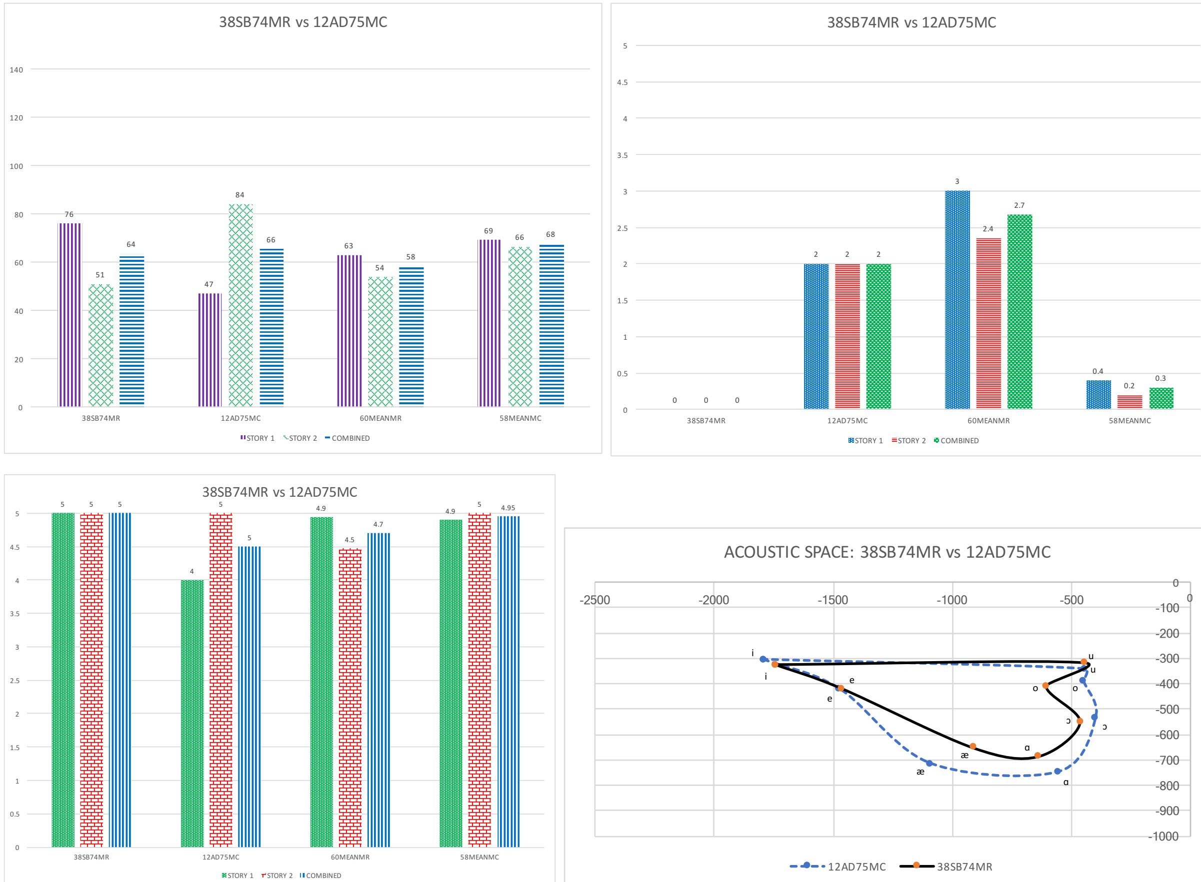


Fig 3.296 to 3.301: 38SB74MR - The bar graphs are comparisons at the level of discourse. The last diagram is an acoustic space.

A. DISCOURSE

1. Pitch range

We can observe the following from fig 3.296: 38SB74MR has a pitch range of 25 Hz in the first story in comparison with 12AD75MC, who has a pitch range of 37 Hz. 60MEANMR has a pitch range of 40 Hz in the first story while 58MEANMC has a pitch range of 53 Hz in the first story. 38SB74MR has a pitch range of 31 Hz in the second story in comparison with 12AD75MC, who has a pitch range of 48 Hz. 60MEANMR has a pitch range of 39 Hz in the second story while 58MEANMC has a pitch range of 55 Hz in the second story. 38SB74MR has a pitch range of 28 Hz in the mean of the stories in comparison with 12AD75MC, who has a pitch range of 43 Hz. 60MEANMR has a pitch range of 39 Hz in the mean of the two stories while 58MEANMC has a pitch range of 54 Hz in the same. The RHD participant has a pitch range, which is not much smaller than the control participant but is much smaller than the control group mean and the RHD group mean, as well.

2. **Fluency**

We can observe the following from fig 3.297: 38SB74MR has 152 words in story 1 in comparison with 12AD75MC, who has 85 words, which is a huge difference. 38SB74MR has a word rate of 120 wpm in story 1 in comparison with 12AD75MC, who has 108 wpm. 38SB74MR has 122 words in story 2 in comparison with 12AD75MC, who has 143 words. 38SB74MR has a word rate of 144 wpm in story 2 in comparison with 12AD75MC, who has 102 wpm. 38SB74MR has 140 words in the combined mean of the two stories in comparison with 12AD75MC, who has 115 words. 38SB74MR has a word rate of 132 wpm in the combined mean of the two stories in comparison with 12AD75MC, who has 105 wpm. The RHD participant has a better performance than the control participant.

3. **Duration**

We can observe the following from fig 3.298: 38SB74MR took 76 seconds (fluency – 120 words per minute) to complete narrating the first story in comparison with 12AD75MC, who took 47 seconds (fluency – 108 words per minute). 38SB74MR took 51 seconds (fluency – 144 words per minute) to complete narrating the second story in comparison with 12AD75MC, who took 84 seconds (fluency – 102 words per minute). 38SB74MR has a mean duration of 64 seconds (fluency – 132 words per minute) whereas, 12AD75MC has a mean of 66 seconds (fluency – 105 words per minute). 58MEANMC took a time of 68 seconds (fluency – 125 words per minute) and 60MEANMR took a time of 58 seconds (fluency – 113 words per minute), in the mean of the two stories.

4. Digressions and lapses

Story 1 (Narrator)	RHD participant	Control participant
There was a deer. It was standing at the edge of the river. It saw its majestic antlers in the river, as a reflection. It kept praising it. Next it saw its feet and started to demean it because it was thin and did not match the overall beauty of the whole body. In the meantime, a hunter shot an arrow but missed. The deer started running in fear but ultimately got caught by the antlers in a bushy area. He exclaimed that the antlers he was praising put him in utter danger but	A deer was standing by a river and noticed its reflection. It praised its beautiful antlers and felt good. Soon it noticed its thin legs and felt ashamed of those and insulted those. In the meantime, a hunter shot an arrow at the deer but missed. But the deer started running in fear. Soon the deer got caught by the antlers in a bush and it got stuck. Then the deer realized that even if the antler was	<u>The deer stood by a pond</u>. It saw its reflection in it and praised its antlers and then insulted it. <u>Then saw its body, which was thin and the legs were thin.</u> Then an arrow fell in the water and the deer ran. The deer

his legs he was demeaning, tried to help him run that far.	praised it didn't help the deer but the legs even on being insulted helped it run.	got caught in the jungle. Then the deer said that the antlers caught the deer.

Story 2 (Narrator)	RHD participant	Control participant
Thousands of frogs lived in a small pond. They were happy but they wanted a king. So, they prayed to God for a king. God sent a big tree trunk to them. At first, they were intimidated by its size but soon they discovered, their new king did not move and did not talk. One brave frog climbed to the top of the trunk and after that many others gathered the courage and climbed to the top. They were unhappy and they prayed to God again stating that the king they were sent was inanimate and they want a new king who would be alive and actually rule over them. God got a bit angry. He sent a stork to the pond and the stork ate up all the frogs.	Many frogs lived in a small pond and they realized that they needed a king, so they prayed to God for the same. God sent a tree bark to them. At first they were afraid but soon a frog touched and was intimidated by its size. They soon started to notice that the king didn't move at all and didn't rule over them. Disappointed, they prayed to God again for another king who would actually rule over them. God got pissed at this and sent a stork to their pond. This stork killed all the frogs and ate all of them.	Many frogs lived in a pond. They wanted a king from God. God sent them a tree bark after one day exactly. The frogs realized that the king wasn't moving, even on being touched. One frog climbed the king and yet it didn't move. Then they complained to God, that they wanted a king who would actually rule them and be alive. Then God was displeased and sent a stork to them who came and ate all the frogs.

The RHD participant has no digressions in both the stories as well as no lapses. The control participant on the other hand had 2 digressions in the first story and 2 digressions in the second story as well. There were major lapses, even in the narration of the control participant as well, in both the stories.

5. Questions answered

STORY 1				
	Questions	Actual answer	RHD participant	Control participant
1	Which animal(s) were mentioned in the story?	A deer	A deer	A deer
2	What was the deer doing?	Looking at his reflection	Looking at its reflection	Looking at his reflection
3	Why did the deer run?	A hunter shot an arrow but it didn't touch	A hunter followed it	A hunter shot an arrow. The deer ran for its life.
4	Why was he caught?	His big antlers were caught in a bush	Antlers	**The antlers caught the deer**
5	What was the deer insulting, in the beginning?	His thin legs, that don't match his antlers and body.	The legs	His thin legs, that don't match his antlers and body.

STORY 2				
	Questions	Actual answer	RHD participant	Control participant

1	Which animal(s) were mentioned in the story?	Frogs, stork	Frogs and a stork in the end	Frogs, stork
2	Where did the frogs live?	In a small pond	In a marshy and small pond	In a small pond
3	What did the frogs want the first time?	A king	A king	A king
4	What did the frogs want the second time?	A king who would actually be alive and rule over them	A king who would rule and be alive	A king who would actually be alive and rule over them
5	Why did all the frogs die?	The stork ate them all	The stork killed them all	The stork ate them all

We can observe the following from fig 3.300: 38SB74MR has been able to answer all 5 questions in the first story and 4 in the second story. The control participant answered 4 questions in the first story and all questions in the second story.

B. Vowels

Fig 3.301 compares female RHD participant 38SB74MR with the individual age and gender matched male, that is 15AK57MC. We can observe the following from the figure displayed previously: The vowel /i/ (f1=-326, f2-f1=-1742) in 38SB74MR is almost at the same place as vowel /i/ (f1=-305, f2-f1=-1793) in 12AD75MC. The vowel /e/ (f1=-418, f2-f1=-1467) in 38SB74MR is is almost at the same place as vowel /e/ (f1=-419, f2-f1=-1476) in 12AD75MC. The vowel /æ/ (f1=-651, f2-f1=-912) in 38SB74MR is slightly higher and backed comparison than vowel /æ/ (f1=-714, f2-f1=-1095) in 12AD75MC. The vowel /ɑ/ (f1=-686, f2-f1=-640) in 38SB74MR is higher and fronted in comparison with vowel /ɑ/ (f1=-748, f2-f1=-557) in 12AD75MC. The vowel /ɔ/ (f1=-552, f2-f1=-462) in 38SB74MR is slightly lower and fronted in comparison with vowel /ɔ/ (f1=-533, f2-f1=-400) in 12AD75MC. The vowel /o/ (f1=-410, f2-f1=-604) in 38SB74MR is slightly lower and fronted in comparison with vowel /o/ (f1=-390, f2-f1=-451) in 12AD75MC. The vowel /u/ (f1=-319, f2-f1=-444) in 38SB74MR is almost at the same place in comparison with vowel /u/ (f1=-342, f2-f1=-446) in 12AD75MC. The area of the acoustic space chart for 38SB74MR is 262374.5 and for 12AD75MC is 366966, and 96MEANMR is 336881. The area of 38SB74MR is 28.5% smaller than that of the individual control and 22.1% smaller than the mean of RHD participants. The acoustic space of the RHD participant is significantly smaller. We can discern that the RHD participant has limited high-low vowel capabilities in comparison with the control participant.

3.5.18. CASE STUDY 18

Primary info

Codified Name: 39SR34MR.

Male, 34 years of age, at the time of recording and case study.

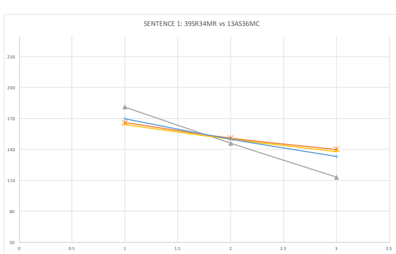
Age and gender matched control: 13AS36MC
Time since incidence: approximately 6 months back, at the time of recording.

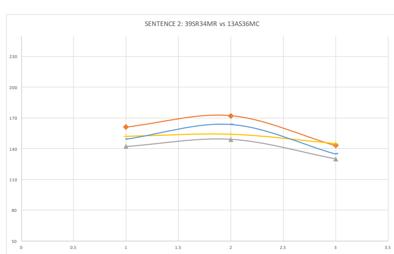
Participant information

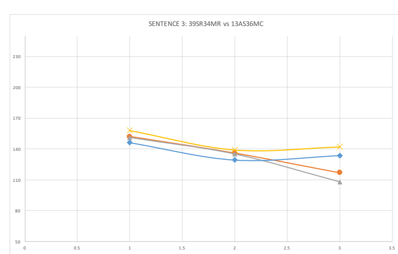
Condition of participant: The participant was fully conscious, having scored 12 on the GCS. He also scored 25 on the MMSE. The participant can walk without problems. The doctor asked him to do some actions with his hands, involving muscle coordination and he could do it with ease. Although, the participant alleged that he experienced extreme pain in his limbs while doing what he was asked to do. The participant could also perform actions based on instructions, which involved complicated and elaborate instructions. The speech of the participant was slightly slurred but was easy to understand. The participant did not display any left hemisphere neglect and his color recognition was perfect. The doctor also performed a test in which he held both of the participant's hands in his hands and then asked the participant to keep holding them where he is holding them, after he lets them go. He could maintain the position of both the hands, although again, the participant experienced extreme pain in his left hand. The participant had some issues in remembering things. He is undergoing no physiotherapy because of his financial condition. **Observations made by doctor:** The doctor mentions that he has no agraphia, no dementia, and no alexia. Participant is highly hypertensive. Participant is not an alcoholic or a smoker. Participant has some problems in planning and judgement. He wore the wrong side of trousers and he generally cannot figure out which side is the front side of a shirt. **Diagnosis made by doctor:** The doctor mentions that the participant has almost no chances of suffering another stroke. He was asked to continue medicines for blood pressure and to follow up in three months. **Region of damage:** Subacute infarcts involving the **right frontal, parietal and occipital lobes;** insula as well as **right ganglio-capsular region (right MCA territory)** with internal hemorrhagic transformation.

Comprehensive study of participant at the 3 levels of communication

Fig 3.302 to 3.307: 39SR34MR - The bar graphs are comparisons at the level of discourse. The last diagram is an acoustic space.







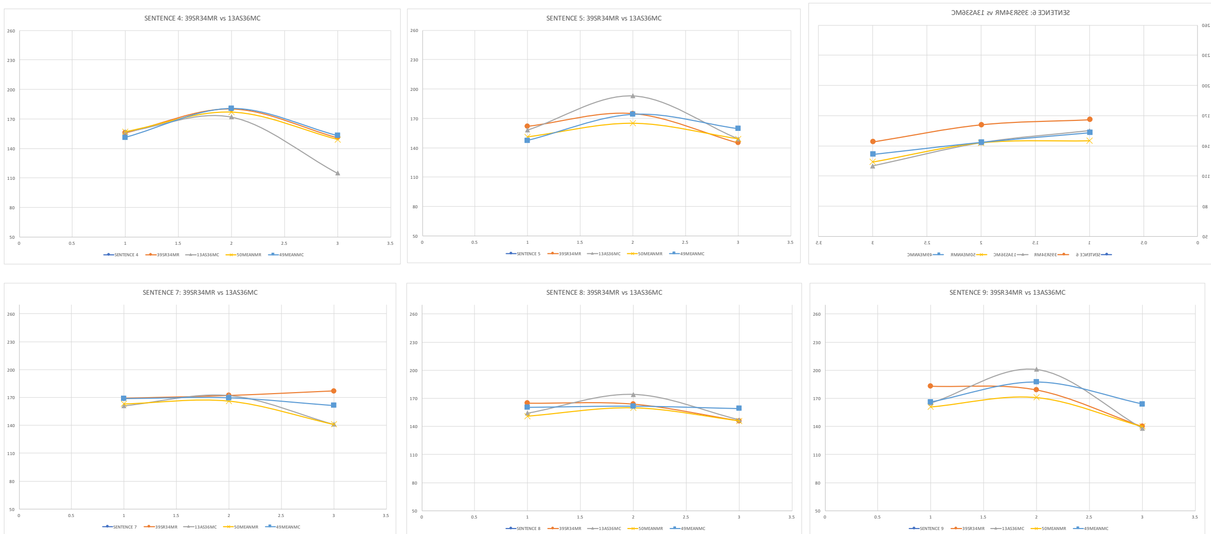


Fig 3.308 to 3.316: 39SR34MR - First three diagrams in first line are declarative sentences. The next line is composed of 3 imperative sentences and the third line has three interrogative sentences.

A. DISCOURSE

1. Pitch range

We can observe the following from fig 3.302: 39SR34MR has a pitch range of 50 Hz in the first story in comparison with 13AS36MC, who has a pitch range of 49 Hz. 60MEANMR has a pitch range of 40 Hz in the first story while 58MEANMC has a pitch range of 53 Hz in the first story. 39SR34MR has a pitch range of 45 Hz in the second story in comparison with 13AS36MC, who has a pitch range of 67 Hz. 60MEANMR has a pitch range of 39 Hz in the first story while 58MEANMC has a pitch range of 55 Hz in the second story. 39SR34MR has a pitch range of 48 Hz in the mean of the stories in comparison with 13AS36MC, who has a pitch range of 58 Hz. The difference in pitch range is not very significant. 60MEANMR has a pitch range of 39 Hz in the mean of the two stories while 58MEANMC has a pitch range of 54 Hz in the same. The pitch range of the RHD participant isn't much smaller than the control participant and has similar pitch ranges.

2. Fluency

We can observe the following from fig 3.303: 39SR34MR has 46 words in story 1 in comparison with 13AS36MC, who has 168 words, which is a huge difference. 39SR34MR has a word rate of 78 wpm in story 1 in comparison with 13AS36MC, who has 138 wpm.

39SR34MR has 98 words in story 2 in comparison with 13AS36MC, who has 169 words. 39SR34MR has a word rate of 78 wpm in story 2 in comparison with 13AS36MC, who has 132 wpm. 39SR34MR has 72 words in the combined mean of the two stories in comparison with 13AS36MC, who has 169 words. 39SR34MR has a word rate of 78 wpm in the combined mean of the two stories in comparison with 13AS36MC, who has 135 wpm. The RHD participant has a very low total word count as well as fluency rates per minute and has performed very poorly in comparison with the control participant, the RHD group mean and the control group mean.

3. **Duration**

We can observe the following from fig 3.304: 39SR34MR took 35 seconds (fluency – 156 words per minute) to complete narrating the first story in comparison with 13AS36MC, who took 71 seconds (fluency – 138 words per minute). 39SR34MR took 75 seconds (fluency – 180 words per minute) to complete narrating the second story in comparison with 13AS36MC, who took 64 seconds (fluency – 132 words per minute). 39SR34MR has a mean duration of 55 seconds (fluency – 168 words per minute) whereas, 13AS36MC has a mean of 68 seconds (fluency – 135 words per minute). We can see that 39SR34MR has taken lesser time than 13AS36MC in both the stories but also has lesser has lesser content than everybody else. The participant was speaking in a hurry. 39SR34MR also completed the stories faster than 58MEANMC with a duration of 68 seconds (fluency – 125 words per minute) and 60MEANMR with a duration of 58 seconds (fluency – 113 words per minute), in the mean of the two stories.

4. Digressions and lapses

Story 1 (Narrator)	RHD participant	Control participant
There was a deer. It was standing at the edge of the river. It saw its majestic antlers in the river, as a reflection. It kept praising it. Next it saw its feet and started to demean it because it was thin and did not match the overall beauty of the whole body. In the meantime, a hunter shot an arrow but missed. The deer started running in fear but ultimately got caught by the antlers in a bushy area. He exclaimed that the antlers he was praising put him in utter danger but his legs he was demeaning, tried to help him run that far.	A deer was looking at its own reflection at a river side. It was looking at its antlers. Somebody shot an arrow from its side and fell into the water. Then the deer ran into the forest and got caught. Then the hunter came and caught it. The deer realized the legs	A deer went to drink water at a river side. It noticed its reflection and saw its antlers first. It praised its antlers and felt good. After that it saw its thin legs and felt bad, demeaned it. In the meantime, a hunter shot an arrow which missed but the deer started to run. Unfortunately, the deer got stuck in a hedge. Then it realized that the antler which it was praising, got it caught but the legs it was demeaning actually tried to run, to help it.

	deserved more praise than insult.	

Story 2 (Narrator)	RHD participant	Control participant
Thousands of frogs lived in a small pond. They were happy but they wanted a king. So, they prayed to God for a king. God sent a big tree trunk to them. At first, they were intimidated by its size but soon they discovered, their new king did not move and did not talk. One brave frog climbed to the top of the trunk and after that many others gathered the courage and climbed to the top. They were unhappy and they prayed to God again stating that the king they were sent was inanimate and they want a new king who would be alive and actually rule over them. God got a bit angry. He sent a stork to the pond and the stork ate up all the frogs.	In a small pond, many frogs lived. They prayed to God for a good king. No, a big king. A tree bark dropped from above. The frogs hit the tree bark at the side and the bark didn't move. There was no noise. Then they started to climb the tree bark, all of them. Then a stork came and ate all the frogs. The frogs wanted a bigger pandit to be sent to them, than the original one. So God sent another pandit.	Many frogs lived in a small pond and they were happy. Suddenly they thought that they needed a king and prayed to God for a king. God sent them a big bark of tree. At first the frogs touched it and then realized the king didn't move. Eventually a brave frog climbed the king and others followed. They realized it was not a proper king and they prayed to God again for a king who would actually rule them. God was angry and sent a stork to their place. The stork started to eat all the frogs one by one.

We can see 4 digressions in story 1 for the RHD participant and 4 in story 2. The RHD participant also could not remember the story in the correct chronological order and there were huge lapses. The control participant on the other hand had no digressions in both the stories. There were no lapses in the narration of the control participant as well, in both the stories.

5. **Questions answered**

STORY 1				
	Questions	Actual answer	RHD participant	Control participant
1	Which animal(s) were mentioned in the story?	A deer	A deer	A deer
2	What was the deer doing?	Looking at his reflection	Looking at its reflection	Looking at his reflection
3	Why did the deer run?	A hunter shot an arrow but it didn't touch	A hunter followed it	A hunter shot an arrow. The deer ran for its life.
4	Why was he caught?	His big antlers were caught in a bush	Antlers	His big antlers were caught in a bush
5	What was the deer insulting, in the beginning?	His thin legs, that don't match his antlers and body.	The legs	His thin legs, that don't match his antlers and body.

STORY 2				
	Questions	Actual answer	RHD participant	Control participant
1	Which animal(s) were mentioned in the story?	Frogs, stork	Frogs and a stork in the end	Frogs, stork

2	Where did the frogs live?	In a small pond	In a marshy and small pond	In a small pond
3	What did the frogs want the first time?	A king	A king	A king
4	What did the frogs want the second time?	A king who would actually be alive and rule over them	A king who would actually rule over them	A king who would actually be alive and rule over them
5	Why did all the frogs die?	The stork ate them all	The stork killed them all	The stork ate them all

We can observe the following from fig 3.306: 39SR34MR has been able to answer all 5 questions in the first story and the second story. The control participant answered all questions, as well as the mean of the control group 58MEANMC and the mean of the RHD group 60MEANFR.

B. SENTENCES

Declaratives

Fig 3.308 – 3.310. We can observe the following from the figure displayed previously: In sentence 1, 39SR34MR, 13AS36MC, 50MEANMR and 49MEANMC, all have recorded curves belonging to the type C. In sentence 2 39SR34MR has recorded a type D curve, in comparison with 13AS36MC, 50MEANMR and 49MEANMC, who have also recorded curves belonging to the type D. 49MEANMC recorded at a pitch range which is much higher than the mean of the RHD group 50MEANMR. In sentence 3, 39SR34MR has a type C curve in comparison with 13AS36MC who also has the same type C sentence. 50MEANMR and 49MEANMC have recorded type B sentences.

Imperatives

Fig 3.311 – 3.313. We can observe the following from the figure displayed previously: In sentence 4, 39SR34MR, 13AS36MC, 50MEANMR and 49MEANMC have all made type D sentences. In sentence 5, 39SR34MR, 13AS36MC, 50MEANMR and 49MEANMC all have type D sentences. In a type D sentence, the highest pitch point in a sentence is in the middle. In sentence 6, 39SR34MR, 13AS36MC, 50MEANMR and 49MEANMC all have type C sentences.

Interrogatives

Fig 3.314 – 3.316. We can observe the following from the figure displayed previously: In sentence 7, 39SR34MR has a A type sentence in comparison with 13AS36MC, who has a type

D sentences. 50MEANMR and 49MEANMC also have recorded type D sentences. In sentence 8, 39SR34MR has made a type C sentence in comparison with 13AS36MC, who has made a type D sentence. 50MEANMR also has a type D sentence and from the chart 49MEANMC has no visible contour, but on checking the figures, 49MEANMC has made a type D sentence as well. In sentence 9, 39SR34MR has a type C curve in comparison with 13AS36MC, 50MEANMR and 49MEANMC who have type D sentences.

C. **VOWELS**

Fig 3.307 compares female RHD participant 39SR34MR with the individual age and gender matched male, that is 13AS36MC. We can observe the following from the figure displayed previously: The vowel /i/ (f1=-340, f2-f1=-1960) in 39SR34MR is more fronted than vowel /i/ (f1=-340, f2-f1=-1725) in 13AS36MC. The vowel /e/ (f1=-421, f2-f1=-1616) in 39SR34MR is a lot more fronted and slightly lower than vowel /e/ (f1=-416, f2-f1=-1423) in 13AS36MC. The vowel /æ/ (f1=-615, f2-f1=-1228) in 39SR34MR is lower and fronted in comparison vowel with vowel /æ/ (f1=-604, f2-f1=-1154) in 13AS36MC. The vowel /ɑ/ (f1=-708, f2-f1=-565) in 39SR34MR is lower and backed in comparison with vowel /ɑ/ (f1=-639, f2-f1=-759) in 13AS36MC. The vowel /ɔ/ (f1=-620, f2-f1=-475) in 39SR34MR is lower than vowel /ɔ/ (f1=-555, f2-f1=-492) in 13AS36MC. The vowel /o/ (f1=-492, f2-f1=-553) in 39SR34MR is backed and lower than vowel /o/ (f1=-447, f2-f1=-727) in 13AS36MC. The vowel /u/ (f1=-393, f2-f1=-523) in 39SR34MR is lower and slightly backed in comparison with vowel /u/ (f1=-359, f2-f1=-567) in 13AS36MC. The area of the acoustic space chart for 39SR34MR is 273457 and for 13AS36MC is 198261.5, and 96MEANMR is 336881. The area of 39SR34MR is 37.9% bigger than that of the individual control and 18.8% smaller than the mean of RHD participants. The area of the RHD participant is significantly larger than the acoustic space area of the control. The RHD participant has a bigger acoustic space area, hence has more tongue movement in the front and back, as can be discerned from the chart. It is important to notice that the control participant in this case has limited movement in comparison with most other cases, where RHD participants have lesser acoustic space areas.

3.5.19. CASE STUDY 19

PRIMARY INFO

Codified Name: 40SB82MR.

Male, 82 years of age, at the time of recording and case study.

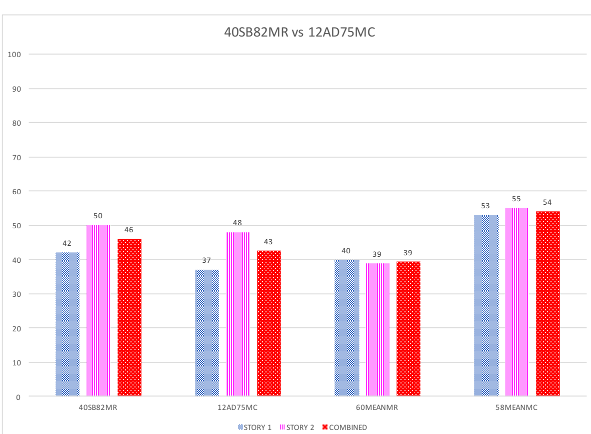
Age and gender matched control: 12AD75MC for the discourse level. 21SD82MC for sentences and vowels.

Time since incidence: approximately 4 months back, at the time of recording.

Participant information

Condition of participant: The participant was fully conscious, having scored 11 on the GCS. He also scored 24 on the MMSE. The participant could not walk. He needs his family members to walk. The doctor asked him to do some actions with his hands, involving muscle coordination and he could do it, but very slowly. The participant could also perform actions based on instructions, which involved complicated and elaborate instructions. The speech of the participant was slightly slurred but was easy to understand. The participant displayed left hemisphere neglect. His color recognition was perfect. The doctor also performed a test in which he held both of the participant's hands in his hands and then asked the participant to keep holding them where he is holding them, after he lets them go. He could maintain the position of both the hands. The participant had issues in remembering things. He is undergoing no physiotherapy due to the poor financial condition of his family. **Observations made by doctor:** The doctor mentions that he has agraphia, mild dementia, and has alexia. Participant is highly hypertensive. Participant was an alcoholic and a smoker. Participant has problems in planning and judgement. **Diagnosis made by doctor:** The doctor mentions that even if the participant might suffer another stroke if he cannot bring down his tension levels. He was asked to continue medicines for blood pressure and to follow up in two months. **Region of damage:** Infarction at the **right temporo-parietal lobes (hypodense area)**

Comprehensive study of participant at the 3 levels of communication



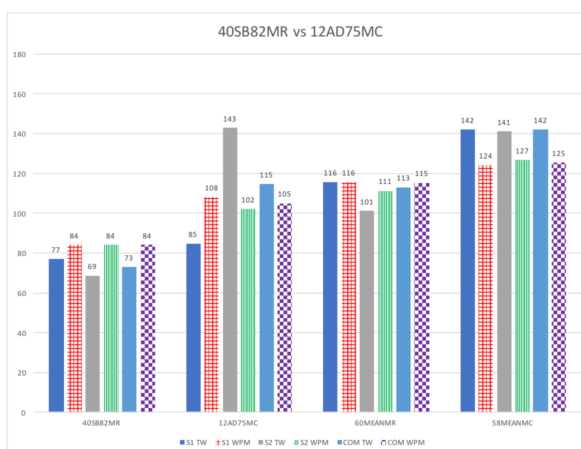
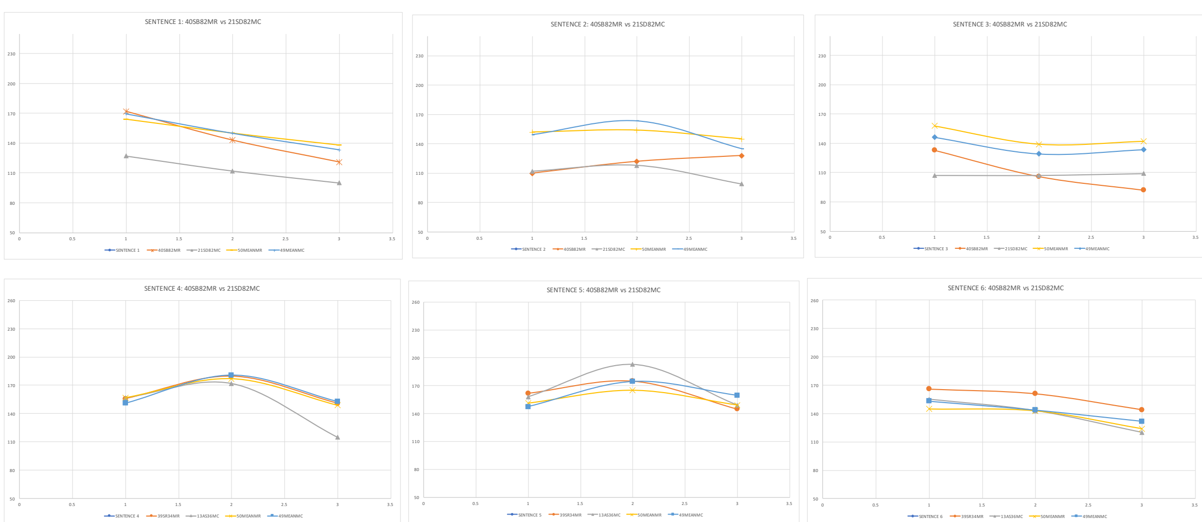
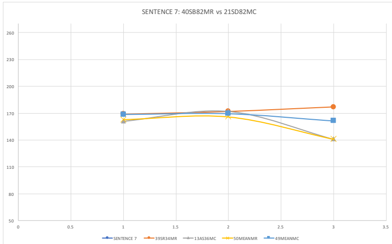
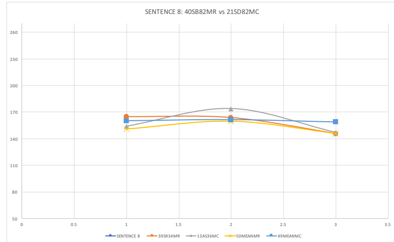


Fig 3.317 to 3.322: 40SB82MR - The bar graphs are comparisons at the level of discourse. The last diagram is an acoustic space.







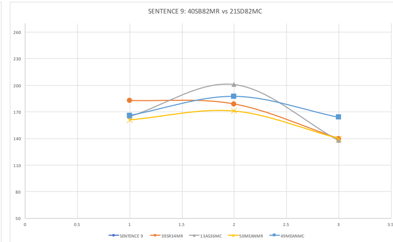


Fig 3.323 to 3.331: 40SB82MR - First three diagrams in first line are declarative sentences. The next line is composed of 3 imperative sentences and the third line has three interrogative sentences.

A. DISCOURSE

1. Pitch range

We can observe the following from fig 3.317: 40SB82MR has a pitch range of 42 Hz in the first story in comparison with 12AD75MC, who has a pitch range of 37 Hz. 60MEANMR has a pitch range of 40 Hz in the first story while 58MEANMC has a pitch range of 53 Hz in the first story. 40SB82MR has a pitch range of 50 Hz in the second story in comparison with 12AD75MC, who has a pitch range of 48 Hz. 60MEANMR has a pitch range of 39 Hz in the second story while 58MEANMC has a pitch range of 55 Hz in the second story. 40SB82MR has a pitch range of 46 Hz in the mean of the stories in comparison with 12AD75MC, who has a pitch range of 43 Hz. 60MEANMR has a pitch range of 39 Hz in the mean of the two stories while 58MEANMC has a pitch range of 54 Hz in the same. The RHD participant and the control participant have similar pitch ranges.

2. Fluency

We can observe the following from fig 3.318: 40SB82MR has 77 words in story 1 in comparison with 12AD75MC, who has 85 words, which is a huge difference. 40SB82MR has a word rate of 84 wpm in story 1 in comparison with 12AD75MC, who has 108 wpm. 40SB82MR has 69 words in story 2 in comparison with 12AD75MC, who has 143 words. 40SB82MR has a word rate of 84 wpm in story 2 in comparison with 12AD75MC, who has 102 wpm. 40SB82MR has 73 words in the combined mean of the two stories in comparison with 12AD75MC, who has 115 words. 40SB82MR has a word rate of 84 wpm in the combined mean of the two stories in comparison with 12AD75MC, who has 105 wpm. The RHD participant has a very low total word count as well as fluency rates per minute and has performed very poorly in comparison with the control participant, the RHD group mean and the control group mean.

3. **Duration**

We can observe the following from fig 3.319: 40SB82MR took 55 seconds (fluency – 84 words per minute) to complete narrating the first story in comparison with 12AD75MC, who took 47 seconds (fluency – 108 words per minute). 40SB82MR took 49 seconds (fluency – 84 words per minute) to complete narrating the second story in comparison with 12AD75MC, who took 84 seconds (fluency – 102 words per minute). 40SB82MR has a mean duration of 52 seconds (fluency – 84 words per minute) whereas, 12AD75MC has a mean of 66 seconds (fluency – 105 words per minute). 58MEANMC took a time of 68 seconds (fluency – 125 words per minute) and 60MEANMR took a time of 58 seconds (fluency – 113 words per minute), in the mean of the two stories.

4. Digressions and lapses

Story 1 (Narrator)	RHD participant	Control participant
There was a deer. It was standing at the edge of the river. It saw its majestic antlers in the river, as a reflection. It kept praising it. Next it saw its feet and started to demean it because it was thin and did not match the overall beauty of the whole body. In the meantime, a hunter shot an arrow but missed. The deer started running in fear but ultimately got caught by the antlers in a bushy area. He exclaimed that the antlers he was praising put him in utter danger but his legs he was demeaning, tried to help him run that far.	A deer was at a water side. It was telling that its body was nice but the legs were thin. Actually, a hunter shot an arrow and it sped past the deer's legs. Then it ran and ran and ran. It got stuck in a creeper and it died.	The deer stood by a pond. It saw its reflection in it and praised its antlers and then insulted it. Then saw its body, which was thin and the legs were thin. Then an arrow fell in the water and the deer ran. The deer got caught in the jungle. Then the deer said that the antlers caught the deer.

Story 2 (Narrator)	RHD participant	Control participant
Thousands of frogs lived in a small pond. They were happy but they wanted a king. So, they prayed to God for a king. God sent a big tree trunk to them. At first, they were intimidated by its size but soon they discovered, their new king did not move and did not talk. One brave frog climbed to the top of the trunk and after that many others gathered the courage and climbed to the top. They were unhappy and they prayed to God again stating that the king they were sent was inanimate and they want a new king who	There are birds. There is a small pond and many frogs stay there. God sent such a man like a king… It was not God. Another God was sent. They said, since you are mischievous, a	Many frogs lived in a pond. They wanted a king from God. God sent them a tree bark after one day exactly. The frogs realized that the king wasn't moving, even on being touched. One frog climbed the king and yet it didn't move. Then they complained to God, that they wanted a king who would actually rule them and be alive. Then God was displeased and sent

would be alive and actually rule over them. God got a bit angry. He sent a stork to the pond and the stork ate up all the frogs.	<u>bird will eat you all, one by one.</u>	a stork to them who came and ate all the frogs.

We can see 7 digressions in story 1 for the RHD participant and 10 digressions in story 2 (the lapses have been counted as digressions as well). From the table above, which contain the stories, we can discern that the RHD participant had some major issues in remembering and also had lapses in both the stories as well. The RHD participant could not remember the story at all and added elements of his own to make sense of the story. He also could not remember the chronological order of the events, of whatever he remembered. The control participant on the other hand had 2 digressions in the first story and 2 digressions in the second story as well. There were major lapses, even in the narration of the control participant as well, in both the stories.

5. **Questions answered**

STORY 1				
	Questions	Actual answer	RHD participant	Control participant
1	Which animal(s) were mentioned in the story?	A deer	A deer	A deer
2	What was the deer doing?	Looking at his reflection	Looking at its reflection	Looking at his reflection
3	Why did the deer run?	A hunter shot an arrow but it didn't touch	**<u>A hunter mounted it</u>**	A hunter shot an arrow. The deer ran for its life.
4	Why was he caught?	His big antlers were caught in a bush	Antlers	**<u>The antlers caught the deer</u>**
5	What was the deer insulting, in the beginning?	His thin legs, that don't match his antlers and body.	The legs	His thin legs, that don't match his antlers and body.

STORY 2				
	Questions	Actual answer	RHD participant	Control participant
1	Which animal(s) were mentioned in the story?	Frogs, stork	Frogs and a stork in the end	Frogs, stork
2	Where did the frogs live?	In a small pond	In a marshy and small pond	In a small pond
3	What did the frogs want the first time?	A king	A king	A king
4	What did the frogs want the second time?	A king who would actually be alive and rule over them	A king who would actually rule over them	A king who would actually be alive and rule over them
5	Why did all the frogs die?	The stork ate them all	**<u>God killed them all</u>**	The stork ate them all

We can observe the following from fig 3.321: 40SB82MR has been able to answer 4 questions in the first story and the second story. The control participant answered 4 questions in the first story and 5 questions in the second story.

B. Sentences

Declaratives

Fig 3.323 – 3.325. We can observe the following from the figure displayed previously: In sentence 1, 40SB82MR has a type C curve, which is similar to 21SD82MC, 50MEANMR and 49MEANMC, who have also recorded curves belonging to the type C of sentence. The type C sentence begins at the highest pitch point, the second point is lower than the starting point and the third point is either equal to or lower than the pitch point in the middle. In sentence 2 40SB82MR has recorded a type A curve, in comparison with 21SD82MC, who has a type A curve. 50MEANMR and 49MEANMC, have recorded curves belonging to the type D. Type A sentences generally denote a yes/no question. In sentence 3, 40SB82MR has a type C sentence while 21SD82MC, 50MEANMR and 49MEANMC have recorded type B sentences.

Imperatives

Fig 3.326 – 3.328. We can observe the following from the figure displayed previously: In sentence 4, 40SB82MR, 21SD82MC, 50MEANMR and 49MEANMC have all made type D sentences. In sentence 5, 40SB82MR has made a type D sentence in comparison with 21SD82MC, who has a type A sentence. 50MEANMR and 49MEANMC show type D sentences. In a type D sentence, the highest pitch point in a sentence is in the middle. But a type A sentence generally denotes a yes/no question. In sentence 6, 40SB82MR conforms to a type C sentence while 21SD82MC, 50MEANMR and 49MEANMC have also made type C sentences.

Interrogatives

Fig 3.429 – 3.331. We can observe the following from the figure displayed previously: In sentence 7, 40SB82MR has a A type sentence in comparison with 21SD82MC, who has a type D sentences. This is in contrast with 50MEANMR and 49MEANMC who have recorded type D sentences. In sentence 8, 40SB82MR has made a type C sentence in comparison with 21SD82MC, who has made a type D sentence. 50MEANMR has a type D sentence and from the chart 49MEANMC has no visible contour, but on checking the figures, 49MEANMC has made a type D sentence as well. In sentence 9, 40SB82MR has a type C curve in comparison with 21SD82MC, 50MEANMR and 49MEANMC who have type D sentences.

C. VOWELS

Fig 3.322 compares female RHD participant 40SB82MR with the individual age and gender matched male, that is 15AK57MC. We can observe the following from the figure displayed previously: The vowel /i/ (f1=-312, f2-f1=-2063) in 40SB82MR is more fronted than vowel /i/ (f1=-326, f2-f1=-1793) in 21SD82MC. The vowel /e/ (f1=-404, f2-f1=-1629) in 40SB82MR is more fronted and higher than vowel /e/ (f1=-444, f2-f1=-1496) in 21SD82MC. The vowel /æ/ (f1=-698, f2-f1=-1385) in 40SB82MR is lower and fronted in comparison vowel /æ/ (f1=-577, f2-f1=-1133) in 21SD82MC. The vowel /ɑ/ (f1=-881, f2-f1=-488) in 40SB82MR is lower and slightly backed in comparison with vowel /ɑ/ (f1=-758, f2-f1=-649) in 21SD82MC. The vowel /ɔ/ (f1=-595, f2-f1=-435) in 40SB82MR is lower and backed in comparison with vowel /ɔ/ (f1=-537, f2-f1=-519) in 21SD82MC. The vowel /o/ (f1=-420, f2-f1=-402) in 21SD82MC is almost at the same place as vowel /o/ (f1=-490, f2-f1=-1074) in 40SB82MR. The vowel /o/ in 21SD82MC is closer to vowel /e/ (f1=-444, f2-f1=-1496) in 21SD82MC. The vowel /u/ (f1=-322, f2-f1=-547) in 40SB82MR is slightly fronted and slightly lower than vowel /u/ (f1=-318, f2-f1=-399) in 21SD82MC. The area of the acoustic space chart for 40SB82MR is 519492 and for 21SD82MC is 295629.5, and 96MEANMR is 336881. The area of 40SB82MR is 75.7% bigger than that of the individual control and 54.2% bigger than the mean of RHD participants. The RHD participant has a much bigger acoustic space, as can be discerned and has a bigger high low and front back than the control participant.

3.5.20.CASE STUDY 20

PRIMARY INFO

Codified Name: 41SK55MR.

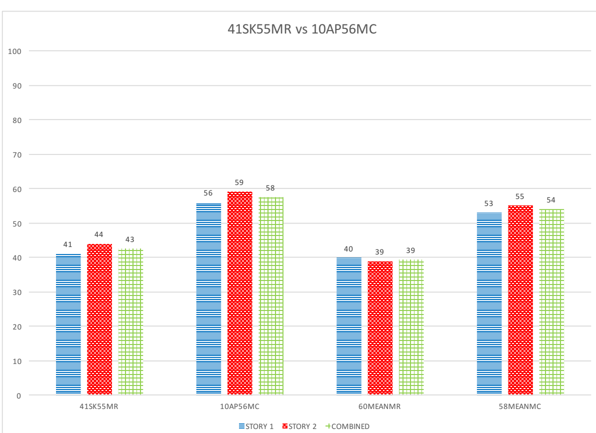
Male, 55 years of age, at the time of recording and case study.

Age and gender matched control: 10AP56MC
Time since incidence: approximately 6 months back, at the time of recording.

PARTICIPANT INFORMATION

Condition of participant: The participant was fully conscious, having scored 11 on the GCS. He also scored 26 on the MMSE. The participant could walk without any problems. The doctor asked him to do some actions with his hands, involving muscle coordination and he could do it with ease. The participant could also perform actions based on instructions, which involved complicated and elaborate instructions. The speech of the participant was not slurred and was easy to understand. The participant displayed no left hemisphere neglect. His color recognition was perfect. The doctor also performed a test in which he held both of the participant's hands in his hands and then asked the participant to keep holding them where he is holding them, after he lets them go. He could not maintain the position of the hands. The participant had mild issues in remembering things. He is undergoing no physiotherapy because he is normal now. **Observations made by doctor:** The doctor mentions that he has no agraphia, mild dementia, and alexia. Participant is hypertensive. Participant is an alcoholic and a smoker. Participant has no problems in planning and judgement. Damaged episodic memory and shaky short-term memory. **Diagnosis made by doctor:** The doctor mentions that even if the participant might suffer another stroke if he cannot bring down his tension levels. The participant was also asked to stop manual labor. He was asked to continue medicines for blood pressure and to follow up in six months. **Region of damage:** Hyper dense well-defined lesion with mild edema **<u>in right upper parietal cortex</u>**. Could be subacute to chronic ICH.

<u>COMPREHENSIVE STUDY OF PARTICIPANT AT THE 3 LEVELS OF COMMUNICATION</u>



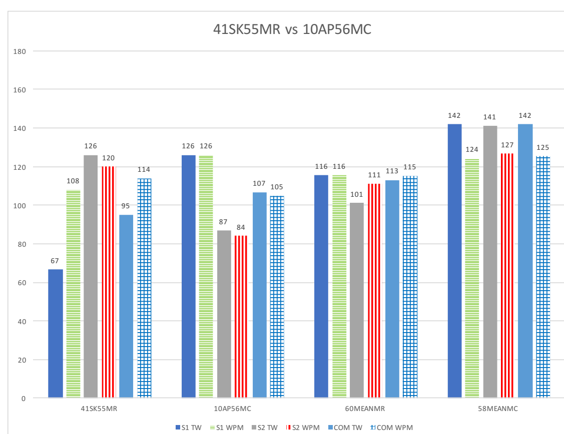


Fig 3.332 to 3.37: 41SK55MR - The bar graphs are comparisons at the level of discourse. The last diagram is an acoustic space.

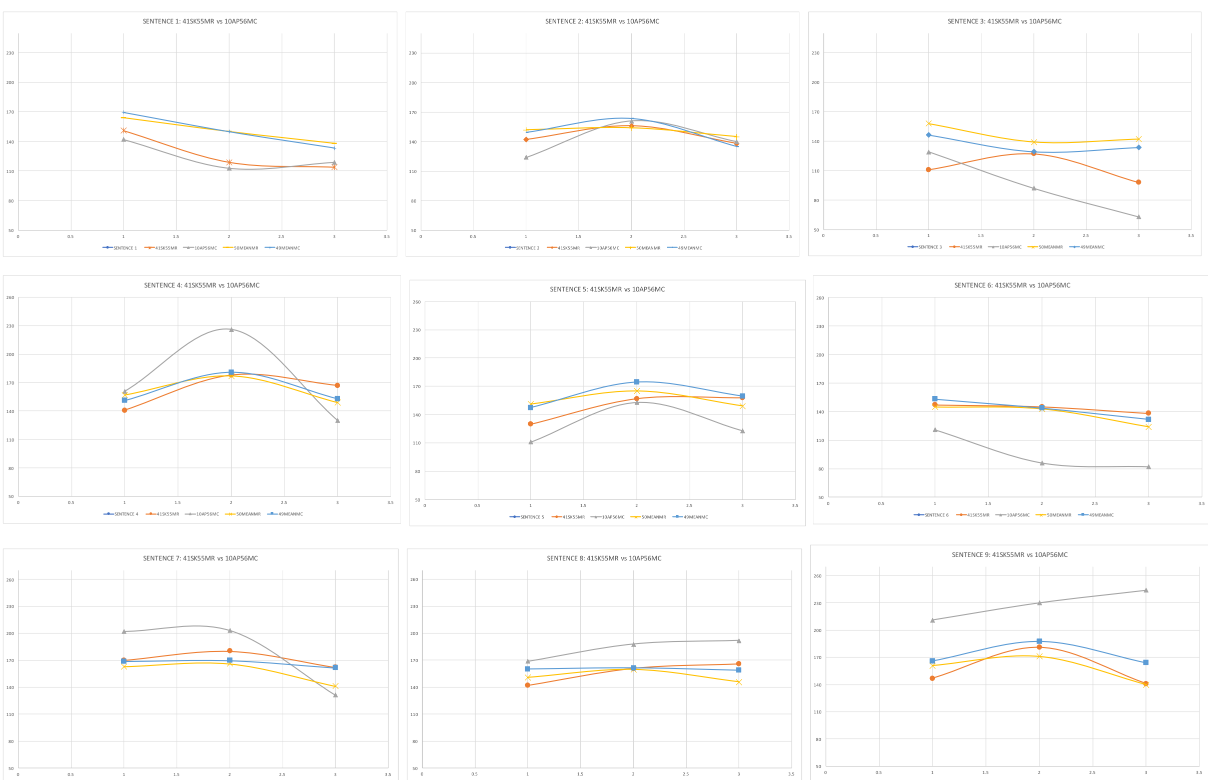


Fig 3.338 to 3.346: 41SK55MR - First three diagrams in first line are declarative sentences. The next line is composed of 3 imperative sentences and the third line has three interrogative sentences.

A. DISCOURSE

1. Pitch range

We can observe the following from fig 3.332: 41SK55MR has a pitch range of 41 Hz in the first story in comparison with 10AP56MC, who has a pitch range of 56 Hz. 60MEANMR has a pitch range of 40 Hz in the first story while 58MEANMC has a pitch range of 53 Hz in the first story. 41SK55MR has a pitch range of 44 Hz in comparison with 10AP56MC, who has a pitch range of 59 Hz. 60MEANMR has a pitch range of 39 Hz in the second story while 58MEANMC has a pitch range of 55 Hz in the second story. 41SK55MR has a pitch range of 43 Hz in the mean of the two stories, in comparison with 10AP56MC, who has a pitch range of 58 Hz in the mean of the two stories. 60MEANMR has a pitch range of 39 Hz in the mean of the two stories while 58MEANMC has a pitch range of 54 Hz in the same. The RHD participant has a much smaller pitch range than the control participant.

2. Fluency

We can observe the following from fig 3.333: 41SK55MR has 67 words in story 1 in comparison with 10AP56MC, who has 126 words, which is a huge difference. 41SK55MR has a word rate of 108 wpm in story 1 in comparison with 10AP56MC, who has 126 wpm. 41SK55MR has 126 words in story 2 in comparison with 10AP56MC, who has 87 words. 41SK55MR has a word rate of 120 wpm in story 2 in comparison with 10AP56MC, who has 84 wpm. 41SK55MR has 95 words in the combined mean of the two stories in comparison with 10AP56MC, who has 107 words. 41SK55MR has a word rate of 114 wpm in the combined mean of the two stories in comparison with 10AP56MC, who has 105 wpm. The RHD participant has a performance, which is very similar to that of the control participant.

3. Duration

We can observe the following from fig 3.334: 41SK55MR took 55 seconds (fluency – 108 words per minute) to complete narrating the first story in comparison with 10AP56MC, who took 60 seconds (fluency – 126 words per minute). 41SK55MR took 49 seconds (fluency – 120 words per minute) to complete the second story, in comparison with 10AP56MC, who took 62 seconds (fluency – 84 words per minute). 41SK55MR took 50 seconds (fluency – 114 words per minute) in the mean of the two stories, in comparison with 10AP56MC has a mean of 61 seconds (fluency – 105 words per minute). We can see that 41SK55MR took much less time than 10AP56MC in the first story but has lesser content as well. The second story has similar time and content. 58MEANMC took a time of 68 seconds (fluency – 125 words per minute) and 60MEANMR took 58 seconds (fluency – 113 words per minute), in the mean of the two stories.

4. Digressions and lapses

Story 1 (Narrator)	RHD participant	Control participant
There was a deer. It was standing at the edge of the river. It saw its majestic antlers in the river, as a reflection. It kept praising it. Next it saw its feet and started to demean it because it was thin and did not match the overall beauty of the whole body. In the meantime, a hunter shot an arrow but missed. The deer started running in fear but ultimately got caught by the antlers in a bushy area. He exclaimed that the antlers he was praising put him in utter danger but his legs he was demeaning, tried to help him run that far.	A deer, went to drink water._It saw its face in the water. It praised its antlers. In the meantime, a hunter comes and shoots an arrow but missed and the deer starts to run in fear. The antlers get caught in a creeper bush. The deer was praising the legs but they didn't help at all.	One day a deer went to drink water at a river. It saw its reflection in the water. It felt ashamed for its legs which were thin and didn't match the beautiful antlers and the body. In the meantime, a hunter shot an arrow at the deer and the deer started to run. Unfortunately, the deer got caught by the antlers in a hedge. It realized that what it was feeling ashamed of, the legs, were what tries to help it; while the beautiful antlers just pushed it towards impending death.

Story 2 (Narrator)	RHD participant	Control participant
Thousands of frogs lived in a small pond. They were happy but they wanted a king. So, they prayed to God for a king. God sent a big tree trunk to them. At first, they were intimidated by its size but soon they discovered, their new king did not move and did not talk. One brave frog climbed to the top of the trunk and after that many others gathered the courage and climbed to the top. They were unhappy and they prayed to God again stating that the king they were sent was inanimate and they want a new king who would be alive and actually rule over them. God got a bit angry. He sent a stork to the pond and the stork ate up all the frogs.	There was a small pond and many frogs lived in it. They planned to get a king and prayed to God for the same. God dropped a tree branch. The branch didn't move at all and soon the frigs climbed the tree bark. They were disappointed that the king didn't move and rule. They prayed to God again for another king who would actually rule and be alive. God was irritated at this and sent a stork to the small pond. The stork started to eat all the frogs one by one and they realized it was too late for them to change anything.	In a small pond, lived innumerous frogs. One day they thought that they wanted a king. They prayed to God for the same and God sent a tree bark to the pond. The frogs looked at it and felt it but the king didn't move. They didn't like it. They prayed to God for another king, who would actually rule over them. God got irritated at this. God sent a stork to the small pond and then started eating all the frogs one by one. The frogs realized it was too late for them and what had happened, could not be avoided.

We can see no digressions in story 1 and 2 for the RHD participant but there are lapses in the reproduction of the story. The control participant on the other hand had no digressions in both the stories. There were no lapses in the narration of the control participant as well, in both the stories.

5. **Questions answered**

STORY 1				
	Questions	Actual answer	RHD participant	Control participant
1	Which animal(s) were mentioned in the story?	A deer	A deer	A deer
2	What was the deer doing?	Looking at his reflection	Looking at its reflection	Looking at his reflection
3	Why did the deer run?	A hunter shot an arrow but it didn't touch	A hunter followed it	A hunter shot an arrow. The deer ran for its life.
4	Why was he caught?	His big antlers were caught in a bush	Antlers	His big antlers were caught in a bush
5	What was the deer insulting, in the beginning?	His thin legs, that don't match his antlers and body.	The legs	His thin legs, that don't match his antlers and body.

STORY 2				
	Questions	Actual answer	RHD participant	Control participant
1	Which animal(s) were mentioned in the story?	Frogs, stork	Frogs and a stork in the end	Frogs, stork
2	Where did the frogs live?	In a small pond	In a marshy and small pond	In a small pond
3	What did the frogs want the first time?	A king	A king	A king
4	What did the frogs want the second time?	A king who would actually be alive and rule over them	A king who would actually rule over them	A king who would actually be alive and rule over them
5	Why did all the frogs die?	The stork ate them all	The stork killed them all by eating them	The stork ate them all

We can observe the following from fig 3.336: 41SK55MR has been able to answer all 5 questions in the first story and second story. The control participant answered all questions, as well as the mean of the control group 58MEANMC and the mean of the RHD group 60MEANFR.

B. **SENTENCES**

Declaratives

Fig 3.338 – 3.340. We can observe the following from the figure displayed previously: In sentence 1, 41SK55MR has a type C sentence in comparison with 10AP56MC, who has a type B sentence. 50MEANMR and 49MEANMC have recorded curves belonging to the type C. The type C sentence begins at the highest pitch point, the second point is lower than the starting point and the third point is either equal to or lower than the pitch point in the middle. Type C generally denotes declarative sentences. In sentence 2, 41SK55MR has recorded a type D curve, in comparison with 10AP56MC, who has recorded a type C curve. The RHD participant has an operating range which is higher than the other pitch curves. 50MEANMR and 49MEANMC, have recorded curves belonging to the type D. 49MEANMC recorded at a pitch range which is much higher than the mean of the RHD group 50MEANMR. In sentence 3, 41SK55MR has a type D curve in comparison with 10AP56MC who also has a type C curve. 50MEANMR and 49MEANMC have recorded type B sentences.

Imperatives

Fig 3.341 – 3.343. We can observe the following from the figure displayed previously: In sentence 4, 41SK55MR has a type B sentence while, 10AP56MC, 50MEANMR and 49MEANMC have made type D sentences. In sentence 5, 41SK55MR has a type A sentence while, 10AP56MC, 50MEANMR and 49MEANMC have type D sentences. In a type D sentence, the highest pitch point in a sentence is in the middle. In sentence 6, 41SK55MR has a type C curve and 10AP56MC, 50MEANMR and 49MEANMC also have type C sentences.

Interrogatives

Fig 3.344 – 3.346. We can observe the following from the figure displayed previously: In sentence 7, 41SK55MR has a D type sentence in comparison with 10AP56MC, who also has a type D sentences. 50MEANMR and 49MEANMC also have recorded type D sentences. In sentence 8, 41SK55MR has made a type A sentence in comparison with 10AP56MC, who also has made a type A sentence. 50MEANMR also has a type D sentence and from the chart 49MEANMC has no visible contour, but on checking the figures, 49MEANMC has made a type D sentence as well. In sentence 9, 41SK55MR has a type D curve in comparison with 10AP56MC, who has a type A sentence. 50MEANMR and 49MEANMC have type D sentences.

C. **VOWELS**

Fig 3.337 compares female RHD participant 41SK55MR with the individual age and gender matched male, that is 15AK57MC. We can observe the following from the figure displayed previously: The vowel /i/ (f1=-383, f2-f1=-1978) in 41SK55MR is lower than vowel /i/ (f1=-318, f2-f1=-2014) in 10AP56MC. The vowel /e/ (f1=-414, f2-f1=-1578) in 41SK55MR is almost at the same place as vowel /e/ (f1=-404, f2-f1=-1620) in 10AP56MC. The vowel /æ/

(f1=-792, f2-f1=-939) in 41SK55MR is lower and slightly backed in comparison vowel with vowel /æ/ (f1=-699, f2-f1=-1063) in 10AP56MC. The vowel /ɑ/ (f1=-843, f2-f1=-693) in 41SK55MR is lower and more fronted in comparison with vowel /ɑ/ (f1=-739, f2-f1=-460) in 10AP56MC. The vowel /ɔ/ (f1=-649, f2-f1=-519) in 41SK55MR is lower and fronted than vowel /ɔ/ (f1=-614, f2-f1=-356) in 10AP56MC. The vowel /o/ (f1=-514, f2-f1=-626) in 41SK55MR is lower and more fronted than vowel /o/ (f1=-443, f2-f1=-590) in 10AP56MC. The vowel /u/ (f1=-368, f2-f1=-377) in 41SK55MR is backed and slightly lower in comparison with vowel /u/ (f1=-362, f2-f1=-458) in 10AP56MC. The area of the acoustic space chart for 41SK55MR is 322039 and for 10AP56MC is 353753.5, and 96MEANMR is 336881. The area of 41SK55MR is 9% smaller than that of the individual control and 4.4% smaller than the mean of RHD participants. The area of the RHD participant is significantly smaller than the acoustic space area of the control participant. The RHD participant has, almost the same high low, back front range as the control participant and this can also be discerned from the insignificant difference in area of the acoustic spaces.

3.5.21.CASE STUDY 21

PRIMARY INFO

Codified Name: 42SR44MR.

Male, 44 years of age, at the time of recording and case study.

Age and gender matched control: 20SD48MC

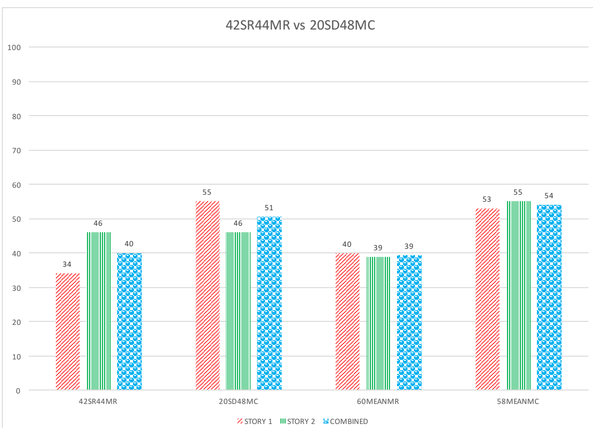
Time since incidence: approximately 3 months back, at the time of recording.

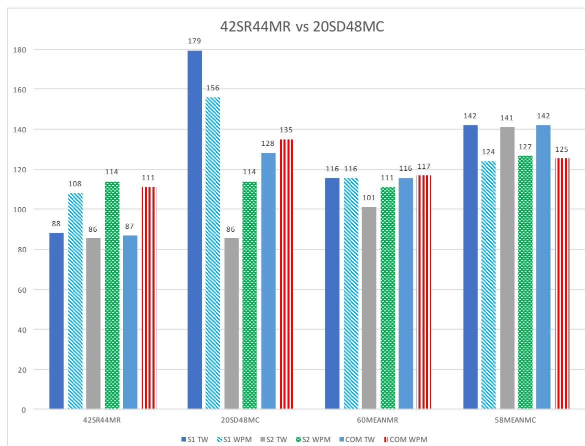
PARTICIPANT INFORMATION

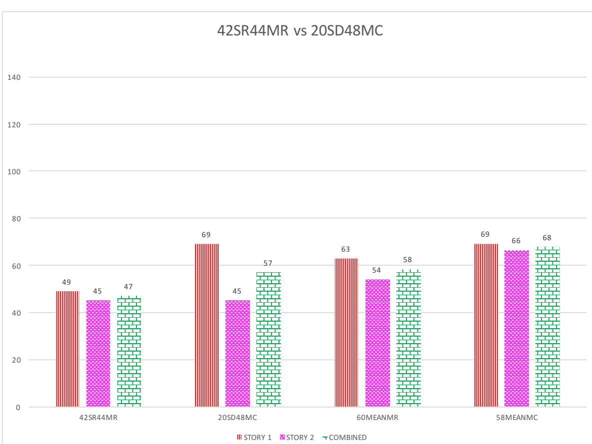
Condition of participant: The participant was conscious, and scored 14 on the GCS. He scored 26 on the MMSE. The participant cannot walk. His family members have to help him. The doctor asked him to do some actions with his hand, involving muscle coordination and he could do it but it needed him time to complete. The participant did not face any difficulty in performing actions based on instructions, which involved complicated and elaborate instructions. The speech of the participant was slurred and was difficult to understand. The participant displays no left hemisphere neglect. His sense of color recognition was intact. The doctor also performed a test in which he held both of the participant's hands in his hands and then asked the participant to keep holding them where he is holding them, after he lets them go.

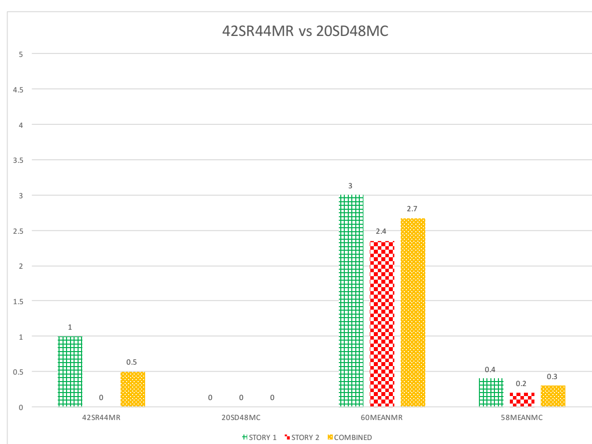
He could maintain the position of the right hand. The left hand fell down a fair bit, before he regained control. The participant had no issues in remembering things. He is undergoing no physiotherapy due to his poor financial condition. **Observations made by doctor:** The doctor mentions that he has no agraphia, no dementia, and no alexia. Participant is not hypertensive. Participant is not an alcoholic and not a smoker. Participant has no problems in planning and judgement. **Diagnosis made by doctor:** The doctor mentions that the participant needs to be start physiotherapy for the hands and legs. He was asked to follow up in three months. **Region of damage:** Subacute lacunar infarct in **<u>the right putaminal and anterior paraventricular region</u>**. Small hyper intensities noted in posterior parietal region.

<u>COMPREHENSIVE STUDY OF PARTICIPANT AT THE 3 LEVELS OF COMMUNICATION</u>









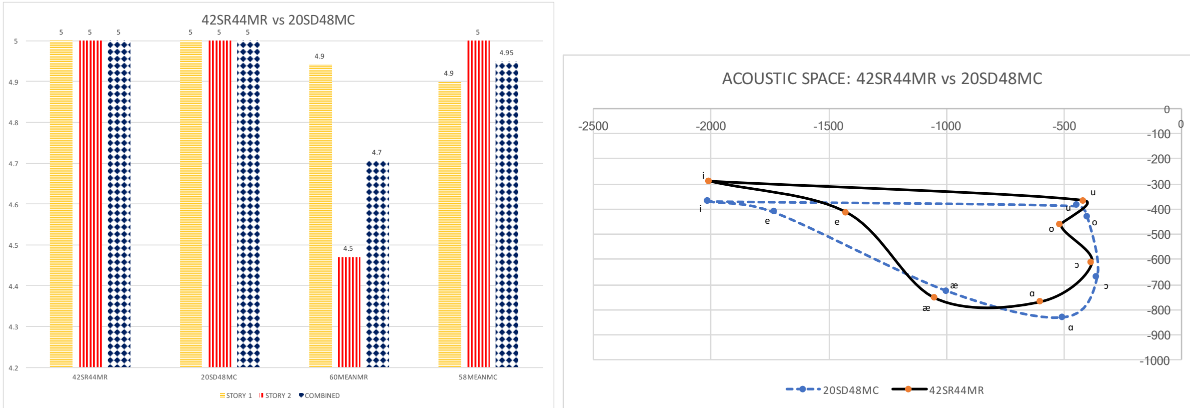


Fig 3.347 to 3.352: 42SR44MR - The bar graphs are comparisons at the level of discourse. The last diagram is an acoustic space.

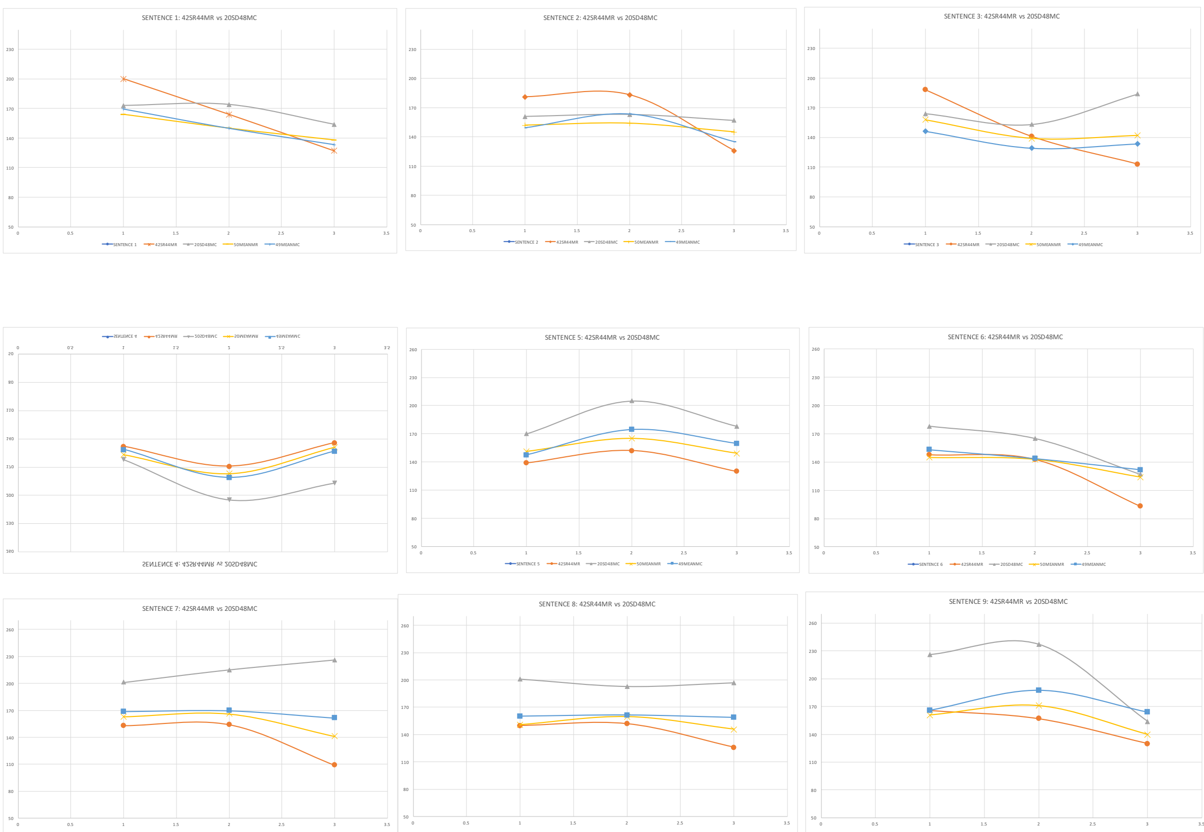


Fig 3.353 to 3.361: 42SR44MR - First three diagrams in first line are declarative sentences. The next line is composed of 3 imperative sentences and the third line has three interrogative sentences.

A. Discourse

1. Pitch range

We can observe the following from fig 3.347: 42SR44MR has a pitch range of 34 Hz in the first story in comparison with 20SD48MC, who has a pitch range of 55 Hz. It is a significant difference. 60MEANMR has a pitch range of 40 Hz in the first story while 58MEANMC has a pitch range of 53 Hz in the first story. 42SR44MR has a pitch range of 46 Hz in the second story in comparison with 20SD48MC, who has a pitch range of 46 Hz. 60MEANMR has a pitch range of 39 Hz in the second story while 58MEANMC has a pitch range of 55 Hz in the second story. 42SR44MR has a pitch range of 40 Hz in the mean of the stories in comparison with 20SD48MC, who has a pitch range of 51 Hz. It is a significant difference and highlights the fact that the RHD participant had a smaller pitch range. 60MEANMR has a pitch range of 39 Hz in the mean of the two stories while 58MEANMC has a pitch range of 54 Hz in the same. It should be noted that the difference in pitch range between the two stories in huge.

2. **Fluency**

We can observe the following from fig 3.348: 42SR44MR has 88 words in story 1 in comparison with 20SD48MC, who has 179 words, which is a huge difference. 42SR44MR has a word rate of 108 wpm in story 1 in comparison with 20SD48MC, who has 156 wpm. 42SR44MR has 86 words in story 2 in comparison with 20SD48MC, who has 86 words. 42SR44MR has a word rate of 114 wpm in story 2 in comparison with 20SD48MC, who has 114 wpm. 42SR44MR has 87 words in the combined mean of the two stories in comparison with 20SD48MC, who has 128 words. 42SR44MR has a word rate of 111 wpm in the combined mean of the two stories in comparison with 20SD48MC, who has 135 wpm. The RHD participant has a performance, which is very similar to that of the RHD group mean but has figures lesser than those of the control group participant and mean.

3. **Duration**

We can observe the following from 3.349: 42SR44MR took 49 seconds (fluency – 108 words per minute) to complete narrating the first story in comparison with 20SD48MC, who took 69 seconds (fluency – 156 words per minute). 42SR44MR took 45 seconds (fluency – 114 words per minute) to complete narrating the second story in comparison with 20SD48MC, who took 45 seconds (fluency – 114 words per minute). 42SR44MR has a mean duration of 47 seconds (fluency – 111 words per minute) whereas, 20SD48MC has a mean of 57 seconds (fluency – 135 words per minute). 58MEANMC took a time of 68 seconds (fluency – 125 words per minute) and 60MEANMR took a time of 58 seconds (fluency – 113 words per minute), in the mean of the two stories.

4. Digressions and lapses

Story 1 (Narrator)	RHD participant	Control participant
There was a deer. It was standing at the edge of the river. It saw its majestic antlers in the river, as a reflection. It kept praising it. Next it saw its feet and started to demean it because it was thin and did not match the overall beauty of the whole body. In the meantime, a hunter shot an arrow but missed. The deer started running in fear but ultimately got caught by the antlers in a bushy area. He exclaimed that the antlers he was praising put him in utter danger but his legs he was demeaning, tried to help him run that far.	<u>A deer was standing at Ganges side</u> and was watching its reflection. It was insulting its thin legs and was praising its antlers. A hunter shot the deer with an arrow but missed and the deer ran in fear. Soon it got stuck by the antler in a bush or creeper. It then realized that the legs, it was insulting saved it but the antlers it was raising actually got it into trouble.	In a forest lived a deer. It went to drink water and noticed its reflection in the water. It praised it beautiful antlers and then suddenly noticed the thin legs and felt ashamed of having such thin legs. In the meantime, a hunter shot an arrow at the deer and missed. The deer started running and then got caught by the antlers in a bush. The deer then realized that what it was praising got it caught but what it was ashamed of helped it escape, although the antlers got it caught finally.

Story 2 (Narrator)	RHD participant	Control participant
Thousands of frogs lived in a small pond. They were happy but they wanted a king. So, they prayed to God for a king. God sent a big tree trunk to them. At first, they were intimidated by its size but soon they discovered, their new king did not move and did not talk. One brave frog climbed to the top of the trunk and after that many others gathered the courage and climbed to the top. They were unhappy and they prayed to God again stating that the king they were sent was inanimate and they want a new king who would be alive and actually rule over them. God got a bit angry. He sent a stork to the pond and the stork ate up all the frogs.	A small pond was there and innumerous frogs lived there. They wanted a king and prayed to God for the same. God dropped a log and it didn't move at all. Soon they were disappointed and realized this was no king. Soon they prayed to God again for another king who would actually rule and be alive and God got angry at this. God sent a stork to their place and the stork ate all the frogs one by one.	Many frogs lived in a small pond. One day they prayed to God for a king. God put a tree bark in the pond. But the frogs noticed that the king didn't move or budge. They touched it and it was inanimate to touch. The frogs felt bad and prayed to God again for another king, a second king, who would actually be animate and rule over them. God got angry at this and sent a stork to their home. The stork then started eating all the frogs one by one.

We can see 1 digression in story 1 for the RHD participant and 0 digressions in story 2. From the table above, which contain the stories, we can discern that the RHD participant had no major issues in remembering and had no lapses in both the stories as well. The control participant had 0 digressions in the first story and 0 digressions in the second story as well. There were no major lapses, even in the narration of the control participant as well, in both the stories.

5. Questions answered

STORY 1				
	Questions	Actual answer	RHD participant	Control participant

1	Which animal(s) were mentioned in the story?	A deer	A deer	A deer
2	What was the deer doing?	Looking at his reflection	Looking at its reflection	Looking at his reflection
3	Why did the deer run?	A hunter shot an arrow but it didn't touch	A hunter followed it	A hunter shot an arrow. The deer ran for its life.
4	Why was he caught?	His big antlers were caught in a bush	Antlers got caught in creepers.	The antlers got caught in a hedge.
5	What was the deer insulting, in the beginning?	His thin legs, that don't match his antlers and body.	The legs	His thin legs, that don't match his antlers and body.

STORY 2				
	Questions	Actual answer	RHD participant	Control participant
1	Which animal(s) were mentioned in the story?	Frogs, stork	Frogs and a stork in the end	Frogs, stork
2	Where did the frogs live?	In a small pond	In a marshy and small pond	In a small pond
3	What did the frogs want the first time?	A king	A king	A king
4	What did the frogs want the second time?	A king who would actually be alive and rule over them	A king who would rule	A king who would actually be alive and rule over them
5	Why did all the frogs die?	The stork ate them all	The stork killed them all	The stork ate them all

We can observe the following from fig 3.351: 42SR44MR has been able to answer all 5 questions in the both stories. The control participant answered all questions in both the stories.

B. SENTENCES

<u>Declaratives</u>

Fig 3.353 – 3.355. We can observe the following from the figure displayed previously: In sentence 1, 42SR44MR has a type C curve, and 20SD48MC, has a type D curve. 50MEANMR and 49MEANMC, have recorded curves belonging to the type C of sentence. The type C sentence begins at the highest pitch point, the second point is lower than the starting point and the third point is either equal to or lower than the pitch point in the middle. In sentence 2, 42SR44MR has recorded a type D curve, in comparison with 20SD48MC, who also has a type D curve. 50MEANMR and 49MEANMC, have recorded curves belonging to the type D. In sentence 3, 20SD48MC has a type C curve while, 50MEANMR and 49MEANMC have type B sentences.

<u>Imperatives</u>

Fig 3.356 – 3.358. We can observe the following from the figure displayed previously: In sentence 4, 42SR44MR, 20SD48MC, 50MEANMR and 49MEANMC have type D sentences. In sentence 5, 42SR44MR, 20SD48MC, 50MEANMR and 49MEANMC have type D sentences. In a type D sentence, the highest pitch point in a sentence is in the middle. In sentence 6, 42SR44MR conforms to a type C sentence while 20SD48MC also conforms to a type C sentence. 50MEANMR and 49MEANMC have type C sentences.

Interrogatives

Fig 3.359 – 3.361. We can observe the following from the figure displayed previously: In sentence 7, 42SR44MR has a D type sentence in comparison with 20SD48MC, who has a type A sentences. This is in contrast with 50MEANMR and 49MEANMC who have recorded type D sentences. In sentence 8, 42SR44MR has made a type D sentence in comparison with 20SD48MC, who has made a type B sentence. 50MEANMR has a type D sentence and from the chart 49MEANMC has no visible contour, but on checking the figures, 49MEANMC has made a type D sentence as well. In sentence 9, 42SR44MR has a type C curve in comparison with 20SD48MC, 50MEANMR and 49MEANMC who also have type D sentences.

C. VOWELS

Fig 3.352 compares female RHD participant 42SR44MR with the individual age and gender matched male, that is 15AK57MC. We can observe the following from the figure displayed previously: The vowel /i/ (f1=-291, f2-f1=-2007) in 42SR44MR is higher than vowel /i/ (f1=-368, f2-f1=-2011) in 20SD48MC. The vowel /e/ (f1=-414, f2-f1=-1427) in 42SR44MR is more backed than vowel /e/ (f1=-412, f2-f1=-1732) in 20SD48MC. The vowel /æ/ (f1=-755, f2-f1=-1047) in 42SR44MR is slightly fronted and lower comparison than vowel /æ/ (f1=-726, f2-f1=-998) in 20SD48MC. The vowel /ɑ/ (f1=-768, f2-f1=-598) in 42SR44MR is higher and fronted in comparison with vowel /ɑ/ (f1=-831, f2-f1=-506) in 20SD48MC. The vowel /ɔ/ (f1=-614, f2-f1=-381) in 42SR44MR is slightly higher and fronted in comparison with vowel /ɔ/ (f1=-670, f2-f1=-361) in 20SD48MC. The vowel /o/ (f1=-463, f2-f1=-514) in 42SR44MR is fronted and lower in comparison with vowel /o/ (f1=-432, f2-f1=-402) in 20SD48MC. The vowel /u/ (f1=-367, f2-f1=-417) in 42SR44MR is almost at the same place as with vowel /u/ (f1=-387, f2-f1=-442) in 20SD48MC. The area of the acoustic space chart for 42SR44MR is 363945 and for 20SD48MC is 387032, and 96MEANMR is 336881. The area of 42SR44MR is 6% smaller than that of the individual control and 8% larger than the mean of RHD participants. The acoustic space of the RHD participant is significantly smaller. The difference in area is insignificant and that can also be seen in the high low and front back capabilities of the RHD participant in comparison with the control participant.

3.5.22. CASE STUDY 22

PRIMARY INFO

Codified Name: 43SK55MR.

Male, 55 years of age, at the time of recording and case study.

Age and gender matched control: 14AK56MC

Time since incidence: approximately 3 months back, at the time of recording.

PARTICIPANT INFORMATION

Condition of participant: The participant was conscious, and scored more than 12 on the GCS. He scored 27 on the MMSE. The participant can walk with support from walking aids or with support from family members. The doctor asked him to do some actions with his hand, involving muscle coordination and he could do it but it needed him to put in extreme effort. The participant did not face any difficulty in performing actions based on instructions, which involved complicated and elaborate instructions. The speech of the participant was slurred and was difficult to understand. The help of the family was needed to understand the participant properly. The participant displays extreme left hemisphere neglect. The family members allege that he doesn't eat the food from the left side of his food plate. He keeps on bumping into objects to the left of him. His sense of color recognition was intact. The doctor also performed a test in which he held both of the participant's hands in his hands and then asked the participant to keep holding them where he is holding them, after he lets them go. He could maintain the position of the right hand. The left hand fell down a fair bit, before he regained control. The participant had no issues in remembering things. He is undergoing no physiotherapy due to his poor financial condition. **Observations made by doctor:** The doctor mentions that he has no agraphia, no dementia, and no alexia. Participant is not hypertensive. Participant is not an alcoholic but not a smoker. Participant has no problems in planning and judgement. **Diagnosis made by doctor:** The doctor mentions that the participant needs to be start physiotherapy for the hands and legs. He was asked to follow up in three months. **Region of damage:** Ischemic infarct at **right basal ganglia** and **right temporo parietal lobes**.

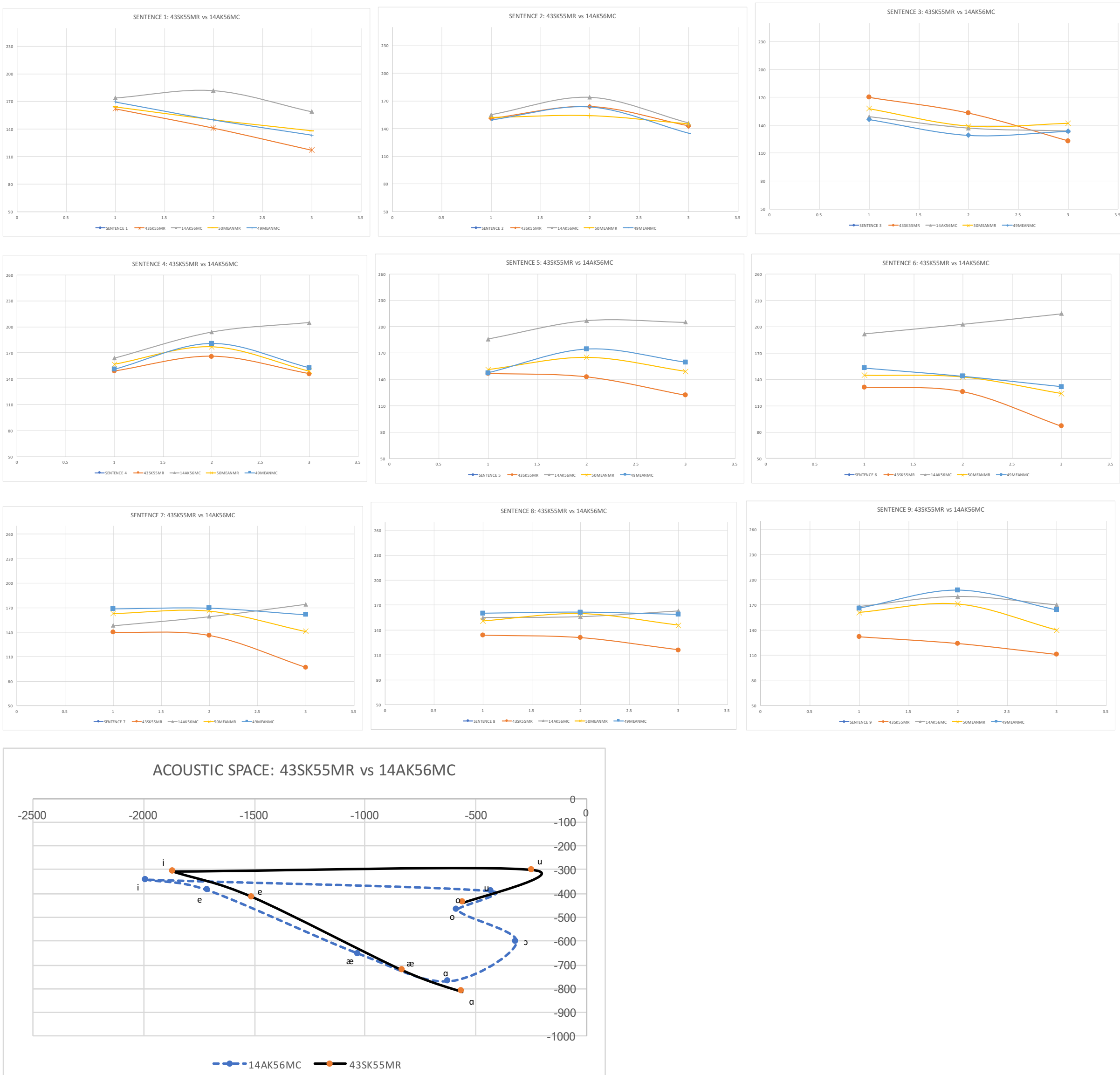


Fig 3.362 to 3.371: 43SK55MR - First three diagrams in first line are declarative sentences. The next line contains 3 imperative sentences and the third line has three interrogative sentences. The last diagram is an acoustic space.

A. SENTENCES

Declaratives

Fig 3.362 – 3.364. We can observe the following from the figure displayed previously: In sentence 1, 43SK55MR has a type C curve, and 14AK56MC, has a type D curve. 50MEANMR and 49MEANMC, have recorded curves belonging to the type C of sentence. The type C sentence begins at the highest pitch point, the second point is lower than the starting point and the third point is either equal to or lower than the pitch point in the middle. In sentence 2, 43SK55MR has recorded a type D curve, in comparison with 14AK56MC, who also has a type D curve. 50MEANMR and 49MEANMC, have recorded curves belonging to the type D. In sentence 3, 14AK56MC has a type C curve while, 50MEANMR and 49MEANMC have type B sentences.

Imperatives

Fig 3.365 – 3.367. We can observe the following from the figure displayed previously: In sentence 4, 14AK56MChas a type A sentence while 43SK55MR, 50MEANMR and 49MEANMC have type D sentences. In sentence 5, 43SK55MR has a type C sentence while, 14AK56MC, 50MEANMR and 49MEANMC have type D sentences. In a type D sentence, the highest pitch point in a sentence is in the middle. In sentence 6, 43SK55MR conforms to a type C sentence while 14AK56MC conforms to a type A sentence. 50MEANMR and 49MEANMC have type C sentences.

Interrogatives

Fig 3.368 – 3.370. We can observe the following from the figure displayed previously: In sentence 7, 43SK55MR has a C type sentence in comparison with 14AK56MC, who has a type A sentences. This is in contrast with 50MEANMR and 49MEANMC who have recorded type D sentences. In sentence 8, 43SK55MR has made a type C sentence in comparison with 14AK56MC, who has made a type A sentence. 50MEANMR has a type D sentence and from the chart 49MEANMC has no visible contour, but on checking the figures, 49MEANMC has made a type D sentence as well. In sentence 9, 43SK55MR has a type C curve in comparison with 14AK56MC, 50MEANMR and 49MEANMC who also have type D sentences.

B. **VOWELS**

Fig 3.371 compares female RHD participant 43SK55MR with the individual age and gender matched male, that is 15AK57MC. We can observe the following from the figure displayed previously: The vowel /i/ (f1=-308, f2-f1=-1867) in 43SK55MR is higher and a bit more backed than vowel /i/ (f1=-343, f2-f1=-1988) in 14AK56MC. The vowel /e/ (f1=-415, f2-f1=-1509) in 43SK55MR is more backed and a bit lower than vowel /e/ (f1=-387, f2-f1=-1710) in 14AK56MC. The vowel /æ/ (f1=-722, f2-f1=-831) in 43SK55MR is slightly lower and backed than vowel /æ/ (f1=-654, f2-f1=-1029) in 14AK56MC. The vowel /ɑ/ (f1=-812, f2-f1=-563) in 43SK55MR is lower and more backed in comparison with vowel /ɑ/ (f1=-770, f2-f1=-622) in

14AK56MC. The vowel /ɔ/ was not produced by 43SK55MR in comparison with vowel /ɔ/ (f1=-604, f2-f1=-316) in 14AK56MC. The participant wasn't willing to record the word with the /ɔ/ vowel. The vowel /o/ (f1=-558, f2-f1=-439) in 43SK55MR is slightly higher and fronted in comparison with vowel /o/ (f1=-469, f2-f1=-583) in 14AK56MC. The vowel /u/ (f1=-302, f2-f1=-244) in 43SK55MR is a lot more backed and higher in comparison with vowel /u/ (f1=-392, f2-f1=-487) in 14AK56MC. The area of the acoustic space chart for 43SK55MR is 344865.5 and for 14AK56MC is 308161.5, and 96MEANMR is 336881. The area of 43SK55MR is 12.6% bigger than that of the individual control and 2.4% bigger than the mean of RHD participants. The acoustic space of the RHD participant is significantly smaller. The difference in area is insignificant, despite the RHD participant missing out a vowel recording and that can also be seen in the high low and front back capabilities of the RHD participant in comparison with the control participant.

3.5.23.CASE STUDY 23

PRIMARY INFO

Codified Name: 44ZS64MR.

Male, 64 years of age, at the time of recording and case study.

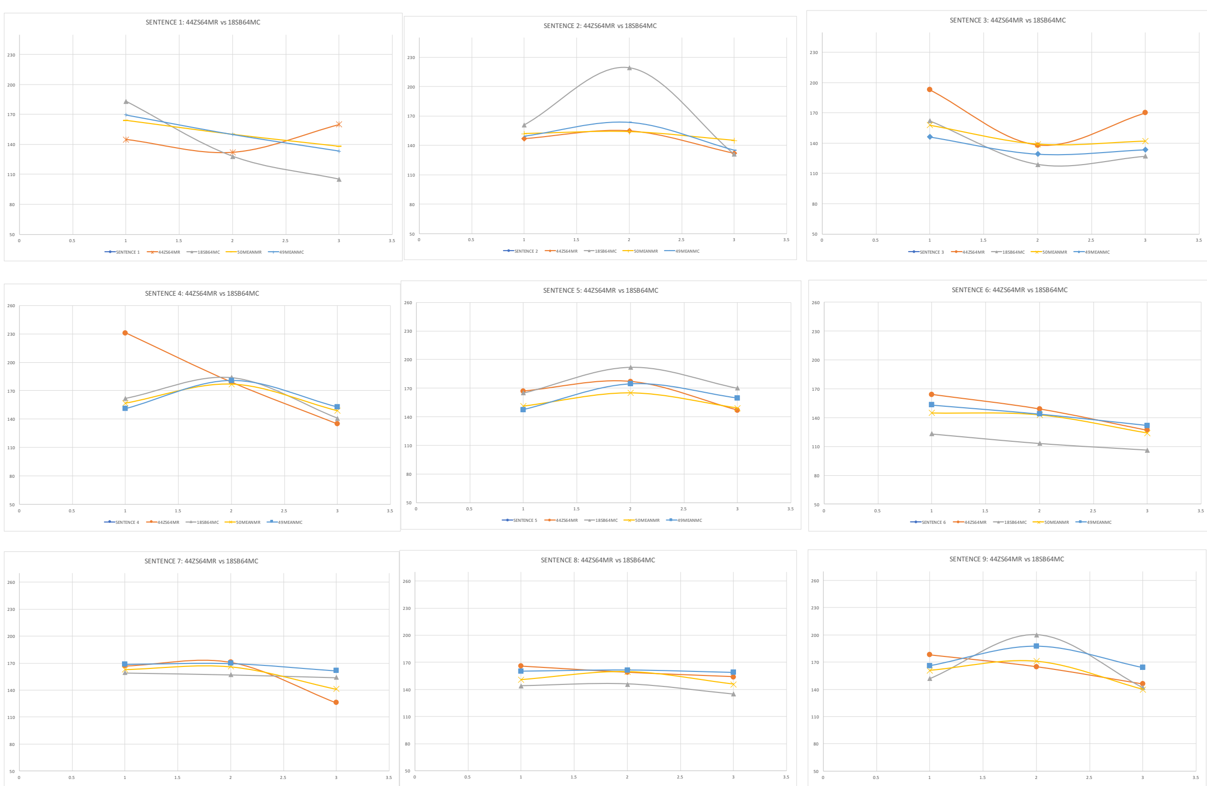
Age and gender matched control: 18SB64MC

Time since incidence: approximately 6 months back, at the time of recording.

PARTICIPANT INFORMATION

Condition of participant: The participant was conscious, and scored 11 on the GCS. He scored 29 on the MMSE. The participant can walk with support from walking aids or with support from family members. The participant also suffered from polio and already had weakened legs before the stroke happened. The doctor asked him to do some actions with his hand, involving muscle coordination and he could not do it. The participant did not face any difficulty in understanding elaborate and complicated instructions but could not perform them due to hemiparesis. The speech of the participant was highly slurred and was difficult to understand. The help of the family was needed to understand the participant properly. The participant displays extreme left hemisphere neglect. He keeps on bumping into objects to the left of him. The doctor also gave him a foot ruler and asked him to mark the mid-point. He marked a point towards the third quarter. His sense of color recognition was intact. The doctor also performed a test in which he held both of the participant's hands in his hands and then asked the participant to keep holding them where he is holding them, after he lets themgo. He could maintain the position of the right hand. The left hand fell down and he could not regain control. The participant had no issues in remembering things. He is undergoing no physiotherapy due to his poor financial condition. **Observations made by doctor:** The doctor mentions that he has no agraphia, no dementia, and no alexia. Participant is not hypertensive. Participant is not an alcoholic but not a smoker. Participant has no problems in planning and judgement. **Diagnosis made by doctor:** The doctor mentions that the participant needs to start physiotherapy for the hands and legs. He was asked to follow up in one months. **Region of damage:** Massive **15cc clot at right temporal lobe**, spread over to the **right basal ganglia.**

Comprehensive study of participant at the 3 levels of communication



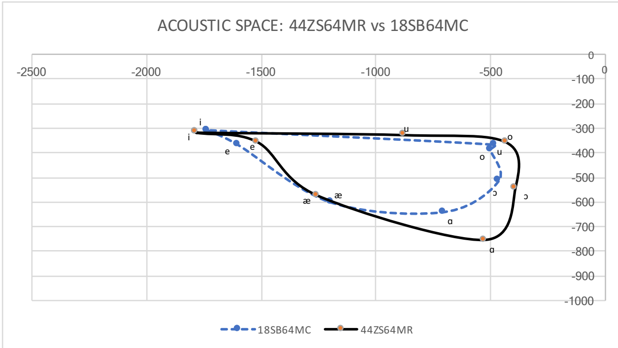


Fig 3.372 to 3.381: 44ZS64MR - First three diagrams in first line are declarative sentences. The next line contains 3 imperative sentences and the third line has three interrogative sentences. The last diagram is an acoustic space.

A. **SENTENCES**

<u>Declaratives</u>

Fig 3.372 – 3.374. We can observe the following from the figure displayed previously: In sentence 1, 44ZS64MR has a type B curve, and 18SB64MC, has a type C curve. 50MEANMR and 49MEANMC, have recorded curves belonging to the type C of sentence. The type C sentence begins at the highest pitch point, the second point is lower than the starting point and the third point is either equal to or lower than the pitch point in the middle. In sentence 2, 44ZS64MRhas recorded a type D curve, in comparison with 18SB64MC, who also has a type D curve. 50MEANMR and 49MEANMC, have recorded curves belonging to the type D. In sentence 3, 18SB64MC has a type B curve while, 50MEANMR and 49MEANMC also have type B sentences.

<u>Imperatives</u>

Fig 3.375 – 3.377. We can observe the following from the figure displayed previously: In sentence 4, 18SB64MChas a type C sentence while 44ZS64MR, 50MEANMR and 49MEANMC have type D sentences. In sentence 5, 44ZS64MR has a type D sentence while, 18SB64MC, 50MEANMR and 49MEANMC also have type D sentences. In a type D sentence, the highest pitch point in a sentence is in the middle. In sentence 6, 44ZS64MR conforms to a type C sentence while 18SB64MC also conforms to a type C sentence. 50MEANMR and 49MEANMC have type C sentences.

<u>Interrogatives</u>

Fig 3.378 – 3.380. We can observe the following from the figure displayed previously: In sentence 7, 44ZS64MR has a D type sentence in comparison with 18SB64MC, who has a type C sentences. This is in contrast with 50MEANMR and 49MEANMC who have recorded type

D sentences. In sentence 8, 44ZS64MR has made a type C sentence in comparison with 18SB64MC, who has made a type D sentence. 50MEANMR has a type D sentence and from the chart 49MEANMC has no visible contour, but on checking the figures, 49MEANMC has made a type D sentence as well. In sentence 9, 44ZS64MR has a type C curve in comparison with 18SB64MC, 50MEANMR and 49MEANMC who have type D sentences.

B. VOWELS

Fig 3.481 compares female RHD participant 44ZS64MR with the individual age and gender matched male, that is 15AK57MC. We can observe the following from the figure displayed previously: The vowel /i/ (f1=-317, f2-f1=-1787) in 44ZS64MR is almost at the same place as vowel /i/ (f1=-307, f2-f1=-1736) in 18SB64MC. The vowel /e/ (f1=-355, f2-f1=-1520) in 44ZS64MR is a bit more backed than vowel /e/ (f1=-366, f2-f1=-1606) in 18SB64MC. The vowel /æ/ (f1=-575, f2-f1=-1256) in 44ZS64MR is slightly higher and fronted than vowel /æ/ (f1=-601, f2-f1=-1199) in 18SB64MC. The vowel /ɑ/ (f1=-756, f2-f1=-530) in 44ZS64MR is lower and more backed in comparison with vowel /ɑ/ (f1=-640, f2-f1=-705) in 18SB64MC.The vowel /ɔ/ (f1=-544, f2-f1=-393) in 44ZS64MR is lower and backed in comparison with vowel /ɔ/ (f1=-514, f2-f1=-467) in 18SB64MC. The participant wasn't willing to record the word with the /ɔ/ vowel. The vowel /o/ (f1=-356, f2-f1=-435) in 44ZS64MR is slightly higher and backed in comparison with vowel /o/ (f1=-386, f2-f1=-504) in 18SB64MC. The vowel /u/ (f1=-327, f2-f1=-878) in 44ZS64MR is a lot more fronted, in the position of a mid-vowel and slightly higher in comparison with vowel /u/ (f1=-367, f2-f1=-485) in 18SB64MC. The area of the acoustic space chart for 44ZS64MR is 321792.5 and for 18SB64MC is 252738.5, and 96MEANMR is 336881. The area of 44ZS64MR is 27.3% bigger than that of the individual control and 4.5% smaller than the mean of RHD participants. The acoustic space of the RHD participant is significantly smaller. The difference in area is insignificant and it can also be seen in the high low and front back capabilities of the RHD participant in comparison with the control participant.

4. ANALYSIS AND DISCUSSION

In the previous chapter, we have discussed the individual case studies in comparison with their age and gender matched control participants. We discussed the subject selection procedure and then displayed the organization of the 23 case studies which followed. Then we dived into the actual case studies section. The following flowchart summarizes the organization of the case studies.

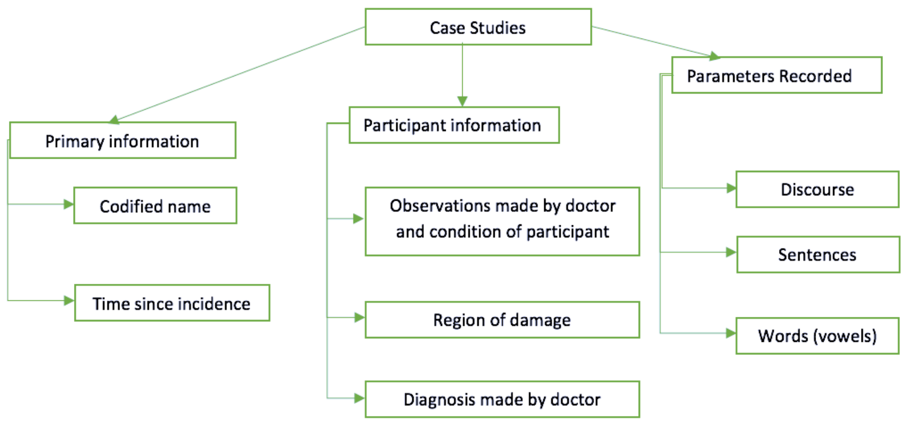


Fig 4.1: A flowchart depicting the organization of individual case studies

After the section on organization of the case studies, we discussed the control participants and viewed their patterns at the level of discourse, at the level of sentences and at the level of vowels. Then, we discussed the case studies one by one, using the template displayed above.

The present section summarizes the case studies, previously discussed in details in the last chapter. Let us take a look at the mean values of the following parameters studied under every cast study in the previous chapter.

4.1.1. At the level of discourse: We study male and female RHD group for **Pitch Variation**, **Fluency** (words per minute), **Duration**, **Thematic Digressions**, **Questions Answered**

4.1.2. At the level of sentences: Compare pitch variations in the 9 sentences, recorded from 4 female RHD participants and 18 male RHD participants.

4.1.3. At the level of words: Compare the formant values of vowels in words and the vowel durations in words.

It is worth mentioning here that the male groups have not been compared to the female groups because of the huge disparity in the number of participants recorded; as well as the fact that males and females have different pitch ranges for speech. After these comparisons have been made, we would like to revisit the research questions for the present research in light of the empirical findings made throughout the present research.

4.1. MEAN COMPARISONS

This section discusses the graphs, comparing the mean of the RHD groups to the mean of the control groups. The comparisons have been divided on the basis of the levels of communication, namely; at the level of discourse, at the level of sentences and at the level of vowels.

4.1.1. DISCOURSE

4.1.1.1. FEMALES

PITCH VARIATION

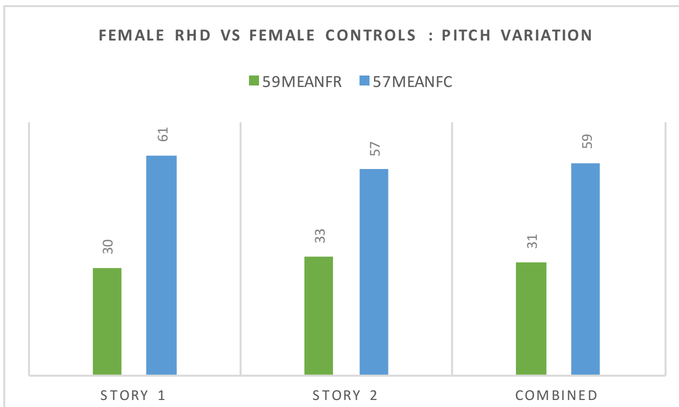


Fig 4.2: A chart depicting the pitch variations in the female RHD group in comparison with the female control group participants.

We can discern the following from the image above: The female RHD group has a mean pitch variation of 30 Hz in the first story in comparison with the female control group, with a mean of 61 Hz. There is a difference of 29 Hz. The female RHD group has a mean pitch variation of 33 Hz in the first story in comparison with the female control group, with a mean of 57 Hz. There is a difference of 24 Hz, which is significant. The female RHD group has a mean pitch variation of 31 Hz in the mean of both the stories in comparison with the female control group, with a mean of 59 Hz. There is a difference of 28 Hz, which is significant. The female RHD participants have a much smaller pitch range in discourse, in comparison with the female control group participants.

FLUENCY

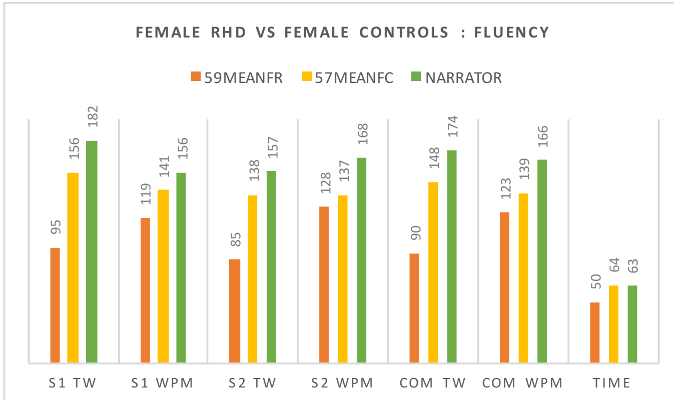


Fig 4.3: A chart comparing the fluency figures (words spoken per minute) in the story recordings of the female RHD participants vs. the female control group participants vs. the narrator.

We can discern the following from the image above: 59MEANFR has 95 words in story 1 in comparison with 57MEANFC who has 156 words and the NARRATOR who has 182 words. 59MEANFR has a fluency rate of 119 wpm in story 1 in comparison with 57MEANFC who has a fluency rate of 141 wpm. 59MEANFR has 85 words in story 2 in comparison with 57MEANFC who has 138 words and the NARRATOR who has 157 words. 59MEANFR has a fluency rate of 128 wpm in story 1 in comparison with 57MEANFC who has a fluency rate of 137 wpm. 59MEANFR has a combined mean of 90 words for the combined mean of both the stories with a fluency rate of 123 wpm and took 50 seconds to complete the stories. In comparison, 57MEANFC has 148 words and took 64 seconds and has a fluency rate of 139, whereas, the NARRATOR has 174 words and took 63 seconds and has a fluency rate of 166 wpm. The female RHD group took the least amount of time to speak the least amount of words, in comparison with the other two means. The RHD group has a fluency figure, which is close to that of the control group mean but, the RHD group has spoken for much lower amount of time, in comparison with the control group and hence much lower number of total words, even if they have a good fluency rate.

DURATION

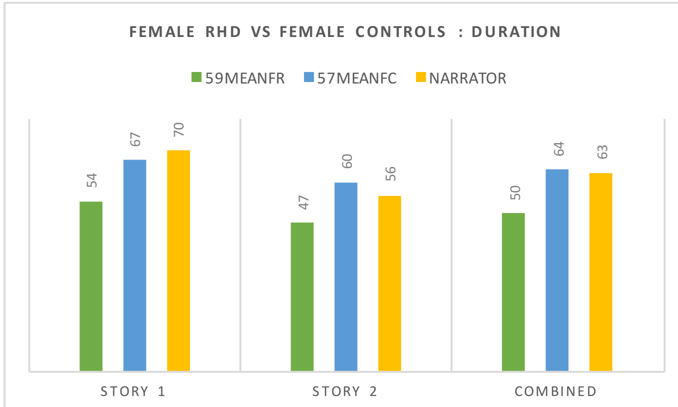


Fig 4.4: A chart comparing the durations taken by the female RHD group vs. the female control group vs. the narrator, to narrate the stories.

We can discern the following from the image above: The female RHD participants have taken 54 seconds to narrate the first story, in comparison with the female control group participants, who took 67 seconds. In comparison, the narrator took 70 seconds. The female RHD participants have taken 47 seconds to narrate the first story, in comparison with the female control group participants, who took 60 seconds. In comparison, the narrator took 56 seconds. The female RHD participants have taken 50 seconds in the combined mean of both the stories, in comparison with the female control group participants, who took 64 seconds. In comparison, the narrator took 63 seconds. The RHD participants have taken lesser time to narrate the stories in comparison with the control group participants. This can be attributed to the fact that many of the RHD participants had major lapses in the narrations of the stories and left out major details, unlike the control group participants.

DIGRESSIONS

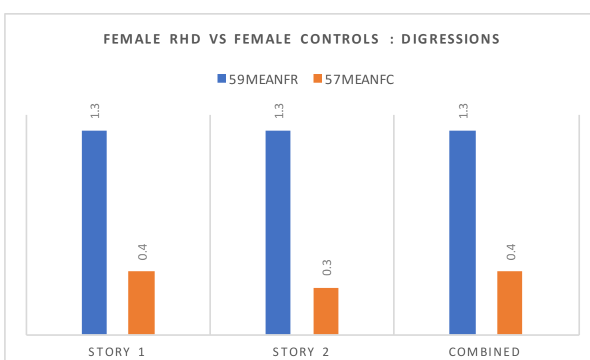


Fig 4.5: A chart comparing the number of digressions in the story recordings of the female RHD group vs. the female control group.

We can discern the following from the image above: The female RHD participants made 1.3 digressions in the first story, in comparison with the female control group, with 0.4 digressions. The female RHD participants made 1.3 digressions in the second story, in comparison with the female control group, with 0.3 digressions. The female RHD participants made 1.3 digressions in the mean of both the stories, in comparison with the female control group, with 0.4 digressions. We can notice that the RHD group participants had way more digressions in their story recordings, in comparison with the control group participants. This can be attributed to the fact that RHD causes the affected to sometimes have thematic digressions while speaking.

QUESTIONS ANSWERED

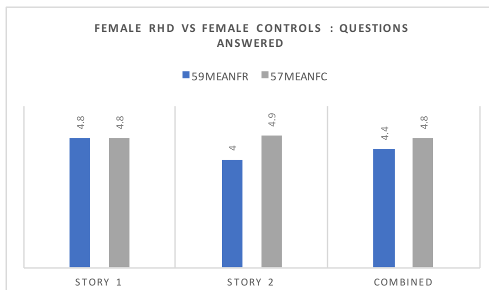


Fig 4.6: A chart comparing the number of questions answered in the stories for the female RHD group vs the female control group.

We can discern the following from the image above: The female RHD group participants could answer all 5 questions in the first story, in comparison with the female control group participants, who answered 4.8 questions. The female RHD group participants could answer 4 questions in the second story, in comparison with the female control group participants, who answered 4.9 questions. The female RHD group participants could answer 4.4 questions in the mean of the two stories, in comparison with the female control group participants, who answered 4.8 questions. Here we can notice that the RHD group answered almost the same number of questions, as the control group participants.

4.1.1.2. MALE PARTICIPANTS

PITCH VARIATION

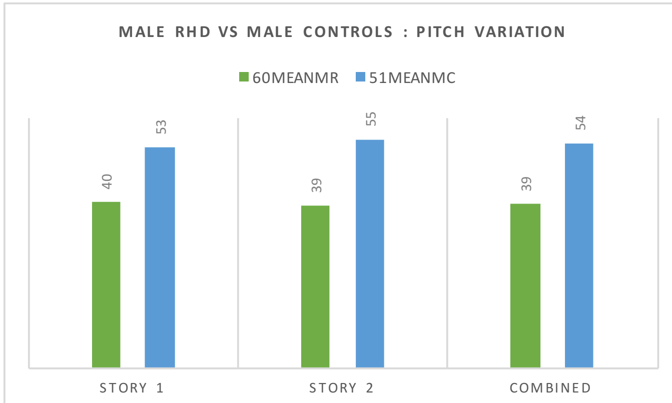


Fig 4.7: A chart depicting the pitch variations in the male RHD group in comparison with the male control group participants.

We can discern the following from the image above: The male RHD group has a mean pitch variation of 40 Hz in the first story in comparison with the female control group, with a mean of 53 Hz. There is a difference of 13 Hz. It is a significant difference considering the number of participants being calculated in the mean. The male RHD group has a mean pitch variation of 39 Hz in the first story in comparison with the male control group, with a mean of 55 Hz. There is a difference of 16 Hz, which is significant, considering the number of participants being calculated in the mean. The male RHD group has a mean pitch variation of 39 Hz in the mean of both the stories in comparison with the female control group, with a mean of 54 Hz. There is a difference of 15 Hz and it is significant. The male RHD participants have a smaller pitch range in discourse, in comparison with the male control group participants.

FLUENCY

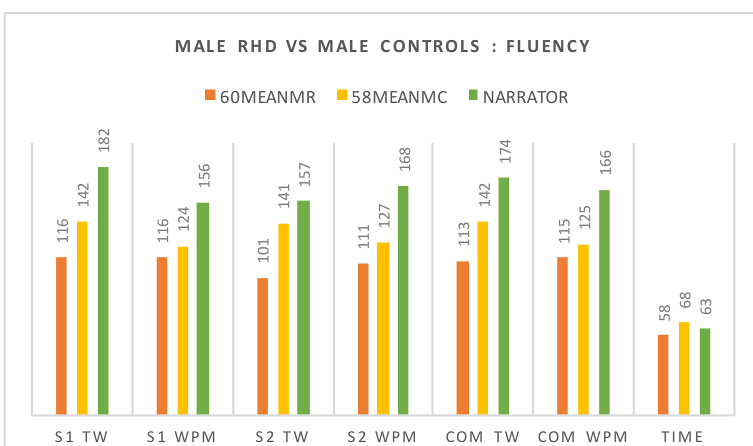


Fig 4.8: A chart comparing the fluency figures (words spoken per minute) in the story recordings of the male RHD participants vs. the male control group participants vs. the narrator.

We can discern the following from the image above: 60MEANMR has 116 words in story 1 in comparison with 58MEANMC who has 142 words and the NARRATOR who has 182 words. 60MEANMR has a fluency rate of 116 wpm in story 1 in comparison with 58MEANMC who has a fluency rate of 124 wpm. 60MEANMR has 101 words in story 2 in comparison with 58MEANMC who has 141 words and the NARRATOR who has 157 words. 60MEANMR has a fluency rate of 111 wpm in story 1 in comparison with 58MEANMC who has a fluency rate of 127 wpm. 60MEANMR has a combined mean of 113 words for the combined mean of both the stories with a fluency rate of 115 wpm and took 58 seconds to complete the stories. In comparison, 58MEANMC has 142 words and took 68 seconds and has a fluency rate of 125, whereas, the NARRATOR has 174 words and took 63 seconds and has a fluency rate of 166 wpm. The male RHD group took the least amount of time to speak the least amount of words, in comparison with the other two means. The RHD group has a fluency figure, which is close to that of the control group mean but, the RHD group has spoken for much lower amount of time, in comparison with the control group and hence much lower number of total words, even if they have a good fluency rate.

DURATION

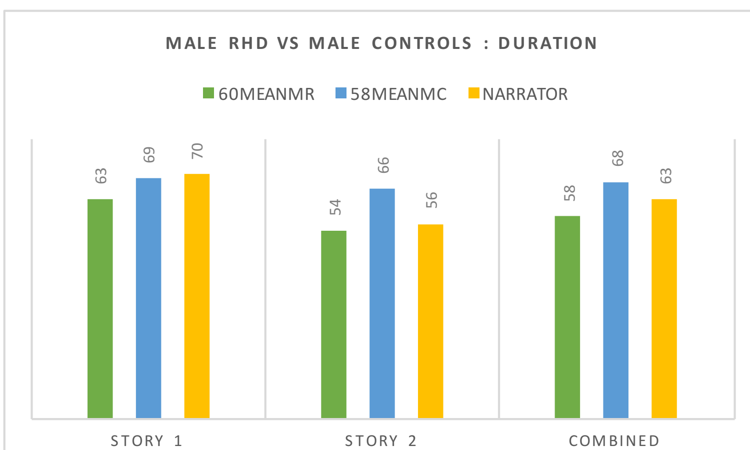


Fig 4.9: A chart comparing the durations taken by the male RHD group vs. the male control group vs. the narrator, to narrate the stories.

We can discern the following from the image above: The male RHD participants have taken 63 seconds to narrate the first story, in comparison with the male control group participants, who took 69 seconds. In comparison, the narrator took 70 seconds. The male RHD participants have taken 54 seconds to narrate the first story, in comparison with the male control group participants, who took 66 seconds. In comparison, the narrator took 56 seconds. The male RHD participants have taken 58 seconds in the combined mean of both the stories, in comparison with the male control group participants, who took 68 seconds. In comparison, the narrator took 63 seconds. The RHD participants have taken lesser time to narrate the stories in comparison with the control group participants. This can be attributed to the fact that many of the RHD participants had major lapses in the narrations of the stories and left out major details, unlike the control group participants.

DIGRESSIONS

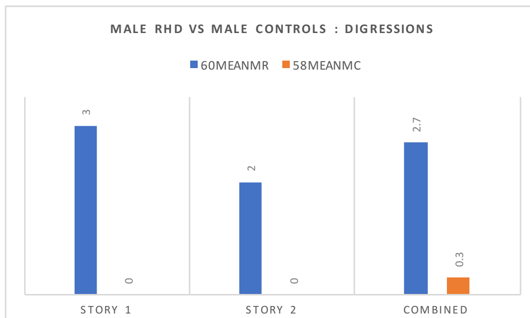


Fig 4.10: A chart comparing the number of digressions in the story recordings of the male RHD group vs. the male control group.

We can discern the following from the image above: The male RHD participants made 3 digressions in the first story, in comparison with the male control group, with 0 digressions. The male RHD participants made 2 digressions in the second story, in comparison with the male control group, with 0 digressions. The male RHD participants made 2.7 digressions in the mean of both the stories, in comparison with the male control group, with 0.3 digressions. We can notice that the RHD group participants had way more digressions in their story recordings, in comparison with the control group participants. This can be attributed to the fact that RHD causes the affected to sometimes have thematic digressions while speaking.

QUESTIONS ANSWERED

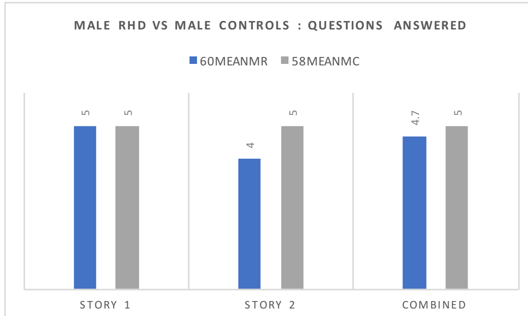


Fig 4.11: A chart comparing the number of questions answered in the stories for the female RHD group vs the female control group.

We can discern the following from the image above: The male RHD group participants could answer all 5 questions in the first story, in comparison with the male control group participants, who also answered 5 questions. The male RHD group participants could answer 4 questions in the second story, in comparison with the male control group participants, who answered 5 questions. The male RHD group participants could answer 4.7 questions in the mean of the two stories, in comparison with the male control group participants, who answered 5 questions. Here we can notice that the RHD group answered almost the same number of questions, as the control group participants.

4.1.2. SENTENCES

4.1.2.1. FEMALE PARTICIPANTS

DECLARATIVE SENTENCES

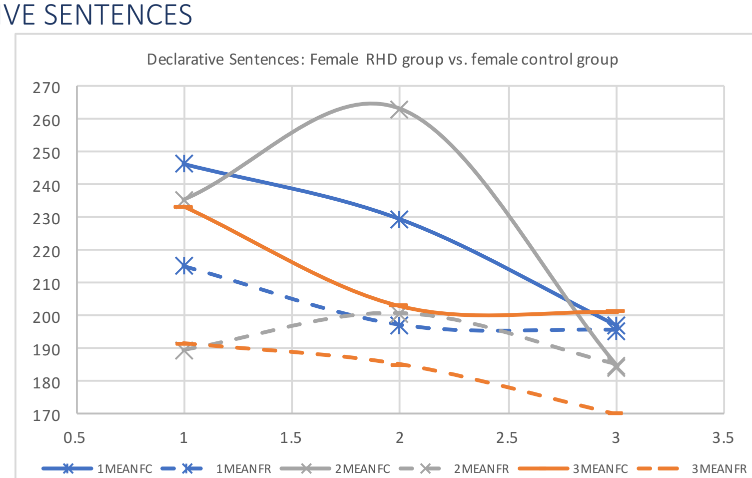


Fig 4.12: A scatter chart comparing the declarative sentences recorded from the female RHD group, in comparison with the female control group.

We can discern the following from the graph above: Sentence 1 (marked in dashed blue) in the female RHD group is a type B sentence, while sentence 1 (marked in blue) in the female control group is a type C sentence. Sentence 2 (marked in dashed grey) in the female RHD group is a type D sentence, while sentence 2 (marked in grey) in the female control group is also a type D sentence. Sentence 3 (marked in dashed orange) in the female RHD group is a type C sentence, while sentence 3 (marked in orange) in the female control group is a type C sentence (but with a much steeper gradient. There is a lot of pitch difference between its pitch points).

IMPERATIVE SENTENCES

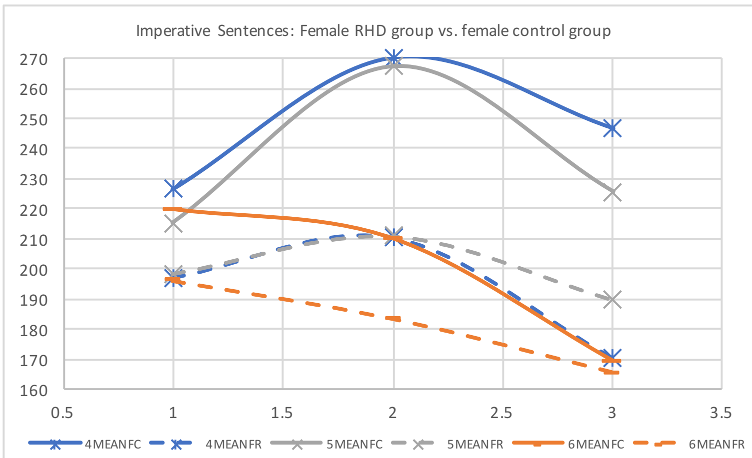


Fig 4.13: A scatter chart comparing the imperative sentences recorded from the female RHD group, in comparison with the female control group.

We can discern the following from the graph above: Sentence 4 (marked in dashed blue) in the female RHD group is a type D sentence, while sentence 4 (marked in blue) in the female control group is also a type D sentence. The pitch difference between the pitch points are much more than in the RHD participant. Sentence 5 (marked in dashed grey) in the female RHD group is a type D sentence, while sentence 5 (marked in grey) in the female control group is also a type D sentence. The pitch difference between the pitch points are much more than in the RHD participant. Sentence 6 (marked in dashed orange) in the female RHD group is a type C sentence, while sentence 6 (marked in orange) in the female control group is also a type C sentence.

INTERROGATIVE SENTENCES

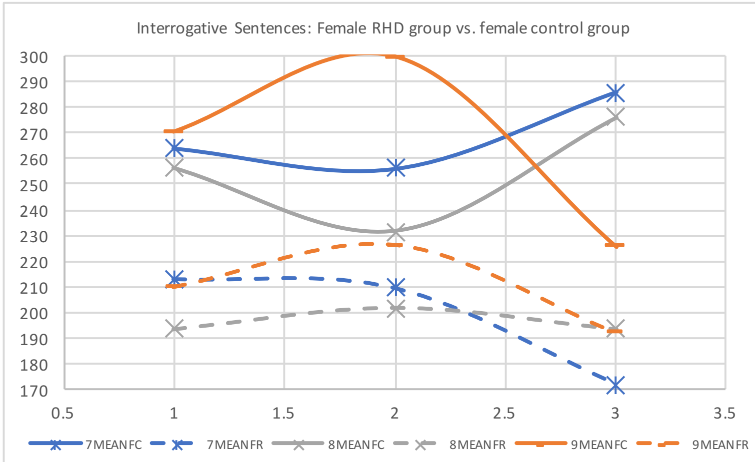


Fig 4.14: A scatter chart comparing the interrogative sentences recorded from the female RHD group, in comparison with the female control group.

We can discern the following from the graph above: Sentence 7 (marked in dashed blue) in the female RHD group is a type C sentence, while sentence 7 (marked in blue) in the female control group is a type B sentence. Sentence 8 (marked in dashed grey) in the female RHD group is a type D sentence, while sentence 8 (marked in grey) in the female control group is a type B sentence. The pitch difference between the pitch points are much more than in the RHD participant. Sentence 9 (marked in dashed orange) in the female RHD group is a type D sentence, while sentence 9 (marked in orange) in the female control group is also a type D sentence (but with a much steeper gradient. There is a lot of pitch difference between its pitch points).

1.1.2.2. MALE PARTICIPANTS

DECLARATIVE SENTENCES

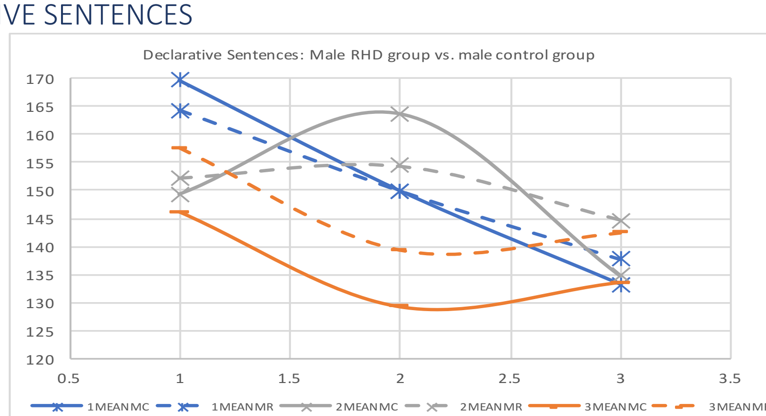


Fig 4.15: A scatter chart comparing the declarative sentences recorded from the male RHD group, in comparison with the male control group.

We can discern the following from the graph above: Sentence 1 (marked in dashed blue) in the male RHD group is a type C sentence, while sentence 1 (marked in blue) in the male control group is a type C sentence. Sentence 2 (marked in dashed grey) in the male RHD group is a type D sentence, while sentence 2 (marked in grey) in the male control group is also a type D sentence. Sentence 3 (marked in dashed orange) in the male RHD group is a type B sentence, while sentence 3 (marked in orange) in the male control group is a type B sentence.

IMPERATIVE SENTENCES

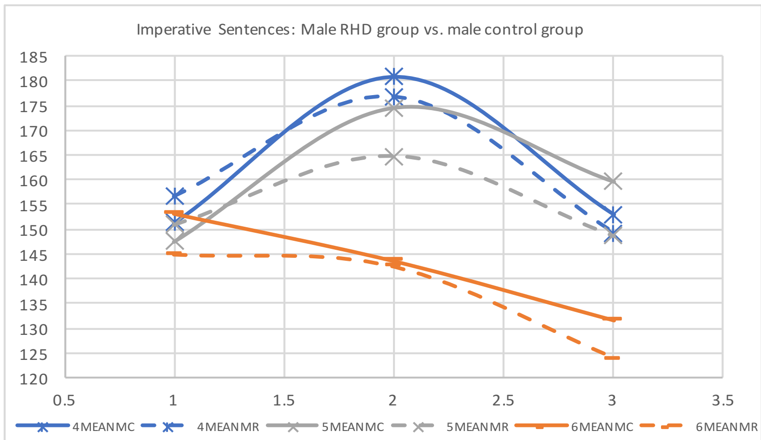


Fig 4.16: A scatter chart comparing the imperative sentences recorded from the male RHD group, in comparison with the male control group.

We can discern the following from the graph above: Sentence 4 (marked in dashed blue) in the male RHD group is a type D sentence, while sentence 4 (marked in blue) in the male control group is a type D sentence. Sentence 5 (marked in dashed grey) in the male RHD group is a type D sentence, while sentence 5 (marked in grey) in the male control group is also a type D sentence. Sentence 6 (marked in dashed orange) in the male RHD group is a type C sentence, while sentence 6 (marked in orange) in the male control group is a type C sentence.

INTERROGATIVE SENTENCES

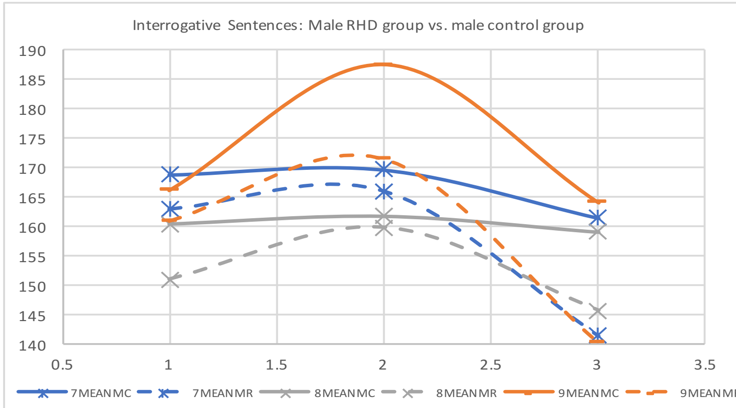


Fig 4.17: A scatter chart comparing the interrogative sentences recorded from the male RHD group, in comparison with the male control group.

We can discern the following from the graph above: Sentence 7 (marked in dashed blue) in the male RHD group is a type D sentence, while sentence 7 (marked in blue) in the male control group is a type D sentence. Sentence 8 (marked in dashed grey) in the male RHD group is a type D sentence, while sentence 8 (marked in grey) in the male control group is also a type D sentence. Sentence 9 (marked in dashed orange) in the male RHD group is a type D sentence, while sentence 9 (marked in orange) in the male control group is a type D sentence.

4.1.3. VOWELS

1.1.3.1. FEMALE PARTICIPANTS

ACOUSTIC SPACE

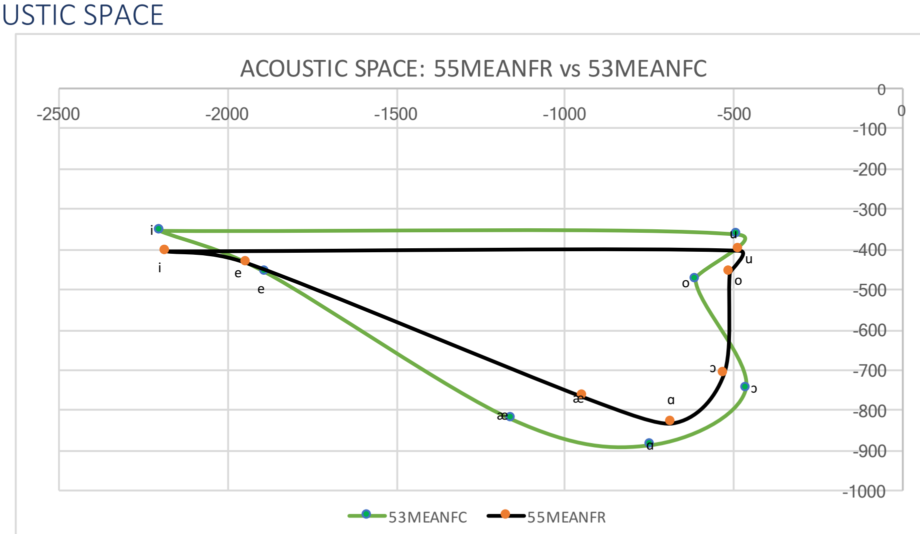


Fig 4.18: A vowel space graph comparing the female RHD group to the female control group.

Fig above compares the male RHD group 53MEANFR with the male control group 55MEANFC. We can observe the following from the figure displayed previously: The vowel /i/ (f1=-404, f2-f1=-2181) in 53MEANFR is almost at the same place as vowel /i/ (f1=-355, f2-f1=-2200) in 55MEANFC. The vowel /e/ (f1=-433, f2-f1=-1946) in 53MEANFR is more backed and a bit lower than vowel /e/ (f1=-458, f2-f1=-1887) in 55MEANFC. The vowel /æ/ (f1=-767, f2-f1=-945) in 53MEANFR is almost at the same place as vowel /æ/ (f1=-822, f2-f1=-1158) in 55MEANFC. The vowel /ɑ/ (f1=-831, f2-f1=-683) in 53MEANFR is slightly fronted and lower in comparison with vowel /ɑ/ (f1=-887, f2-f1=-745) in 55MEANFC. The vowel /ɔ/ (f1=-711, f2-f1=-532) in 53MEANFR is slightly fronted and higher, in comparison with vowel /ɔ/ (f1=-749, f2-f1=-464) in 55MEANFC. The vowel /o/ (f1=-457, f2-f1=-514) in 53MEANFR is slightly lower and fronted in comparison with vowel /o/ (f1=-476, f2-f1=-613) in 55MEANFC. The vowel /u/ (f1=-403, f2-f1=-485) in 53MEANFR is a slightly higher and fronted in comparison with vowel /u/ (f1=-365, f2-f1=-487) in 55MEANFC. The area of the acoustic space chart for 53MEANFR is 363352.5 and for 54MEANFC is 521601.5. The area of 56MEANMR is 30% smaller than that of 55MEANFC. We can discern from the vowel space graph above that the female RHD group has decreased high/low capabilities but the front/back capabilities of the female RHD group seems almost similar to that of the female control group.

VOWEL DURATION

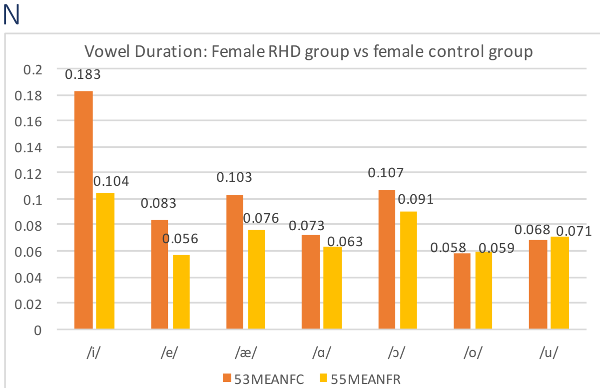


Fig 4.19: A bar graph comparing vowel durations of the female RHD group to the female control group.

We can discern the following from the chart above: The RHD group took 0.183 seconds to articulate the vowel /i/ in comparison with the control group, who took 0.104 seconds. The RHD group took 0.083 seconds to articulate the vowel /e/ in comparison with the control group, who took 0.056 seconds. The RHD group took 0.103 seconds to articulate the vowel /æ/ in comparison with the control group, who took 0.076 seconds. The RHD group took 0.073

seconds to articulate the vowel /ɑ/ in comparison with the control group, who took 0.063 seconds. The RHD group took 0.107 seconds to articulate the vowel /ɔ/ in comparison with the control group, who took 0.091 seconds. The RHD group took 0.058 seconds to articulate the vowel /o/ in comparison with the control group, who took 0.059 seconds. The RHD group took 0.068 seconds to articulate the vowel /u/ in comparison with the control group, who took 0.071 seconds. Except for vowels /o/ and /u/ the RHD group took more time to articulate the vowels, in comparison with the control group. Vowel /i/ in the RHD group has the longest duration.

1.1.3.2. MALE PARTICIPANTS

ACOUSTIC SPACE

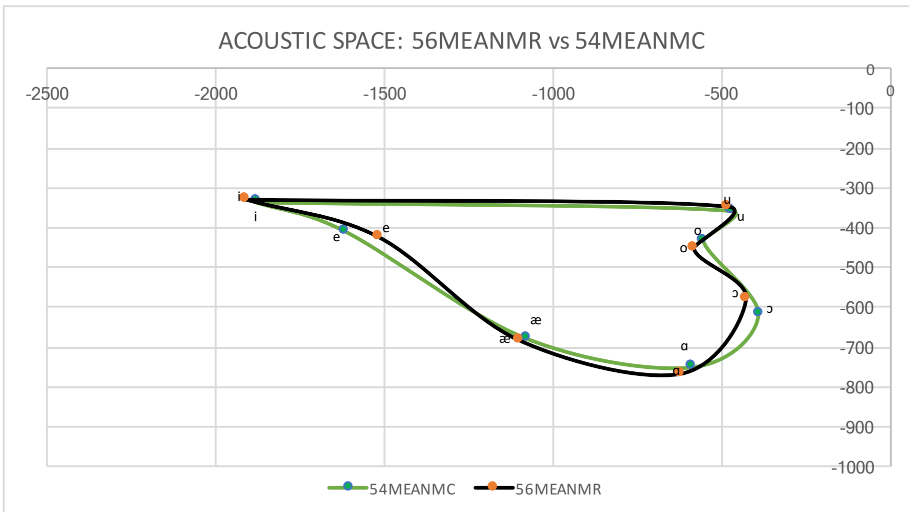


Fig 4.20: A vowel space graph comparing the male RHD group to the male control group.

Fig above compares the male RHD group 56MEANMR with the male control group 54MEANMC. We can observe the following from the figure displayed previously: The vowel /i/ (f1=-329, f2-f1=-1909) in 56MEANMR is almost at the same place as vowel /i/ (f1=-335, f2-f1=-1880) in 54MEANMC. The vowel /e/ (f1=-423, f2-f1=-1517) in 56MEANMR is more backed and a bit lower than vowel /e/ (f1=-408, f2-f1=-1617) in 54MEANMC. The vowel /æ/ (f1=-683, f2-f1=-1102) in 56MEANMR is almost at the same place as vowel /æ/ (f1=-676, f2-f1=-1080) in 54MEANMC. The vowel /ɑ/ (f1=-769, f2-f1=-622) in 56MEANMR is slightly fronted and lower in comparison with vowel /ɑ/ (f1=-749, f2-f1=-591) in 54MEANMC. The vowel /ɔ/ (f1=-579, f2-f1=-427) in 56MEANMR is slightly fronted and higher, in comparison with vowel /ɔ/ (f1=-618, f2-f1=-391) in 54MEANMC. The vowel /o/ (f1=-452, f2-f1=-582) in 56MEANMR is slightly lower and fronted in comparison with vowel /o/ (f1=-432, f2-f1=-554) in 54MEANMC. The vowel /u/ (f1=-347, f2-f1=-481) in 56MEANMR is a slightly higher and fronted in comparison with vowel /u/ (f1=-357, f2-f1=-472) in 54MEANMC. The area of the acoustic space chart for 56MEANMR is 334580 and for 54MEANMC is 342454.5. The area of 56MEANMR is 3% smaller than that of 54MEANMC. We can discern from the vowel space graph above that the low/high, front/back capabilities of the male RHD group seems almost similar to that of the male control group, in spite of case studies who have much smaller vowel spaces, in terms of area and high/low, front/back capabilities.

VOWEL DURATION

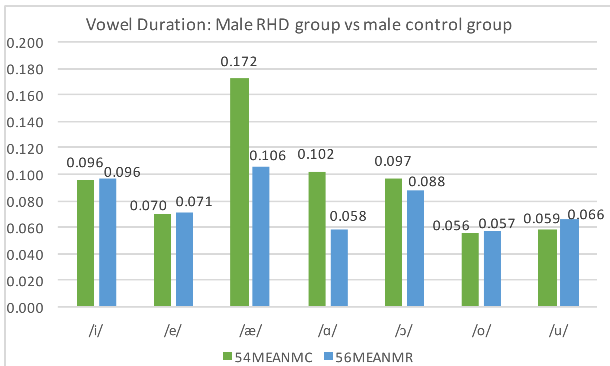


Fig 4.21: A bar graph comparing vowel durations of the female RHD group to the female control group.

We can discern the following from the chart above: The RHD group took 0.096 seconds to articulate the vowel /i/ in comparison with the control group, who took 0.096 seconds. The RHD group took 0.070 seconds to articulate the vowel /e/ in comparison with the control group, who took 0.071 seconds. The RHD group took 0.172 seconds to articulate the vowel /æ/ in comparison with the control group, who took 0.106 seconds. The RHD group took 0.102 seconds to articulate the vowel /ɑ/ in comparison with the control group, who took 0.058 seconds. The RHD group took 0.097 seconds to articulate the vowel /ɔ/ in comparison with the control group, who took 0.088 seconds. The RHD group took 0.056 seconds to articulate the vowel /o/ in comparison with the control group, who took 0.057 seconds. The RHD group took 0.059 seconds to articulate the vowel /u/ in comparison with the control group, who took 0.066 seconds. Vowel /æ/ in the RHD group has the longest duration.

4.2. RESEARCH QUESTIONS REVISITED

Please refer to the research questions in Chapter 1, section **1.4.2**, reiterated below. We revisit these questions in the light of the empirical data collected in the present research and discussions in the previous sections.

RESEARCH QUESTIONS

1. How does RHD affect the use of pitch in verbal communication and fluency?
2. How does RHD affect the use of pitch at the level of segments (primarily vowels), at the level of words and sentences?
3. How does RHD affect pitch at the level of discourse in connected speech?

We have three major research questions to attend to in the present research. We shall answer the questions one by one.

1. How does RHD affect the use of pitch in verbal communication and fluency?

In order to answer the first research question, we must first understand the scope of the question and what it actually asks for. Under the purview of the first question, we shall only look into pitch variations and fluency figures at the level of discourse. The other variables at the level of discourse will be addressed under question number 3. We shall first address pitch variation and then fluency.

PITCH VARIATION

First, we shall reproduce two bar graphs, the first one comparing the mean pitch in Hz, of the female RHD group with the mean of the female control group at the level of discourse and the same graph for males. Here, it is important to remember that every participant in the research were narrated two stories to. At first, the first story was narrated to them and then they were asked five questions from the story and then they were asked to narrate the story back. Then the same was done with the second story. Following is the bar graph comparing the female RHD mean to the female control mean. Here, we compare 4 female RHD participants with 9 female control group participants.

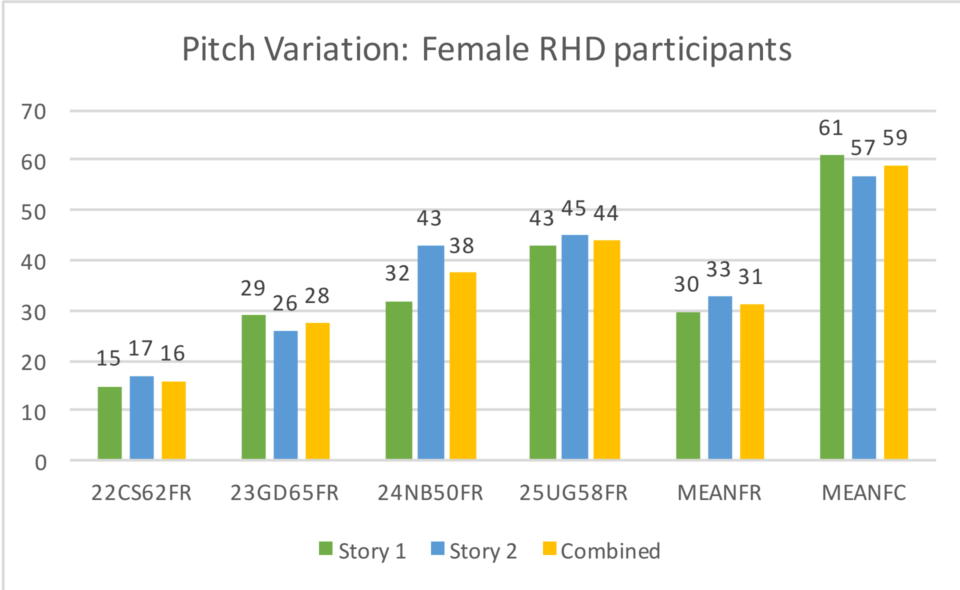


Fig 4.22: A chart depicting the pitch variations in the female RHD group in comparison with the female control group participants.

We can notice major differences in the pitch variations of the RHD group and the control group. In the first story the RHD group has a pitch variation of only 30 Hz whereas the control group mean has a variation of 61 Hz which is double that of the RHD group. In other words, the control group has twice the capacity of the RHD group in terms of pitch variation. In the second story, the RHD group has a pitch variation of 33 Hz whereas the control group has a mean of 57 Hz, which is almost double again. It can be noticed that the pitch range of the RHD individuals have gone down to a considerable amount and this shows in the mean pitch variation graphs as well. In the combined mean, the RHD group has a pitch variation of 31 Hz, whereas the control group has a mean of 59 Hz. Here, again, the control group has double the pitch variation of the RHD group. RHD has actually brought down the ability to use pitch variations in the female RHD participants. Variations can also be noticed across RHD cases, depending on the severity of the cases. 22CS62FR has a pitch range of 16 Hz, which is extremely poor and has a minimal pitch variation in speech whereas 25UG58FR has a pitch variation of 44 Hz which is in the region of normal controls. Here, we have also noted that the difference in pitch between two stories in each of the participants are not very high and the pitch ranges of every female participants in either stories are consistent.

In order to further understand the nature of the participants, we have to take a look at the following table, which arranges the participants in the order of their severity (the most severe i.e., minimum pitch range at the top and maximum pitch range at the bottom of the table).

FEMALE RHD PITCH RANGE			
PARTICIPANT	**STORY 1**	**STORY 2**	**COMBINED**
22CS62FR	15	17	16
23GD65FR	29	26	28
24NB50FR	32	43	38
25UG58FR	43	45	44
MEANFR	**30**	**33**	**31**
MEANFC	**61**	**57**	**59**

Table 4.1: A table arranging the female RHD participants in order of their severity

22CS62FR displays minimum pitch range in both the stories at 15 Hz and 17 Hz and is the most severe case noted, under pitch variations. 23GD65FR, who has better performance than 22CS62FR in the severity scale has a pitch range of 29 Hz and 26 Hz. 24NB50FR has a pitch range of 32 Hz and 43 Hz, which is much nearer to the pitch range of the control group. 25UG58FR is the least severe case study and has a pitch range of 43 Hz and 45 Hz. What we have found here, also pertain to the overall comprehensive comparisons index tables (table 4.20 to 4.22). 22CS62FR has the lowest GCS and MMSE scores while 25UG58FR has the maximum MMSE and GCS scores.

Let us take a look at the male RHD group vs the male control group. The following figure compares 17 male RHD participants with 10 male control group participants. Here, we compare 4 female RHD participants with 9 female control group participants.

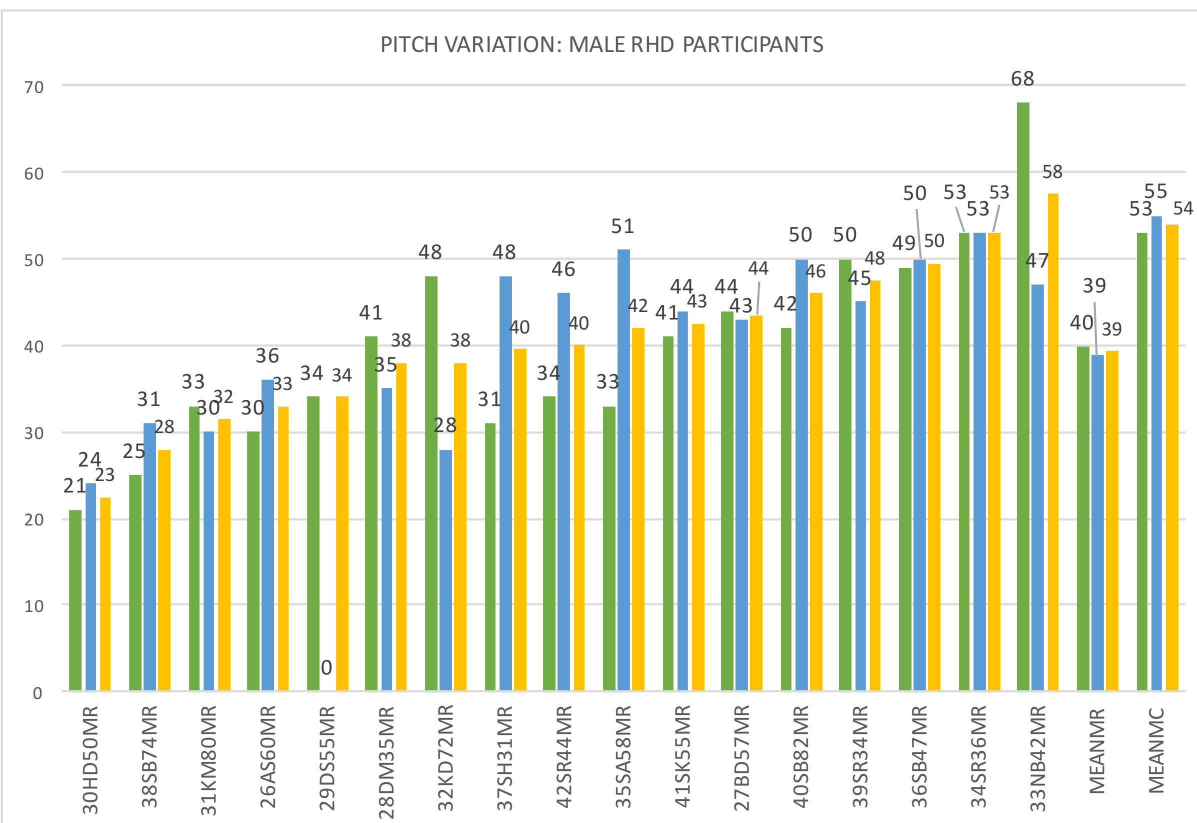


Fig 4.23: A chart depicting the pitch variations in the male RHD group in comparison with the male control group participants.

In the first story the male RHD group has a pitch variation of 40 Hz whereas the control group has a pitch variation of 53 Hz. Although the difference is much smaller than the female RHD group, it is important to note that the male RHD group has many more participants. As a matter of fact, the lowest pitch variation in story 1 is by 30HD50MR at 21 Hz followed closely by 35SB74MR at 25 Hz. The highest pitch variation in story 1 is by 33NB42MR at 68 Hz, which is well into control group territory. In the second story the RHD group mean has a pitch variation of 39 Hz, whereas the control group mean has a pitch variation of 55 Hz. The difference is significantly more than story one. In the combined mean of both the stories we notice that the RHD group has a pitch variation of 39 Hz in comparison with the control group mean which is at 54 Hz. The minimum pitch variation in the combined mean is exhibited by 30HD50MR at 23 Hz followed closely by 35SB74MR at 28 Hz. Maximum pitch variation by any individual is exhibited by 33NB42MR at 58 Hz followed closely by 36SB47MR at 50 Hz. Here, similar to the female RHD mean, we notice that that RHD has caused the pitch variation in discourse to significantly go down. We did notice exceptions to that like 33NB42MR who have pitch variations, very similar to the control groups but we also have participants like 30HD50MR who have very poor pitch variations in discourse. We also need to look at the participants who have very inconsistent pitch ranges in both the stories. 32KD72MR, 37SH31MR, 42SR44MR, 35SA58MR and 33NB42MR have all displayed very inconsistent pitch ranges in the two stories. It is important to notice that data of cases in which the pitch ranges in both the stories are consistent are much more reliable because their pitch ranges in both the stories are comparable.

In order to better understand the condition of the participants, a severity index has been created, with all the RHD participants, displayed below.

MALE RHD PITCH RANGE			
PARTICIPANT	STORY 1	STORY 2	COMBINED
26AS60MR	30	36	33
27BD57MR	44	43	44
28DM35MR	41	35	38
29DS55MR	34	0	34
30HD50MR	21	24	23
31KM80MR	33	30	32
32KD72MR	48	28	38
33NB42MR	68	47	58
34SR36MR	53	53	53
35SA58MR	33	51	42
36SB47MR	49	50	50
37SH31MR	31	48	40
38SB74MR	25	31	28
39SR34MR	50	45	48
40SB82MR	42	50	46
41SK55MR	41	44	43
42SR44MR	34	46	40
MEANMR	**40**	**39**	**39**
MEANMC	**53**	**55**	**54**

Table 4.2: A table arranging the male RHD participants in order of their severity

Starting with 37SH31MR, who has a pitch range of 40 Hz, every participant has a pitch range, which is more than the mean of the RHD group. Participants like 39SR34MR, 36SB47MR, 34SR36MR and 33NB42MR have close to control group mean pitch range, which would also mean that they would have communication capabilities, which are very similar to that of the control group.

We use pitch information in speech to convey a number of functions like emotions and moods, empathy or sympathy for a fellow person, depicting one's personality, nervousness and so on (Apple, W., Streeter, L. A., & Krauss, R. M, 1979, pp 715-27). Hence, a depreciation in the pitch information in one's speech would lead to decrease in such aforementioned information in speech, making it difficult for both the speaker and the listener, because every information which could be conveyed through pitch, would then have to be conveyed through words. We have noticed monotonous speech in participants like 22CS62FR and 30HD50MR due to diminished pitch range in their speech. 22CS62FR, 25UG58FR, 26AS60MR and 30HD50MR were noticed to display very less emotions while speaking. It was difficult to understand whether they were happy or sad, angry or frustrated or any other emotion otherwise. Other participants like 24NB50FR, 33NB42MR, 34SR36MR, 39SR34MR and 36SB47MR were found to converse naturally and there were no problems in understanding their speech or emotions or expressions whatsoever.

FLUENCY IN DISCOURSE

Next we shall look into the **fluency** and how RHD affects fluency, if indeed it does affect fluency. Before that, we need to understand that fluency has been measured with two different variables, from the discourse story recordings. The first variable is the total number of words

(TW) used by a participant and the second variable is the number of words a participant spoke in a minute or words per minute (WPM). It is also worth noticing here that the narrator was the researcher himself reading out the stories to the participants from a piece of paper (so that there was no change in the words of the story and the number of words used). Hence, it is but normal for the narrator to have much higher TW and WPM in the comparisons below, because he did not have to remember the passage. He could blatantly read out from a piece of paper.

Now, we need to take a look at the RHD mean vs control mean fluency figures for both males and females. Following is a bar graph comparing the female RHD group with the female control group. Here, we compare 4 female RHD participants with 9 female control group participants.

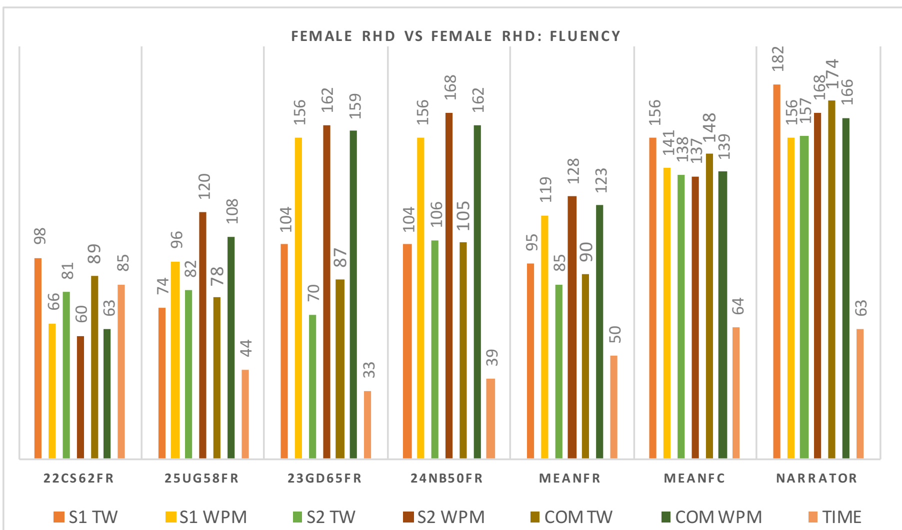


Fig 4.24: A chart comparing the fluency figures (words spoken per minute and total words spoken) in the story recordings of the female RHD participants vs. the female control group participants vs. the narrator.

We notice here that the female RHD group has only 95 total words and has a fluency rate of 119 wpm in the first story in comparison with the female control group, who have 156 words and has a fluency rate of 141 wpm. The difference is a lot indeed both in the total words and in the fluency rate. In the second story, the female RHD group has only 85 words and has a fluency rate of 128 wpm in comparison with the female control group, who have 137 words and has a fluency rate of 148 wpm. Again, the difference is a lot indeed both in the total words and in the fluency rate. In the combined mean of both the stories, we should note that the female RHD group has 90 words with a fluency rate of 123 wpm and took 50 seconds on an average, whereas, the female control group has 148 words with a fluency rate of 139 and took 64 seconds on an average. The narrator took 63 seconds in comparison. The RHD participants spoke lesser than the control group in terms of total words but for much lower time limits respectively. The female RHD participant with the minimum number of total words was 25UG58FR with 78 total words in the combined mean; whereas the maximum number of total words was spoken by 24NB50FR with 105 words. The difference between the minimum and maximum is big as well. In comparison with the actual number of words which was 174, both fall short. The female with the minimum fluency rate was 22CS62FR with 63 wpm and the maximum was 24NB50FR with 162 wpm. The control group has a fluency figure of 139 wpm and this means that 24NB50FR has a fluency rate which is more than the control group but lesser than the NARRATOR at 166 wpm. Below is a table which arranges the participants in order of their severity. The participant with the minimum number of total words has been placed at the top, and the participant with the maximum number of words has been placed at the bottom.

FEMALE CONTROLS FLUENCY							
PARTICIPANT	**S1 TW**	**S1 WPM**	**S2 TW**	**S2 WPM**	**COM TW**	**COM WPM**	**TIME**
22CS62FR	98	66	81	60	89	63	85
25UG58FR	74	96	82	120	78	108	44
23GD65FR	104	156	70	162	87	159	33
24NB50FR	104	156	106	168	105	162	39
MEANFR	**95**	**119**	**85**	**128**	**90**	**123**	**50**
MEANFC	**156**	**141**	**138**	**137**	**148**	**139**	**64**
NARRATOR	**182**	**156**	**157**	**168**	**174**	**166**	**63**

Table 4.3: A table arranging female RHD participants for fluency, in order of their severity.

We can note here that 22CS62FR with 98 words in story 1 and 81 words in story 2, is the participant with the minimum number of total words and spoke for a time of almost 85 seconds on an average for both the stories. 24NB50FR, the participant who seems to be the least severe, has 104 words in story 1 and 106 words in story 2 and took 39 seconds. We can also find the fluency figures for the other participants in the figure displayed previously, along with the respective means.

Let us now, take a look at the male counterpart. The following figure compares 17 male RHD participants with 10 male control group participants.

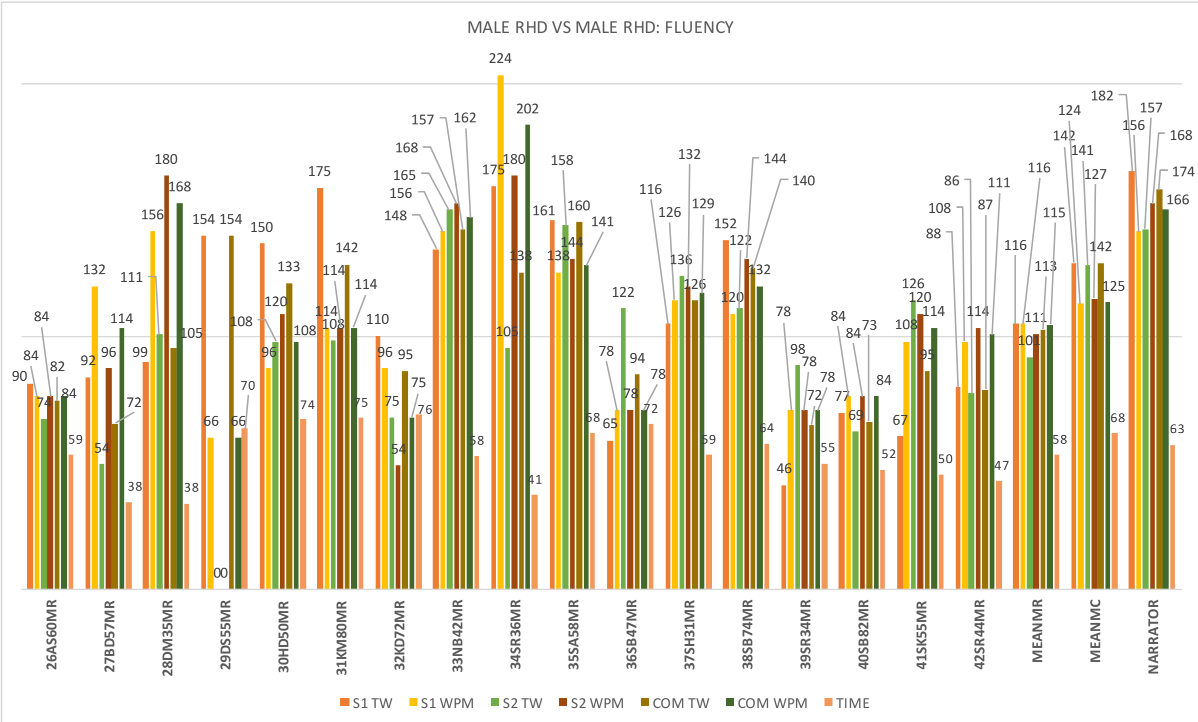


Fig 4.25: A chart comparing the fluency figures (words spoken per minute) in the story recordings of the male RHD participants vs. the male control group participants vs. the narrator.

We notice here that the male RHD group has 116 total words and has a fluency rate of 116 wpm in the first story in comparison with the male control group, who have 142 words and has a fluency rate of 124 wpm. The difference is much less significant in comparison with the females but again, the number of male participants were much higher than the females, in the present research. In the second story, the male RHD group has only 101 words and has a fluency rate of 111 wpm in comparison with the male control group, who have 141 words and has a fluency rate of 127 wpm. In the combined mean of both the stories, we should note that the male RHD group has 113 words with a fluency rate of 115 wpm and took 58 seconds on an average, whereas, the male control group has 142 words with a fluency rate of 125 and took 68 seconds on an average. The narrator took 63 seconds in comparison. It is very clear that the RHD participants spoke much lesser than the control group and in spite of having a near to control fluency rate, they spoke for a lesser amount of time, hence lower total word count. The male RHD participant with the minimum number of total words was 27BD57MR and 39SR34MR with 72 total words in the combined mean; whereas the maximum number of total words was spoken by 35SA58MR with 160 words. The difference between the minimum and maximum is massive. In comparison with the actual number of words which was 174, both fall short, but 35SA58MR comes pretty close. The male with the minimum fluency rate was 32KD72MR with 75 wpm and the maximum was 34SR36MR with 202 wpm, which is abnormally high. The control group has a fluency figure of 139 wpm and this means that 34SR36MR has a fluency rate which is more than the control group but lesser than the NARRATOR at 166 wpm. Below is a table which arranges the participants in order of their severity. The participant with the minimum number of total words has been placed at the top, and the participant with the maximum number of words has been placed at the bottom.

MALE RHD FLUENCY						
PARTICIPANT	**S1 TW**	**S1 WPM**	**S2 TW**	**S2 WPM**	**COM TW**	**COM WPM**	**TIME**
26AS60MR	90	84	74	84	82	84	59
27BD57MR	92	132	54	96	72	114	38
28DM35MR	99	156	111	180	105	168	38
29DS55MR	154	66	0	0	154	66	70
30HD50MR	150	96	108	120	133	108	74
31KM80MR	175	114	108	114	142	114	75
32KD72MR	110	96	75	54	95	75	76
33NB42MR	148	156	165	168	157	162	58
34SR36MR	175	224	105	180	138	202	41
35SA58MR	161	138	158	144	160	141	68
36SB47MR	65	78	122	78	94	78	72
37SH31MR	116	126	136	132	126	129	59
38SB74MR	152	120	122	144	140	132	64
39SR34MR	46	78	98	78	72	78	55
40SB82MR	77	84	69	84	73	84	52
41SK55MR	67	108	126	120	95	114	50
42SR44MR	88	108	86	114	87	111	47
MEANMR	**116**	**116**	**101**	**111**	**113**	**115**	**58**
MEANMC	**142**	**124**	**141**	**127**	**142**	**125**	**68**
NARRATOR	**182**	**156**	**157**	**168**	**174**	**166**	**63**

Table 4.4: A table arranging female RHD participants for fluency, in order of their severity.

Here, we can note that 39SR34MR with 46 words in story 1 and 98 words in story 2 is the most severe case and spoke for an average of 55 seconds. 35SA58MR with 161 words in story 1 and 158 words in story 2, is the least severe case and spoke for 68 seconds on an average. We can also find the fluency figures for the other participants in the figure displayed previously, along with the respective means.

We can note a very prominent trend here that the fluency rate only, is not an important variable when it comes to delineating RHD. Fluency rate (WPM) along with the total number of words and the time actually gives us a complete picture of the fluency rate in speech, because the amount of time a participant spoke is actually important. We have noted that the RHD participants, except a few have spoken with normal fluency rates but have much lower total word count, for both the females and males and have also spoken for a much lower amount of time. According to empirical data, RHD participants might or might not be affected in their fluency levels or words per minute figures but what is affected is the total number of words they use in a discourse and for the amount of time they speak in a discourse.

We have also noted that in the severity index for both pitch range and fluency 22CS62FR was the most severe for the female RHD participants. The least severe female RHD case in terms of pitch range was 25UG58FR and in terms of fluency the least severe female case was 24NB50FR. In case of the male RHD participants 30HD50MR is the most severe case in terms of minimum pitch range and 33NB42MR is the least severe case, in terms of pitch variation. In terms of fluency 39SR34MR is the most severe case and 35SA58MR is the least severe case.

2. How does RHD affect the use of pitch at the level of segments (primarily vowels), at the level of words and sentences?

We discussed pitch levels at the level of discourse under the previous research question and under this research question, we would look into pitch levels at the level of sentences and words (as in vowels). We shall first address pitch variation at the level of sentences and then address the same at the level of words, as in the vowel segments in them.

PITCH VARIATIONS IN SENTENCES FOR FEMALE PARTICIPANTS

Let us take a look at the three scatter graphs, we discussed previously under pitch variations in sentences.

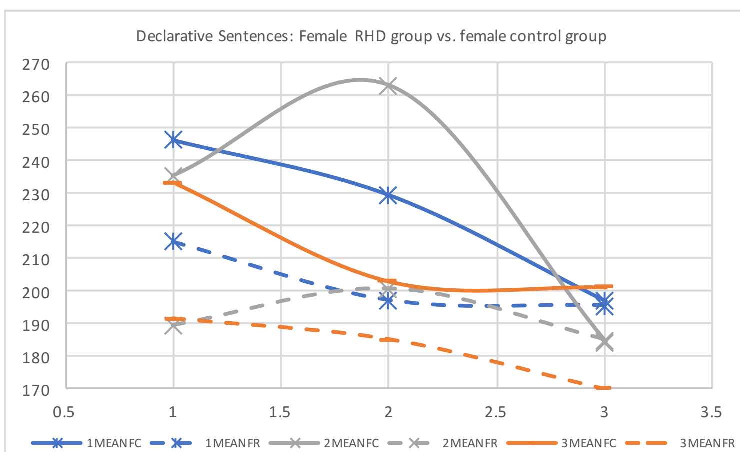


Fig 4.26: Declarative sentences in female participants

Declarative sentences- In the **first sentence,** the **control group mean has a type C** sentence in the which means that the sentence begins at a high pitch point followed by the second pitch point which is lower and the third pitch point which is the lowest (which looks like ‘\’) and every RHD participant has a type C sentence except 23GD65FR, who has a type B curve in which the first measured pitch point is high, followed by the second point which is always lower than the first point. The last measured pitch point in a type B sentence can be either lower than the first measured point or higher or even equal, but never lower than the second point, which is always the lowest (type B curve looks like ‘U’). In the **second sentence**, the **control group mean has a type D** sentence, in which the first pitch point is low, followed by a second point which is higher than the first point and the highest pitch point in the sentence, followed by the third measured pitch point which can be either lower or higher than the first pitch point but never higher than the second pitch point (type D curve looks like a mirror image or opposite ‘U’). We find one exception in the sentence by 25UG58FR who has produced a type B sentence. In the **third sentence** the **control group mean has a type C** sentence. But 22CS62FR, has a type A sentence, in which the lowest pitch point in a sentence is the first point, followed by the second point which is higher than the first and the last point which is the highest (which looks like ‘/’); and 25UG58 has a type B sentence. We notice a much steeper gradient in the curves of the control group mean in the three sentences individually, as well as the individual sentences showing much less range in the articulation of the sentences of the RHD participants. This is true, even in case the sentence types match for both the RHD and the control group.

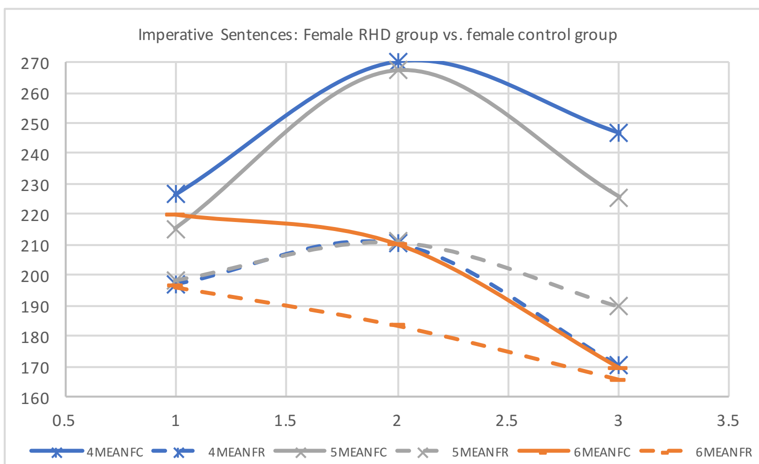


Fig 4.27: Imperative sentence in female participants

<u>**Imperative Sentences -**</u> In the **fourth sentence,** the **control group mean has a type D** and the mean of the RHD group has a type D curve as well but we found one exception in the sentence 22CS62FR who has a type C curve. In the **fifth sentence,** the **control group mean has a type D** and every RHD participant has a type C sentence except 23GD65FR, and the mean of the RHD group also has a type D curve but there are two exceptions in found in 24NB50FR and 25UG58FR, who have both displayed type A sentences. In the **sixth sentence,** the **control group mean has a type C** and the mean of the RHD group has a type C curve as

well but we found one exception in the sentence 25UG58FR who has a type B curve. It is worth noticing that all the control group curves are high above in the pitch range while the RHD curves lack proper contoured curves, which in turn translates to lesser pitch range in the sentences.

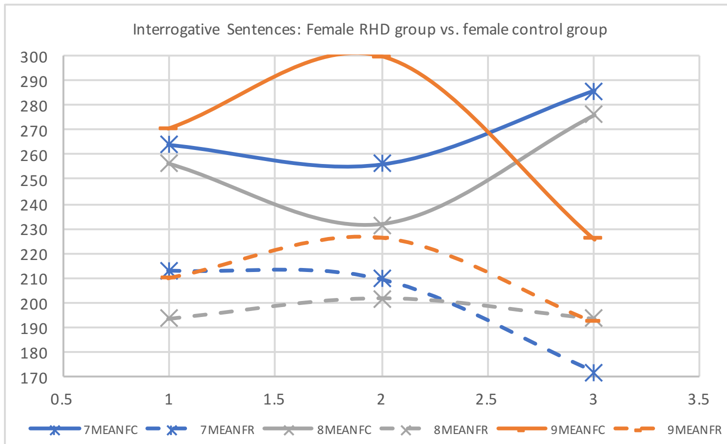


Fig 4.28: Interrogative sentences in female participants

Interrogative sentences - In the **seventh sentence,** the **control group mean has a type B** but the mean of the RHD group has a type C curve. 22CS62FR and 24NB50FR have type D curves while, 23GD65FR has a type C curve. 25UG58FR is the only participant who has a type B curve but the curve is so flat, i.e., it lacks pitch range and looks like a flat curve. In the **eighth sentence,** the **control group mean has a type B** sentence but the RHD group mean has a type D sentence. 22CS62FR has a type C curve, while 23GD65FR has a type A curve and 24NB50FR and 25UG58FR have type D curves. In the **ninth sentence,** the **control group mean has a type D** sentence and the RHD group mean also has a type D sentence. We find only one exception in 23GD65FR who has a type A curve. It should be noted here, again, that the control group curves have much more contour and pitch range in their sentences in comparison with their RHD group counterparts, which lack pitch range and are located in the lower part of the graph, proving that they operate at a lower pitch point as well have much lesser pitch range in their sentences.

For further understanding the variation in the sentences, a table has been created which in turn helps us understand the exact number of variations, the individual participant displayed.

FEMALE RHD DECLARATIVE SENTENCES											
S1				S2				S3			
PARTICIPANT	SENT TYPE	RHD MEAN	CONTROLS	PARTICIPANT	SENT TYPE	RHD MEAN	CONTROLS	PARTICIPANT	SENT TYPE	RHD MEAN	CONTROLS
22CS62FR	C	C	**C**	22CS62FR	D	D	**D**	22CS62FR	A	N.A.	**C**
23GD65FR	B			23GD65FR	D			23GD65FR	C		
24NB50FR	C			24NB50FR	D			24NB50FR	D		
25UG58FR	C			25UG58FR	C			25UG58FR	B		
FEMALE RHD IMPERATIVE SENTENCES											
S4				S5				S6			
PARTICIPANT	SENT TYPE	RHD MEAN	CONTROLS	PARTICIPANT	SENT TYPE	RHD MEAN	CONTROLS	PARTICIPANT	SENT TYPE	RHD MEAN	CONTROLS
22CS62FR	C	D	**D**	22CS62FR	D	D, A	**D**	22CS62FR	C	C	**C**
23GD65FR	D			23GD65FR	D			23GD65FR	C		
24NB50FR	D			24NB50FR	A			24NB50FR	C		
25UG58FR	D			25UG58FR	A			25UG58FR	B		
FEMALE RHD INTERROGATIVE SENTENCES											
S7				S8				S9			
PARTICIPANT	SENT TYPE	RHD MEAN	CONTROLS	PARTICIPANT	SENT TYPE	RHD MEAN	CONTROLS	PARTICIPANT	SENT TYPE	RHD MEAN	CONTROLS
22CS62FR	D	D, C	**B**	22CS62FR	C	C	**B**	22CS62FR	D	D	**D**
23GD65FR	C			23GD65FR	A			23GD65FR	D		
24NB50FR	D			24NB50FR	D			24NB50FR	D		
25UG58FR	C			25UG58FR	C			25UG58FR	D		

Table 4.5: A table summing up all the types of sentences produced by all RHD participants in comparison with the control means in each sentence.

FEMALE RHD TOTAL VARIATIONS	
PARTICIPANT	VARIATIONS FROM CONTROL
25UG58FR	5 OUT OF 9
24NB50FR	4 OUT OF 9
22CS62FR	4 OUT OF 9
23GD65FR	3 OUT OF 9

Table 4.6: A table summing up the number of times a female participant has displayed variations at the level of sentences; helping us discern the severity index of the participants

The two tables above, give us a comprehensive view into the quantity and nature of variations, in terms of sentence type displayed by the female participants. Under table 4.5, each participant and the types of sentence they have used in each sentence individually have been displayed. This is followed by the sentence type used by most RHD participants (N.A. in cases, where no sentence type gets clear majority) and the sentence type used by most control participants.

We notice that most of the female RHD group means are identical to the control group means but exceptions include S3, S5, S7 and S8 where the RHD participants have mostly used a sentence type which does not match the kind of sentence most used by the female controls. We can see here that 25UG58FR has the maximum number of variations in her sentences with 5 out of 9 and 23GD65FR has the minimum number of variations at 3 out of 9. 22CS62FR who was previously found out to be the most severe case under the last question has 4 variations in 9 sentences.

PITCH VARIATIONS IN SENTENCES FOR MALE PARTICIPANTS

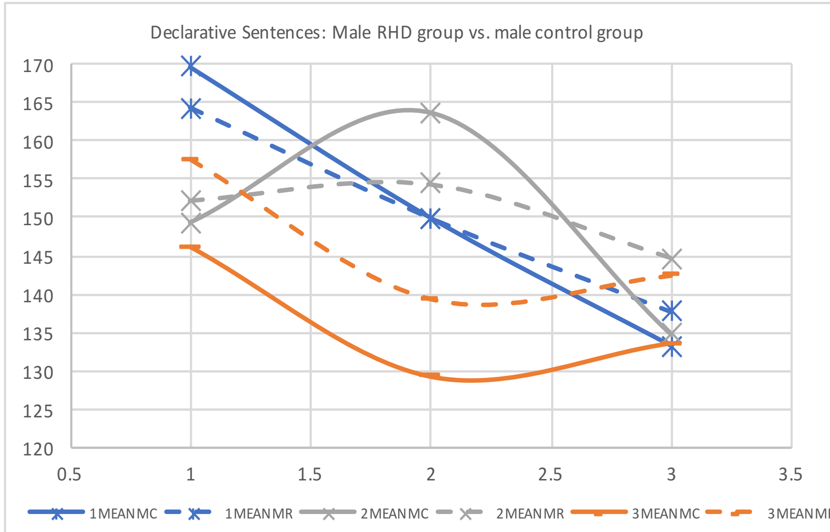


Fig 4.29: Declarative sentences in male participants

Declarative sentences- In the **first sentence,** the **control group mean has a type C** and the RHD group mean has a type C sentence as well. Exceptions include 35SA58MR and 27BD57MR who have type A curves and 30HD50MR and 44ZS64MR, who have type B curves. In the **second sentence,** the **control group mean has a type D** and the RHD group mean has a type D sentence as well but the curve has much lesser pitch range and contour in comparison with the control group curve. Exceptions include 29DS55MR who has a type C curve, 27BD57MR who has a type A curve, 33NB42MR who has a type A curve, 40SB82MR who has a type A curve and 30HD50MR who has a type B curve. In the **third sentence,** the **control group mean has a type B** and the RHD group mean has a type B sentence as well. Exceptions include 29DS55MR, 31SH31MR, 42SR44MR, 39SR34MR, 40SB82MR, 32KD72MR and 43SK55MR with type C curves, 35SA58MR, 41SK55MR and 26AS60MR with type D curves. We found a lot of exceptions in this sentence.

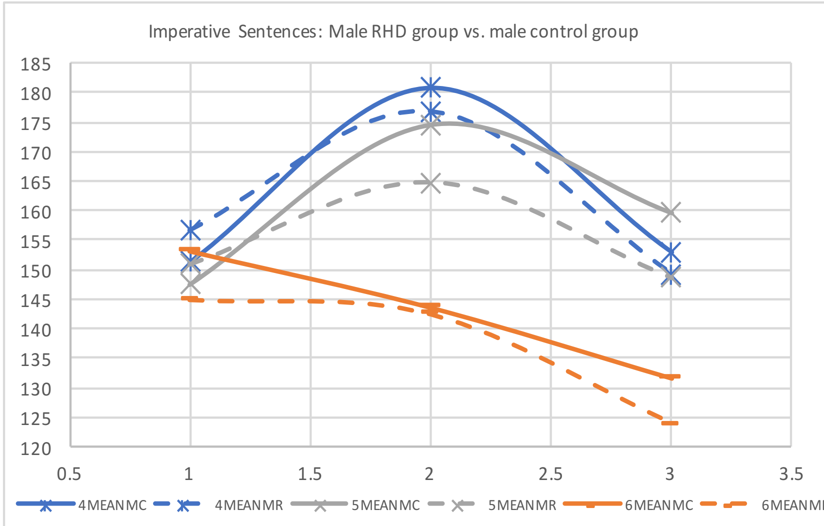


Fig 4.30: Imperative sentences in male participants

<u>Imperative Sentences -</u> In the **fourth sentence,** the **control group mean has a type D** and the mean of the RHD group has a type D curve as well. Exceptions include 44ZS64MR with a type C curve and 33NB42MR with a type A curve. In the **fifth sentence,** the **control group mean has a type D** and the mean of the RHD group has a type D curve as well. Exceptions include 37SH31MR, 35SA58MR and 27BD57MR with type A curves. In the **sixth sentence,** the **control group mean has a type C** and the mean of the RHD group has a type D curve as well. Exceptions include 29DS55MR, 31KM80MR and 35SA58MR with type D curves, 27BD57MR with a type B curve. Here, again, we must notice that the RHD group curves exist under the control group curves graphically, proving that they have lesser pitch range in the respective sentences.

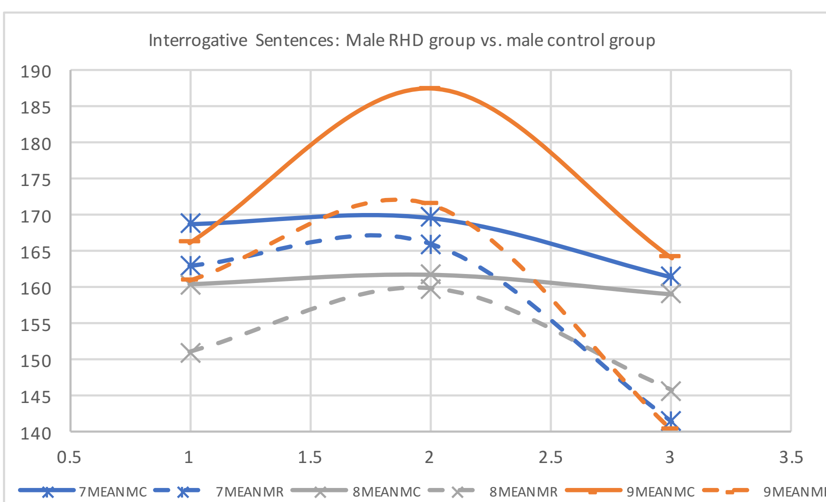


Fig 4.31: Interrogative sentences in male participants

<u>Interrogative sentences -</u> In the **seventh sentence,** the **control group mean has a type D** and the mean of the RHD group has a type D curve. Exceptions include 36SB47MR, 33NB42MR, 43SK55MR and 30HD50MR with type C curves, 27BD57MR with a type B curve and 39SR34MR with type A curve. In the **eighth sentence,** the **control group mean has a type D** and the mean of the RHD group has a type D curve. It is surprising to notice here, that the control group has a much flatter curve than the RHD group. Exceptions to the RHD group include 27BD57MR with a type B curve, 40SB82MR with a type A curve and 39SR34MR and 26AS60MR with type C curves. In the **ninth sentence,** the **control group mean has a type D** and the mean of the RHD group has a type D curve. Here, the control group has a much higher operating pitch range in the sentences. The RHD group mean curve is located under the control group curve, meaning lesser pitch range. Exceptions include 27BD57MR with a type A curve and 43SK55MR with a type C curve.

For further understanding the variation in the sentences, a table has been created which in turn helps us understand the exact number of variations, the individual participant displayed.

MALE RHD DECLARATIVE SENTENCES											
S1				S2				S3			
PARTICIPANT	SENT TYPE	RHD MEAN	CONTROLS	PARTICIPANT	SENT TYPE	RHD MEAN	CONTROLS	PARTICIPANT	SENT TYPE	RHD MEAN	CONTROLS
26AS60MR	C			26AS60MR	D			26AS60MR	D		
27BD57MR	A			27BD57MR	A			27BD57MR	B		
28DM35MR	C			28DM35MR	C			28DM35MR	C		
29DS55MR	C			29DS55MR	C			29DS55MR	C		
30HD50MR	B			30HD50MR	B			30HD50MR	B		
31KM80MR	D			31KM80MR	D			31KM80MR	B		
32KD72MR	C			32KD72MR	D			32KD72MR	C		
33NB42MR	D			33NB42MR	A			33NB42MR	C		
34SR36MR	C	C	**C**	34SR36MR	D	D	**D**	34SR36MR	B	C	**B**
35SA58MR	A			35SA58MR	D			35SA58MR	D		
36SB47MR	C			36SB47MR	C			36SB47MR	B		
37SH31MR	C			37SH31MR	D			37SH31MR	C		
39SR34MR	C			39SR34MR	D			39SR34MR	C		
40SB82MR	C			40SB82MR	A			40SB82MR	C		
41SK55MR	C			41SK55MR	D			41SK55MR	D		
42SR44MR	C			42SR44MR	D			42SR44MR	C		
43SK55MR	C			43SK55MR	D			43SK55MR	C		
44ZS64MR	B			44ZS64MR	D			44ZS64MR	B		

Table 4.7: A table summing up declarative produced by all male RHD participants.

MALE RHD IMPERATIVE SENTENCES											
S4				S5				S6			
PARTICIPANT	SENT TYPE	RHD MEAN	CONTROLS	PARTICIPANT	SENT TYPE	RHD MEAN	CONTROLS	PARTICIPANT	SENT TYPE	RHD MEAN	CONTROLS
26AS60MR	D			26AS60MR	D			26AS60MR	C		
27BD57MR	D			27BD57MR	A			27BD57MR	B		
28DM35MR	D			28DM35MR	D			28DM35MR	C		
29DS55MR	D			29DS55MR	D			29DS55MR	D		
30HD50MR	D			30HD50MR	D			30HD50MR			
31KM80MR	D			31KM80MR	D			31KM80MR	D		
32KD72MR	D			32KD72MR	D			32KD72MR	C		
33NB42MR	A			33NB42MR	D			33NB42MR	A		
34SR36MR	D	D	**D**	34SR36MR	D	D	**D**	34SR36MR	C	C	**C**
35SA58MR	D			35SA58MR	D			35SA58MR	D		
36SB47MR	D			36SB47MR	D			36SB47MR	C		
37SH31MR	D			37SH31MR	A			37SH31MR	C		
39SR34MR	D			39SR34MR	D			39SR34MR	C		
40SB82MR	D			40SB82MR	D			40SB82MR	C		
41SK55MR	D			41SK55MR	A			41SK55MR	C		
42SR44MR	D			42SR44MR	D			42SR44MR	C		
43SK55MR	D			43SK55MR	C			43SK55MR	C		
44ZS64MR	C			44ZS64MR	D			44ZS64MR	C		

Table 4.8: A table summing up imperative produced by all male RHD participants.

MALE RHD INTERRGATIVE SENTENCES											
S7				S8				S9			
PARTICIPANT	SENT TYPE	RHD MEAN	CONTROLS	PARTICIPANT	SENT TYPE	RHD MEAN	CONTROLS	PARTICIPANT	SENT TYPE	RHD MEAN	CONTROLS
26AS60MR	C			26AS60MR	C			26AS60MR	D		
27BD57MR	B			27BD57MR	B			27BD57MR	A		
28DM35MR	C			28DM35MR	C			28DM35MR	C		
29DS55MR	D			29DS55MR	D			29DS55MR	D		
30HD50MR	C			30HD50MR	D			30HD50MR	D		
31KM80MR	D			31KM80MR	D			31KM80MR	D		
32KD72MR	D			32KD72MR	D			32KD72MR	D		
33NB42MR	C			33NB42MR	C			33NB42MR	C		
34SR36MR	D	D	**D**	34SR36MR	D	D	**D**	34SR36MR	D	D	**D**
35SA58MR	D			35SA58MR	D			35SA58MR	D		
36SB47MR	C			36SB47MR	D			36SB47MR	D		
37SH31MR	D			37SH31MR	A			37SH31MR	D		
39SR34MR	A			39SR34MR	C			39SR34MR	C		
40SB82MR	D			40SB82MR	A			40SB82MR	D		
41SK55MR	D			41SK55MR	A			41SK55MR	D		
42SR44MR	D			42SR44MR	D			42SR44MR	C		
43SK55MR	C			43SK55MR	C			43SK55MR	C		
44ZS64MR	D			44ZS64MR	C			44ZS64MR	C		

Table 4.9: A table summing up interrogative produced by all male RHD participants.

MALE RHD TOTAL VARIATIONS	
PARTICIPANT	VARIATIONS FROM CONTROL
33NB42MR	8 OUT OF 9
27BD57MR	7 OUT OF 9
28DM35MR	5 OUT OF 9
43SK55MR	5 OUT OF 9
39SR34MR	4 OUT OF 9
26AS60MR	3 OUT OF 9
29DS55MR	3 OUT OF 9
30HD50MR	3 OUT OF 9
35SA58MR	3 OUT OF 9
37SH31MR	3 OUT OF 9
40SB82MR	3 OUT OF 9
41SK55MR	3 OUT OF 9
44ZS64MR	3 OUT OF 9
31KM80MR	2 OUT OF 9
36SB47MR	2 OUT OF 9
42SR44MR	2 OUT OF 9
32KD72MR	1 OUT OF 9
34SR36MR	0 OUT OF 9

Table 4.10: A table summing up the number of times a male participant has displayed variations at the level of sentences; helping us comprehensively compare the RHD participants

The four tables above, give us a comprehensive view into the quantity and nature of variations, in terms of sentence type displayed by the male participants. Under table 4.7, 4.8 and 4.9, each participant and the types of sentence they have used in each sentence individually, have been displayed. This is followed by the sentence type used by most RHD participants (N.A. in cases, where no sentence type gets clear majority) and the sentence type used by most control participants. Table 4.10 arranges the participants in order of their severity, as discerned at the level of sentences. The participant at the top is the most severe and the participant at the bottom is the least severe.

We notice that most of the male RHD group means are identical to the control group means with one exception in S3, where the RHD group uses type C sentence most prominently and the control group uses type B as the most common type. 33NB42MR is the most severe case with 8 variations out of 9 sentences and 34SR36MR has 0 variations out of the 9 sentences.

ACOUSTIC SPACE OF VOWELS

We already discussed vowel spaces of both males and females in section **4.1.3,** and reiterate the same here for furthering the discussion on acoustic spaces and the area used. It is worth mentioning here that in most cases the vowel spaces of the RHD participants were found to be smaller than those of the control vowel spaces, when we made individual comparisons in the last chapter. It is important understanding here that the comparison made here, after calculating means have transgressed the age and gender matched process of comparing which we have done throughout the case studies. Here we have compared the means of the RHD group with the means of the control group. The individual case studies in the previous chapter hold much more relevance when it comes to acoustic space, because they have been compared with age and gender matched controls, ruling out chances of errors at the level of means.

Following are the acoustic space graphs of the female and male participants respectively and relevant discussions.

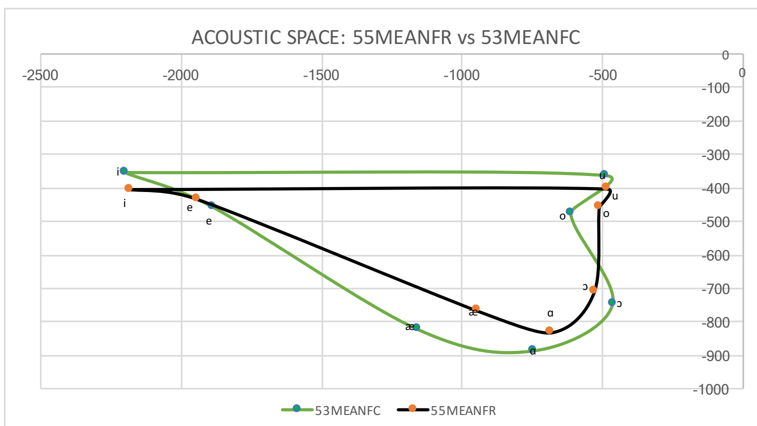


Fig 4.32: Vowel space of female participants

The female control group have an acoustic space area of **525960** and the **female RHD group** have an area of **377232**. The female RHD group is only **71%** of the control acoustic space. We can also discern that the high low capabilities of the RHD group are lower than the control group. But we found multiple instances of exceptions like 24NB50FR who has a vowel space 30.8% smaller than the control mean vowel space and 25UG58FR who has a vowel chart 37.5% bigger than the control vowel chart.

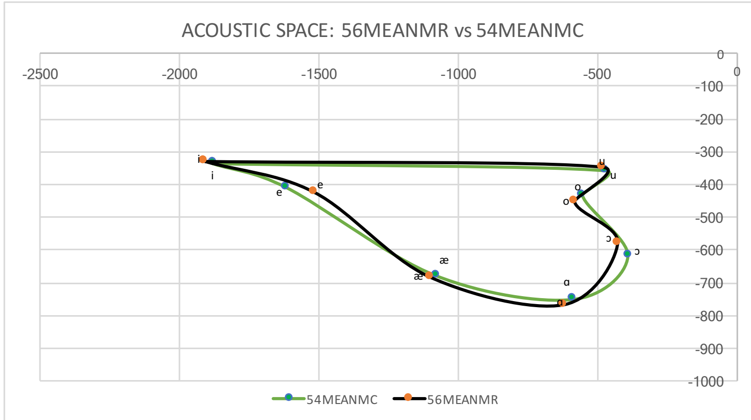


Fig 4.33: Vowel space of male participants

The male control group have an acoustic space area of **327954** and the **male RHD group** have an area of **336881**. The female RHD group is **102%** of the control acoustic space. We looked into the individual participants in previous chapter. We found out the reason for the RHD vowel chart area being more than the control vowel chart. This is because we have participants like 34SR36MR with an area 74.1% larger than the control chart and 40SB82MR with an area 54.2% larger than the control vowel space area. But in all fairness, we also need to name the cases which had acoustic space areas much lower than that of the control mean. 30HD50MR has a vowel space 38.5% smaller than the control vowel space. 32KD72MR has an area which is 31.9% smaller than the control mean-vowel space. Rest of the participants have vowel spaces which are plus or minus 10% area of the control mean vowel space.

We shall now take a look at a table which houses the acoustic space area of all the male and female participants. All participants, who have lower than the mean area, of their respective male or female groups, would then be revisited.

VOWELS RHD					
RHD PARTICIPANT	**Area**	**Control**	**Area**	**% of ind control**	**% of rhd mean**
24NB50FR	261075	04ND51FC	476432.5	-45.2	-30.8
23GD65FR	351705	03NS64FC	396032.5	-11.2	-6.8
22CS62FR	377549.5	07SB60FC	454780.5	-17.0	0.1
25UG58FR	518600	06RB56FC	483885.5	7.2	37.5
96MEANFR	**377232.375**				

Table 4.11: A table summing up all the acoustic space areas of all female participants arranged in ascending order

VOWELS RHD					
RHD PARTICIPANT	**Area**	**Control**	**Area**	**% of ind control**	**% of rhd mean**
30HD50MR	207043	16AP52MC	430473.5	-51.9	-38.5
32KD72MR	229269	12AD75MC	366966	-37.5	-31.9
38SB74MR	262375	12AD75MC	366966	-28.5	-22.1
31KM80MR	265860	21SD82MC	295629.5	-10.1	-21.1
39SR34MR	273457	13AS36MC	198261.5	37.9	-18.8
35SA58MR	290022	15AK57MC	278398.5	4.2	-13.9
33NB42MR	302260	20SD48MC	387032	-21.9	-10.3
44ZS64MR	321793	18SB64MC	252738.5	27.3	-4.5
41SK55MR	322039	10AP56MC	353753.5	-9.0	-4.4
26AS60MR	331662	15AK57MC	278398.5	19.1	-1.5
29DS55MR	338952	10AP56MC	353753.5	-4.2	0.6
43SK55MR	344866	14AK56MC	306181.5	12.6	2.4
28DM35MR	344955	13AS36MC	198261.5	74.0	2.4
27BD57MR	352108	15AK57MC	278398.5	26.5	4.5
42SR44MR	363945	20SD48MC	387032	-6.0	8.0
37SH31MR	371417	17SB30MC	358350	3.6	10.3
36SB47MR	372567	20SD48MC	387032	-3.7	10.6
40SB82MR	519492	21SD82MC	295629.5	75.7	54.2
34SR36MR	586668	13AS36MC	198261.5	195.9	74.1
97MEANMR	**336881.3421**				

Table 4.12: A table summing up all the acoustic space areas of all male participants arranged in ascending order.

After a brief look at table 4.11 and table 4.12 we can discern the following: 24NB50FR has the lowest acoustic space area and is 30.8% smaller than the RHD mean acoustic space, while being 45.2% smaller than the individual control it was compared to. 24NB50FR had above average fluency figures. Also, in respect to this 24NB50FR made 4 deviations from the control types, at the level of sentences. 25UG58FR has the largest acoustic space area and is 37.5% bigger than the RHD mean acoustic space area and 7.2% bigger than the individual control it was compared to. 25UG58FR also had the largest pitch range but less than average fluency figures. Also, in respect to this 25UG58FR made 5 deviations in comparison with the control group sentences. 30HD50MR has the lowest acoustic space area and is 38.5% smaller than the RHD mean acoustic space, while being 51.9% smaller than the individual control it was compared to. 30HD50MR also had the lowest pitch range but had above average fluency figures. Also, in respect to this 30HD50MR made 3 deviations from the control types, at the level of sentences. 34SR36MR has the largest acoustic space area and is 74.1% bigger than the RHD mean acoustic space area and a staggering 195.9% bigger than the individual control it was compared to. 34SR36MR also had one of the largest pitch ranges and more than average fluency figures. Also, in respect to this 34SR36MR made 0 deviations from the control types, at the level of sentences.

Let us take a brief look at the participants who have acoustic spaces smaller than the average of the respective male or female RHD groups. We shall first reproduce the formant figures for the participants who have acoustic space areas lesser than the respective means of their RHD groups.

23GD65FR	/i/	0.134	331	2937	2606	-2606	-331	
	/e/	0.056	419	2489	2070	-2070	-419	
	/æ/	0.058	784	1077	293	-293	-784	
	/ɑ/	0.047	845	1624	779	-779	-845	
	/ɔ/	0.052	674	1277	603	-603	-674	
	/o/	0.049	450	1086	636	-636	-450	
	/u/	0.078	352	919	567	-567	-352	
	/i/	0.134	331	2937	2606	-2606	-331	351705

Table 4.13: Table showing the formant values of 23GD65FR

24NB50FR	/i/	0.073	436	2282	1846	-1846	-436	
	/e/	0.064	446	2156	1710	-1710	-446	
	/æ/	0.165	748	1949	1201	-1201	-748	
	/ɑ/	0.064	744	1378	634	-634	-744	
	/ɔ/	0.084	780	1522	742	-742	-780	
	/o/	0.07	485	973	488	-488	-485	
	/u/	0.067	474	950	476	-476	-474	
	/i/	0.073	436	2282	1846	-1846	-436	261075

Table 4.14: Table showing the formant values of 24NB50FR

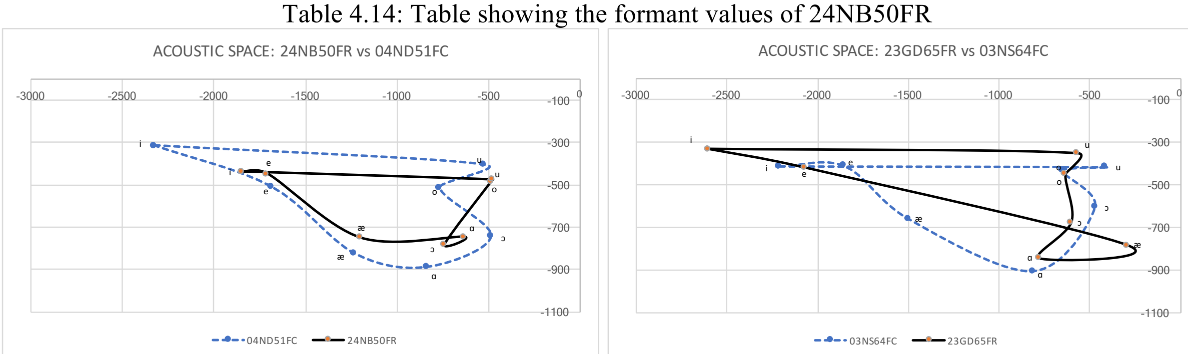


Fig 4.34 – 4.45: Acoustic space diagrams for female RHD participants, who have area much smaller than the average of their RHD

We can discern the following: 24NB50FR displays much diminished front and back ranges in terms of vowel space and the high low ranges are affected as well to a high degree. She scored 14 on the GCS and 26 in MMSE. 23GD65FR displays incorrect position of vowels which makes a very unique acoustic space diagram. The high vowels for her are higher than the individual control she has been compared with. She scored 12 on GCS and 25 in MMSE.

30HD50MR	/i/	0.081	336	2027	1691	-1691	-336	
	/e/	0.052	441	1602	1161	-1161	-441	
	/æ/	0.111	589	1580	991	-991	-589	
	/ɑ/	0.049	721	1472	751	-751	-721	
	/ɔ/	0.078	585	1079	494	-494	-585	
	/o/	0.042	464	1028	564	-564	-464	
	/u/	0.069	340	807	467	-467	-340	
	/i/	0.081	336	2027	1691	-1691	-336	207043

Table 4.15: Table showing the formant values of 30HD50MR

31KM80MR	/i/	0.109	363	2495	2132	-2132	-363	
	/e/	0.035	455	1716	1261	-1261	-455	
	/æ/	0.083	702	1845	1143	-1143	-702	
	/ɑ/	0.061	788	1527	739	-739	-788	
	/ɔ/	0.088	558	1056	498	-498	-558	
	/o/	0.051	490	1564	1074	-1074	-490	
	/u/	0.077	309	824	515	-515	-309	
	/i/	0.109	363	2495	2132	-2132	-363	265859.5

Table 4.16: Table showing the formant values of 31KM80MR

32KD72MR	/i/	0.112	319	2103	1784	-1784	-319	
	/e/	0.07	369	1604	1235	-1235	-369	
	/æ/	0.091	644	1647	1003	-1003	-644	
	/ɑ/	0.081	701	1398	697	-697	-701	
	/ɔ/	0.107	497	1010	513	-513	-497	
	/o/	0.083	415	951	536	-536	-415	
	/u/	0.078	296	808	512	-512	-296	
	/i/	0.112	319	2103	1784	-1784	-319	229269

Table 4.17: Table showing the formant values of 32KD72MR

33NB42MR	/i/	0.093	316	2335	2019	-2019	-316	
	/e/	0.051	435	2085	1650	-1650	-435	
	/æ/	0.087	672	1808	1136	-1136	-672	
	/ɑ/	0.054	721	1540	819	-819	-721	
	/ɔ/	0.077	623	1139	516	-516	-623	
	/o/	0.056	434	1057	623	-623	-434	
	/u/	0.058	402	813	411	-411	-402	
	/i/	0.093	316	2335	2019	-2019	-316	302259.5

Table 4.18: Table showing the formant values of 33NB42MR

38SB74MR	/i/	0.082	326	2068	1742	-1742	-326	
	/e/	0.048	418	1885	1467	-1467	-418	
	/æ/	0.124	651	1563	912	-912	-651	
	/ɑ/	0.054	686	1326	640	-640	-686	
	/ɔ/	0.082	552	1014	462	-462	-552	
	/o/	0.055	410	1014	604	-604	-410	
	/u/	0.058	319	763	444	-444	-319	
	/i/	0.082	326	2068	1742	-1742	-326	262374.5

Table 4.19: Table showing the formant values of 38SB74MR

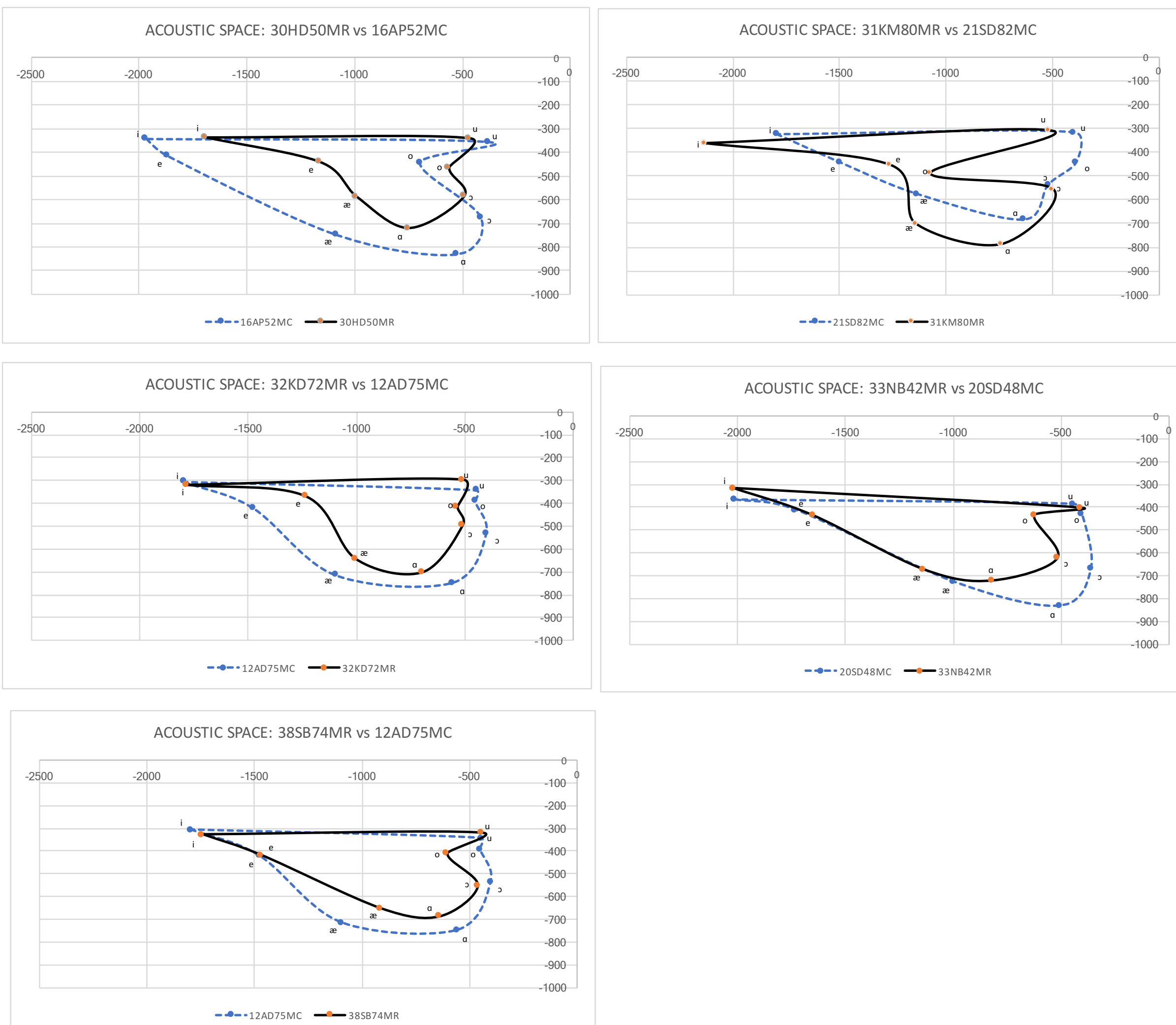


Fig 4.36 – 4.40: Acoustic space diagrams for male RHD participants, who have area much smaller than the average of their RHD

We can discern the following: 30HD50MR displays much high and low range as well as front back range. 30HD50MR also had the lowest MMSE and GCS scores. 31KM80MR has an extremely fronted /i/ vowel but has an /o/ vowel which encroaches the territory of the mid vowels. He scored 12 on the GCS and 27 in MMSE. 32KD72MR has diminished front back, high low range. The mid low vowels have moved towards centre (both the front vowels and the back vowels). He scored 11 on the GCS and 20 in MMSE, which is extremely low. 33NB42MR displays a vowel space diagram in which the back vowels have moved towards the mid vowel positions. He scored 12 on the GCS and 26 in MMSE, which is extremely low. He also has the best pitch range, but has displayed inconsistent pitch ranges in both the stories. 38SB74MR has similar placement of the high vowels but the low vowels have moved further higher, decreasing the total area of the vowel space. He scored 12 on the GCS and 27 in MMSE.

3. How does RHD affect pitch at the level of discourse in connected speech?

In order to answer the third and final research question, we must first understand the scope of the question and what it actually asks for. Under the scope of this question, we shall look at the digressions and the number of questions answered by the RHD participants at the level of discourse in respect to the comprehensive comparisons calculated in tables, in the previous questions, using them as empirical proof.

DIGRESSIONS

The 2 graphs following denote the number of digressions made by every RHD participant, in the course of the research proceedings. It is important to notice here that the mean of the RHD group and the control group does not provide a complete picture of the comparisons. Henceforth, individual comparisons were made in the previous chapter to compare the individual RHD participants to age and gender matched controls. The following means help us get a bigger picture and a gist of the number of digressions.

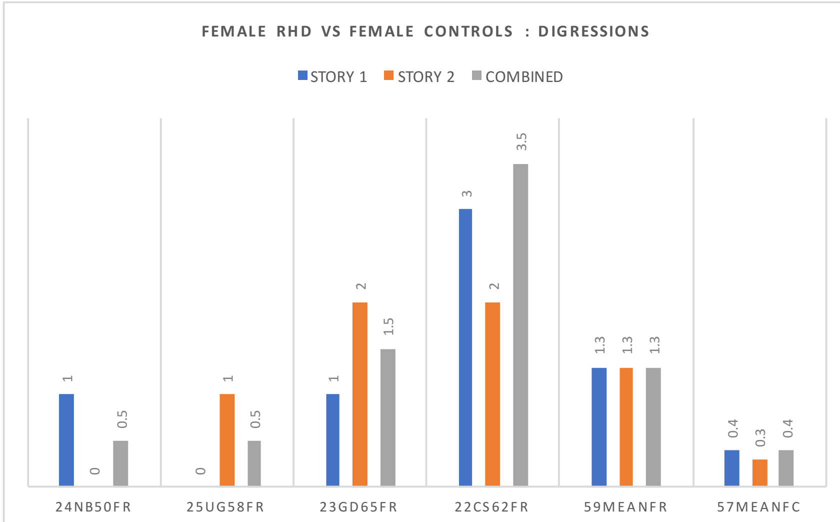


Fig 4.41: A chart comparing the number of digressions in the story recordings of the female RHD group vs. the female control group.

The female RHD group have 1.3 digressions in story 1 and 1.3 digressions in story 2 as well. In comparison, the control group has 0.4 digressions in story 1 and 0.3 digressions in story 2. In the combined mean of both the stories the stories the RHD group has 1.3 digressions while the control group has 0.4 digressions. 22CS62FR has 3 digressions and she introduced a small boy in the story, who was appreciating the deer. 22CS62FR also mentioned that the deer didn't like its body, which never happened and that the deer got stuck in a tree. In story 2 she also mentioned that the tree bark king wasn't working and that the frogs wanted a good king, whereas they just wanted a king who would actually rule over them. 22CS62FR was the most severe case under both pitch variations and fluency. We can also note from the diagram above that 24NB50FR and 25UG58FR have 1 digression each i.e. in accordance with the GCS and the MMSE scale results.

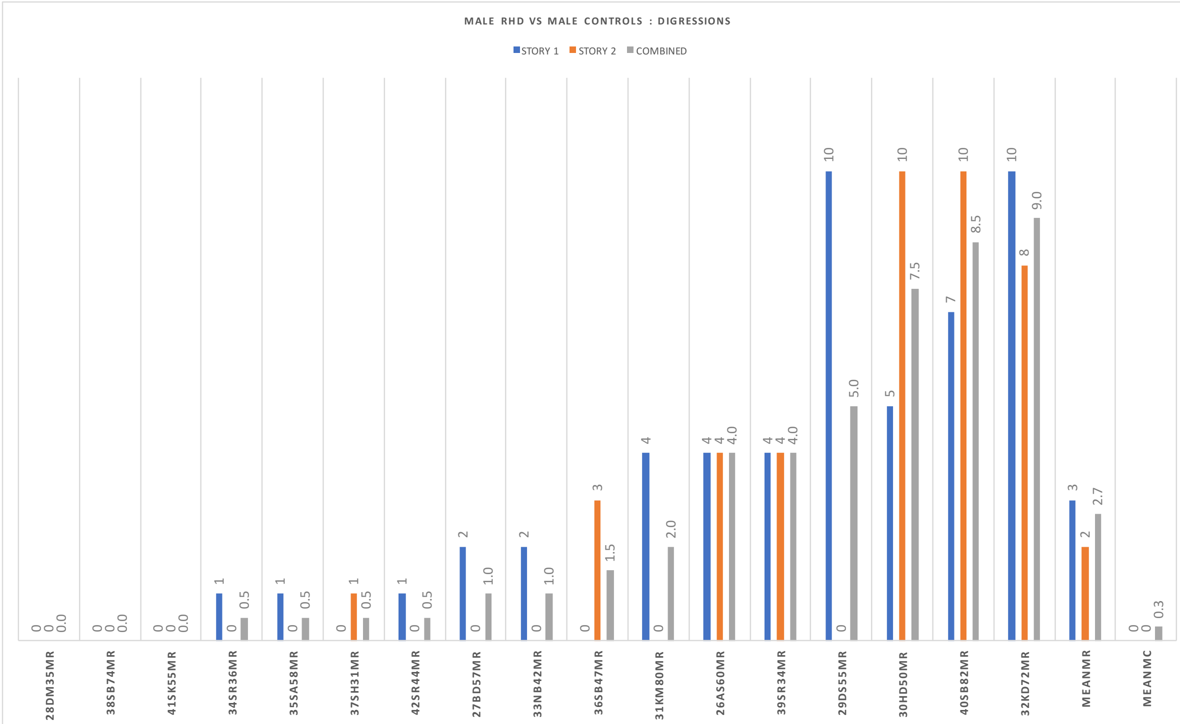


Fig 4.42: A chart comparing the number of digressions in the story recordings of the male RHD group vs. the male control group.

The male RHD group have 3 digressions in story 1 and 2 digressions in story 2. In comparison, the control group has 0 digressions in story 1 and 0 digressions in story 2 as well. In the combined mean of both the stories the stories the RHD group has 2.7 digressions while the control group has 0.3 digressions. In story 1, 26AS60FR has 4 digressions, while 29DS55MR and 32KD72MR have 10 digressions, while 40SB82MR has 7 digressions. In story 2, 30HD50MR has 10 digressions, 32KD72MR has 8 digressions and 40SB82MR has 10 digressions. Upon referring back to the severity index table (table no. 4.22) we realize that the 30HD50MR was also the most severe case under pitch range and acoustic space. 40SB82MR in spite of having a very good acoustic space displayed many digressions.

We noticed more digressions in the RHD participants, than in the control participants. The maximum number of digressions in control recordings can be seen in 02MP76FC, who has 3 digressions in story 1 and 2 in story 2; while for the males 12AD74MC has 2 digressions in story 1 and 2 in story 2.

QUESTIONS ANSWERED

The following graph denotes the number of questions answered made by every female and male RHD participant, in the course of the research proceedings. In the course of the discourse recordings we had asked 5 questions to every participant, pertaining to the stories narrated to them. Questions answered, in the previous chapter catered to the number of questions answered by every participant, either correct or incorrect, with the documentation of the answers provided by them and under this heading we shall take a look at the mean of the whole female and male RHD group. It is important to notice here that the mean of the RHD group and the control group does not provide a complete picture of the comparisons. Henceforth, individual comparisons were made in the previous chapter to compare the individual RHD participants to age and gender matched controls. The following means help us get a bigger picture and a gist of the number of questions answered.

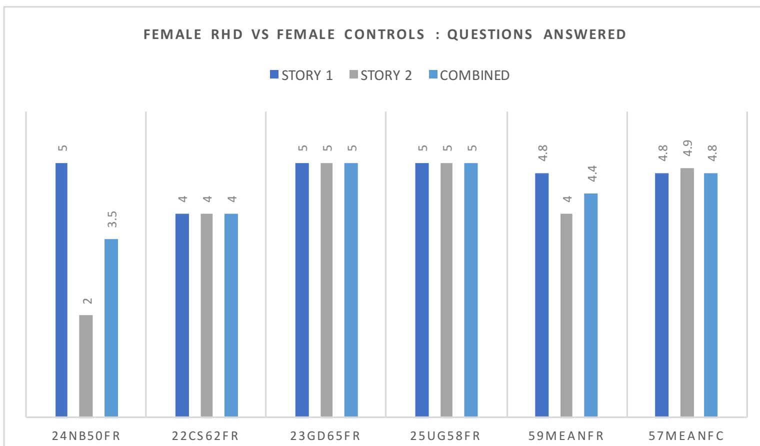


Fig 4.43: A chart comparing the number of questions answered in the stories for the female RHD group vs the female control group.

Here, we can notice that the female RHD group has answered 4.8 questions for story 1 which is exactly the same as the control group. For story 2 the RHD group has answered 4 questions in comparison with the control group with 4.9 questions answered, which is near perfect. In the combined mean of both the stories, the RHD group has 4.4 questions answered whereas the control group has 4.8 questions answered. The trend is that the control group has answered more than the RHD group. But there were participants like 22CS62FR, who answered 4 questions only. 24NB50FR answered only 2 questions in story 2 compared to 5 questions she could answer correctly in story 1. 25UG58FR and 23GD65FR are still the least severe cases, as discernable from the figure displayed previously and could answer all 5 questions correctly. Please refer to the individual case studies in chapter 3.

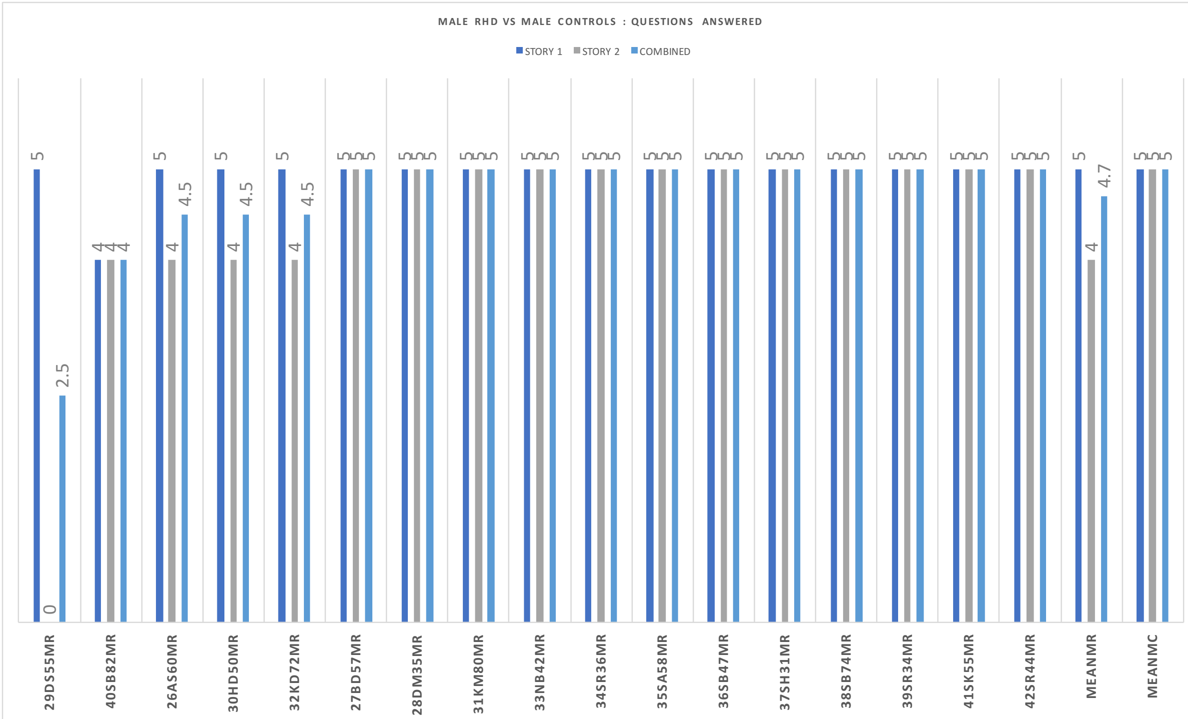


Fig 4.44: A chart comparing the number of questions answered in the stories for the female RHD group vs the female control group.

Here, we can notice that the male RHD group has answered all 5 questions for story 1 which is exactly the same as the control group. For story 2 the RHD group has answered 4 questions in comparison with the control group with 5 questions answered, which is perfect. In the combined mean of both the stories, the RHD group has 4.7 questions answered whereas the control group has 5 questions answered. The trend is that the control group has answered more than the RHD group. But when we check individually, there were participants like 26AS60MR, 30HD50MR, 32KD72MR and 42SB82MR who answered 4 questions only. 29DS55MR could not answer any questions in the second story because he refused to listen to the second story. Upon referring back to table no 23, the severity index we realize that the numbers and figures do match up with the previously decided on severity index. 30HD50MR, 32KD72MR, 40SB82MR and 26AS60MR all have displayed the inability to answer all 5 questions. This also matches with the MMSE and GCS results of the individual participants, according to table number 4.22. Also, please refer back to the individual case studies in chapter 3 for further details on the exact answers they gave to the questions. Among the control participants, on the other hand, there is only one control participant 12AD75MC, who has answered 4 questions in story 1. Except for 12AD75MC, every other participant in every other story has answered all 5 questions with ease. We can notice much less questions answered, in many more instances, for the RHD participants.

4.3. COMPREHENSIVE COMPARISON

All of the parameters discussed previously have been put together with GCS and MMSE scores. While GCS and MMSE give us an assessment of their physical and mental state or condition as assessed by a physician, the other parameters, pertaining to their speech and communication in the following table helps in finding out if there is any correlation between the extent of deficit displayed by GCS/MMSE and the speech and communication tested by us. The first two columns display GCS and MMSE scores of the participants. These two columns together can be used as an indication of the severity of their physical and mental condition as assessed by the physician. So, the first participant showing minimum GCS value should display maximum damage and the participant with the maximum GCS value should show minimum damage or deficit. The same is expected from the MMSE scores. The participant with the minimum MMSE score, is expected to display maximum deficit in the parameters while the participant with the maximum MMSE score is supposed to exhibit minimum deficit in the parameters. The GCS scores act like a **tentative indicator** of the deficit levels of the participants in speech. One should expect the performance of the participants to roughly correspond to the tentative severity, as indicated by the GCS and MMSE scores displayed in the tables below.

The participants have been arranged in ascending order of their GCS scores and in cases where GCS scores are same for more than one participants, the participants have been arranged in ascending order of their MMSE scores for the participants belonging to the same GCS scores. The scores of our tests, i.e., the other variables have been put together in 9 columns along with the GCS and MMSE scores.

Let us first take another look at the short forms of the parameters being studied in the tables to follow, presented below:

GCS- Glasgow Coma Scale scores

MMSE – Mini Mental State Examination scores

S1 PR – Story 1 Pitch Range in Hz

S2 PR – Story 2 Pitch Range in Hz

Pitch Range – Mean Pitch Range in Hz

S1 TW – Story 1 Total Words

S1 WPM – Story 1 Words Per Minute

S2 TW – Story 2 Total words

S2 WPM – Story 2 Words Per Minute

COM TW – Total words in combined means of story 1 and story 2

COM WPM – Words per minute in combined means of story 1 and story 2

TIME – Mean time taken to complete the stories

There are only 4 female participants with 9 female controls and the tabulated details of the 4 female participants have been presented below:

COMPREHENSIVE COMPARISON IN FEMALE RHD PARTICIPANTS												
PARTICIPANT	GCS	MMSE	S1 PR	S2 PR	Pitch Range	S1 TW	S1 WPM	S2 TW	S2 WPM	COM TW	COM WPM	TIME
22CS62FR	11	22	15	17	16	98	66	81	60	89	63	85
23GD65FR	12	25	29	26	28	74	96	82	120	78	108	44
24NB50FR	14	26	32	43	38	104	156	70	162	87	159	33
25UG58FR	15	29	43	45	44	104	156	106	168	105	162	39

Table no 4.20: A table comprehensively comparing all female RHD participants, arranged according to the GCS scores of the participants.

We can discern from table 4.20 that the GCS scores for the 4 female participants are 11, 12, 14 and 15 respectively for 22CS62FR, 23GD65FR, 24NB50FR and 25UG58FR. The MMSE values also seem to be roughly corresponding to the GCS values of the participants and are in the same ascending order like the GCS scores, i.e., 22CS62FR has the lowest MMSE score and 25UG58FR has the highest MMSE score. The participant with the lowest GCS score also has the lowest MMSE score and the participant with the maximum GCS score has the maximum MMSE score. In S1 PR, S2 PR and Pitch Range, we find the same ascending order, as we can expect from the GCS and MMSE scores of the participants. The last participant who is expected to be in a better neurological and cognitive state shows the highest pitch range in all three pitch related parameters. In S1 TW (total words in story 1) 23GD65FR has the minimum number of total words, completed in 44 seconds. In S2 TW 24NB50FR has spoken 70 words in 33 seconds, which is the lowest but has a higher GCS and MMSE scores than everyone except 25UG58FR. And since COM TW is the combined mean of the total words spoken in both the stories, we can notice that even if 23GD65FR has a higher MMSE and GCS score than 22CS62FR, she has a lower total word count at 78 words, completed in 44 seconds.

There are only 19 male participants and 12 control participants and the tabulated details of the 19 male participants have been presented below in tables 4.21 and 4.22.

COMPREHENSIVE COMPARISON IN MALE RHD PARTICIPANTS												
PARTICIPANT	GCS	MMSE	S1 PR	S2 PR	Pitch Range	S1 TW	S1 WPM	S2 TW	S2 WPM	COM TW	COM WPM	TIME
30HD50MR	11	24	21	24	23	150	96	108	120	133	108	74
32KD72MR	11	20	48	28	38	110	96	75	54	95	75	76
40SB82MR	11	24	42	50	46	77	84	69	84	73	84	52
41SK55MR	11	26	41	44	43	67	108	126	120	95	114	50
44ZS64MR	11	29										
29DS55MR	12	24	34	0	34	154	66	0	0	154	66	70
31KM80MR	12	27	33	30	32	175	114	108	114	142	114	75
33NB42MR	12	26	68	47	58	148	156	165	168	157	162	58
38SB74MR	12	27	25	31	28	152	120	122	144	140	132	64
39SR34MR	12	25	50	45	48	46	78	98	78	72	78	55
43SK55MR	12	27										
26AS60MR	14	26	30	36	33	90	84	74	84	82	84	59
27BD57MR	14	26	44	43	44	92	132	54	96	72	114	38
36SB47MR	14	26	49	50	50	65	78	122	78	94	78	72
42SR44MR	14	26	34	46	40	88	108	86	114	87	111	47
28DM35MR	15	29	41	35	38	99	156	111	180	105	168	38
34SR36MR	15	27	53	53	53	175	224	105	180	138	202	41
35SA58MR	15	29	33	51	42	161	138	158	144	160	141	68
37SH31MR	15	28	31	48	40	116	126	136	132	126	129	59

Table no 4.21: A table comprehensively comparing all male RHD participants

We can discern from table 4.21 that more than one participant listed above, have the same GCS score, which brings us to a point where we have to reshuffle the participants according to their MMSE scores for the participants having the same GCS scores. In the table above, the participants have been arranged according to their GCS scores only but in the table which follows, we have determined the order of the participants according to their MMSE scores, for the same GCS scores. In the next table, we have listed all the 19 participants in clusters along with the 9 parameters pertaining to speech and communication, arranged according to their GCS scores. At the end of every cluster, we have also listed the averages of every cluster, so as to compare them with the averages of the other clusters. We have only listed pitch range at the level of discourse and variables studied under the fluency level in discourse like words spoken per minute and total words spoken, along with total time taken. We have not included variables like digressions at the level of discourse and questions answered by the participants at the level of discourse. Following this paragraph is a table which the participants on the basis of GCS scores along with displaying the averages of each parameter in each cluster, added to the end of the clusters.

COMPREHENSIVE COMPARISON IN MALE RHD PARTICIPANTS												
GROUPS	PARTICIPANT	GCS	MMSE	S1 PR	S2 PR	Pitch Range	S1 TW	S1 WPM	S2 TW	S2 WPM	COM TW	COM WPM	TIME
G1	32KD72MR	11	20	48	28	38	110	96	75	54	95	75	76
	30HD50MR	11	24	21	24	23	150	96	108	120	133	108	74
	40SB82MR	11	24	42	50	46	77	84	69	84	73	84	52
	41SK55MR	11	26	41	44	43	67	108	126	120	95	114	50
	AVERAGES	**11**	**24**	**38**	**37**	**37**	**101**	**96**	**94**	**95**	**99**	**95**	**63**
G2	29DS55MR	12	24	34	0	34	154	66	0	0	154	66	70
	39SR34MR	12	25	50	45	48	46	78	98	78	72	78	55
	33NB42MR	12	26	68	47	58	148	156	165	168	157	162	58
	31KM80MR	12	27	33	30	32	175	114	108	114	142	114	75
	38SB74MR	12	27	25	31	28	152	120	122	144	140	132	64
	AVERAGES	**12**	**25.8**	**42**	**38**	**40**	**135**	**107**	**123**	**126**	**133**	**110**	**64**
G3	26AS60MR	14	26	30	36	33	90	84	74	84	82	84	59
	27BD57MR	14	26	44	43	44	92	132	54	96	72	114	38
	36SB47MR	14	26	49	50	50	65	78	122	78	94	78	72
	42SR44MR	14	26	34	46	40	88	108	86	114	87	111	47
	AVERAGES	**14**	**26**	**39**	**44**	**42**	**84**	**101**	**84**	**93**	**84**	**97**	**54**
G4	34SR36MR	15	27	53	53	53	175	224	105	180	138	202	41
	37SH31MR	15	28	31	48	40	116	126	136	132	126	129	59
	28DM35MR	15	29	41	35	38	99	156	111	180	105	168	38
	35SA58MR	15	29	33	51	42	161	138	158	144	160	141	68
	AVERAGES	**15**	**28**	**40**	**47**	**43**	**138**	**161**	**128**	**159**	**132**	**160**	**51**

Table 4.22: A comprehensive comparison of all male participants divided into four clusters, i.e. G1, G2, G3, G4; made according to their GCS scores.

We can discern from table 4.22 that G1 has an MMSE score of 24, G2 has an MMSE score of 25.8, G3 has an MMSE score of 26 and G4 has an MMSE score of 28, which roughly corresponds with the ascending order of the GCS scores of the four clusters, which are 11 for G1, 12 for G2 14 for G3 and 15 for G4. One can see a gradation in the values found out throughout the present research, presented in the table above, roughly corresponding to the MMSE and GCS scores of the RHD participants. In S1 PR, G1 has 38 Hz, G2 has 42 Hz, G3 has 39 Hz and G4 has 40 Hz. In S2 PR, G1 has 37 Hz, G2 has 38 Hz, G3 has 44 Hz and G4 has 47 Hz. In Pitch Range, G1 has 37 Hz, G2 has 40 Hz, G3 has 42 Hz and G4 has 43 Hz. In S1 TW, G1 has 101 total words, G2 has 135 total words, G3 has 84 total words and G4 has 138 total words. In S1 WPM, G1 has 96 words per minute, G2 has 107 words per minute, G3 has 101 words per minute and G4 has 161 words per minute. In S2 TW, G1 has 94 total words, G2 has 123 total words, G3 has 84 total words and G4 has 128 total words. In S2 WPM, G1 has 95 words per minute, G2 has 126 words per minute, G3 has 93 words per minute and G4 has 159 words per minute. In COM TW, G1 has 99 total words, G2 has 133 total words, G3 has 84 total words and G4 has 132 total words. In COM WPM, G1 has 95 words per minute, G2 has 110 words per minute, G3 has 97 words per minute and G4 has 160 words per minute. G1 took 63 seconds, while G2 took 64 seconds to complete the stories. G3 took 54 seconds and G4 took 51 seconds to complete the stories.

G2 has performed better than both G1 and G3 but G4 has the best overall performance. This in a way proves that higher the GCS score, better the mental and physical state of the participants. The parameters listed in tables 4.22 closely follow the physical and mental condition of the participants, as given by the GCS and MMSE scores, with a few exceptions. In S1 PR G3 with GCS at 14 has an average pitch of 39 Hz which is lower than G2 with GCS at 12, but such a gradation has been ruled out in Pitch Range, which is the column which shows the means of the pitch ranges of every RHD participant in the two stories. S2 PR follows the same ascending order of the GCS and MMSE values, hence 35AS58MR and 28DM35MR with the highest MMSE and GCS values have the highest mean pitch ranges at 38 Hz and 42 Hz. In S1 TW G3 with GCS at 14 has spoken an average of 84 words which is much lower than G2 with GCS at 12 with 135 words. In S1 WPM G3 with GCS at 14 has spoken an average of 101 words per minute which is lower than G2 with GCS at 12 with 107 words per minute. In S2 TW G3 with GCS at 14 has spoken an average of 84 words which is much lower than G2 with GCS at 12 with 123 words. In S2 WPM G3 with GCS at 14 has spoken an average of 93 words per minute which is lower than G2 with GCS at 12 with 126 words per minute. In COM TW G3 with GCS at 14 has spoken an average of 84 words which is much lower than G2 with GCS at 12 with 133 words. In COM WPM G3 with GCS at 14 has spoken an average of 97 words per minute which is lower than G2 with GCS at 12 with 110 words per minute. In TIME, G2 with GCS at 12 has taken an average of 64 seconds to complete the stories which is higher than G1 with GCS at 11, at 63 seconds. On an average, we notice that G2 has performed better than G3 in S1 TW, S1 WPM, S2 TW, S2 WPM and COM TW, COM WPM. G2 has also outperformed G4 in COM TW.

We shall now take a look at the four groups in the male RHD participants, divided according to their GCS scores, graphically, displayed below. The first figure displays G1 with GCS at 11 and the participants who are in that category. The next three figures are for the next three consecutive groups. The last figure compares the averages of the four groups. While the first four figures are responsible for intra group comparison of the participants, the last figure gives us an inter group comparison.

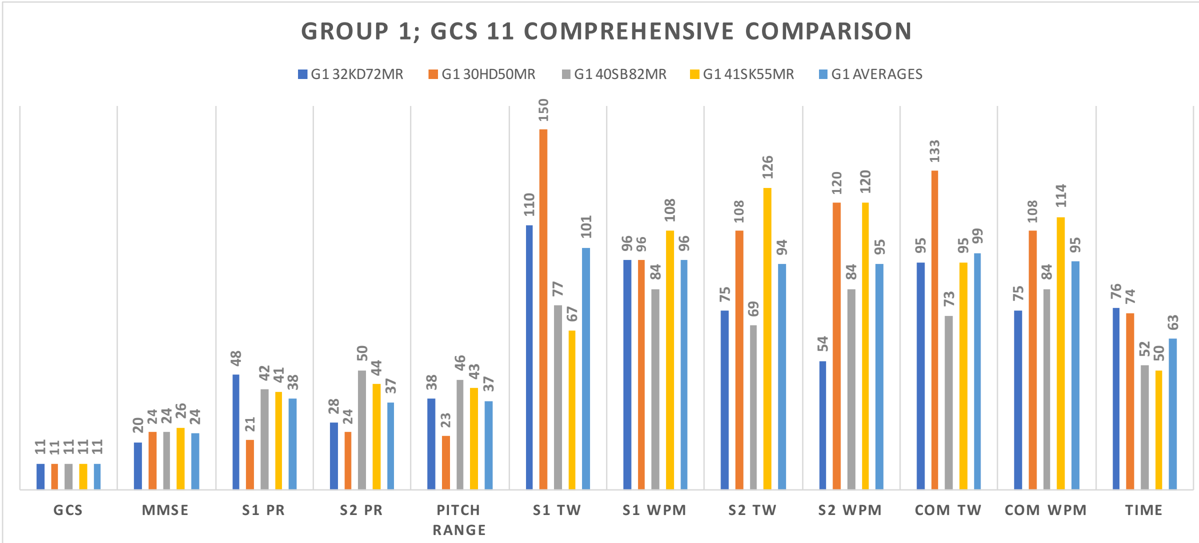


Fig 4.45: Bar graph comparing male participants in G1 with GCS 11

All of the 5 participants in G1 have GCS at 11. 32KD72MR has the lowest MMSE score at 20 but the rest of the participants have an MMSE score of 24 – 26. In S1 PR, the participants have a pitch range of 41 to 48 Hz except for 30HD50MR, who has a range of 21 Hz. In S2 PR, the participants have a pitch range of 44 to 50 Hz except for 30HD50MR, who has a range of 24 Hz and 32KD72MR who has a range of 28 Hz (even if he had a range of 48 Hz in S1 PR). In the mean, Pitch Range, we find a range of 38 Hz- 46 Hz while 30HD50MR has a pitch range of 23 Hz, which is consistently low. Under S1 TW, we find that in spite of having a low Pitch Range, 30HD50MR has the highest total words. In S1 TW, the lowest numbers belong to 40SB82MR and 41SK55MR. In S1 WPM 41SK55MR has the highest at 108 wpm, while others are in the range of 84 – 96 wpm. 30HD50MR seems like a case in which the participant has been speaking in a very low pitch range, since before the stroke hence his pitch range is low, and that seems like the reason that his fluency levels are better than average.

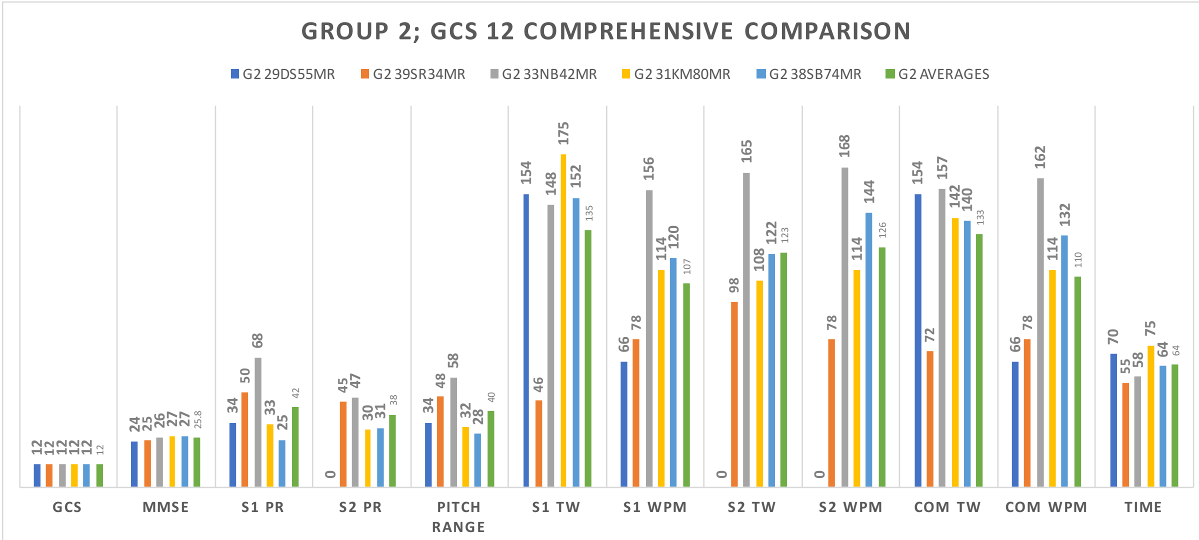


Fig 4.46: Bar graph comparing male participants in G2 with GCS 12

All of the 5 participants in G2 have GCS at 12. 29DS55MR has the lowest MMSE score at 24 and the participants have an MMSE score of 24 – 27. In S1 PR, 38SB74MR has a range of 25 Hz, the lowest. In the mean, Pitch Range, 38SB74MR has a pitch range of 23 Hz, which is consistently low. Under S1 TW, we find that in spite of having a high Pitch Range, 39SR34MR has the lowest total words at 46 words. 29DS55MR displays a sudden drop in total words from story 1 to story 2.

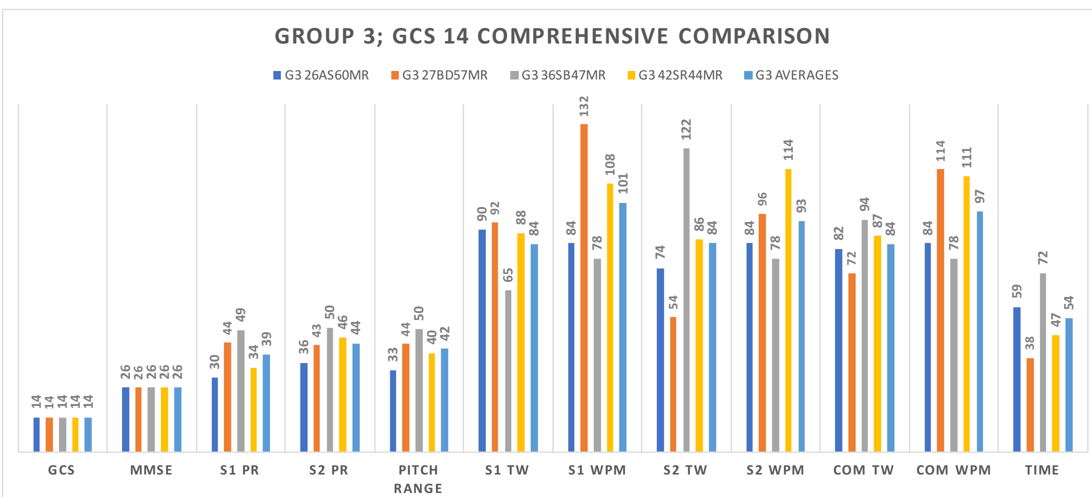


Fig 4.47: Bar graph comparing male participants in G3 with GCS 14

All of the 5 participants in G3 have GCS at 14. All the participants identify with a singular MMSE score, which is 26. Under S1 TW, we find that in spite of having a high Pitch Range, 36SB47MR has the lowest total words at 65 words. took 38 seconds, which is the lowest.

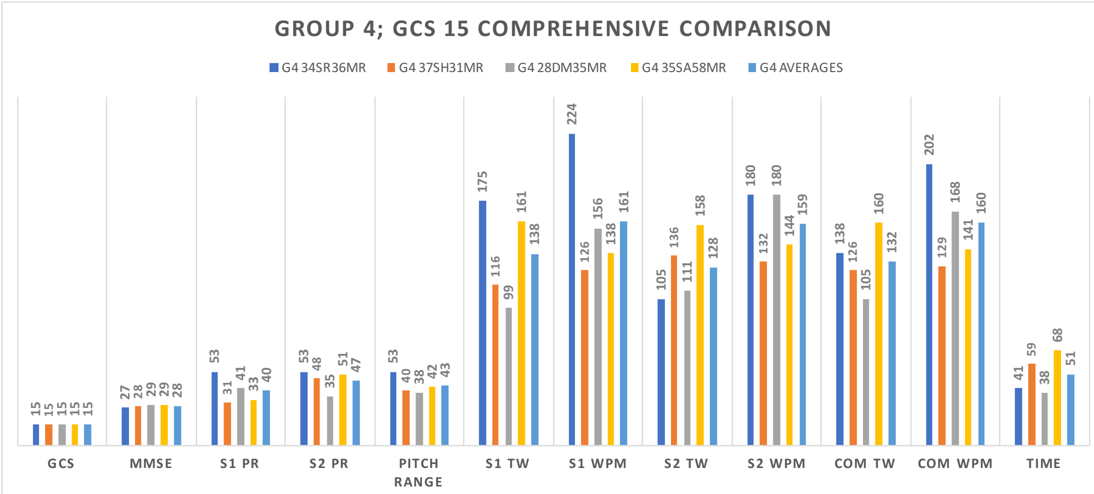


Fig 4.48: Bar graph comparing male participants in G4 with GCS 15

All of the 5 participants in G3 have GCS at 15, which is a perfect score. The participants have MMSE scores in the range of 27 - 29. In S1 PR, 37SH31MR has a range of 31 Hz. In S1 WPM 34SR36MR has the highest at 224 wpm, which is the highest in the present research, while others are in the range of 126 – 156 wpm. 35SA58MR took 68 seconds, which is the maximum while 28DM35MR took 38 seconds, which is the lowest.

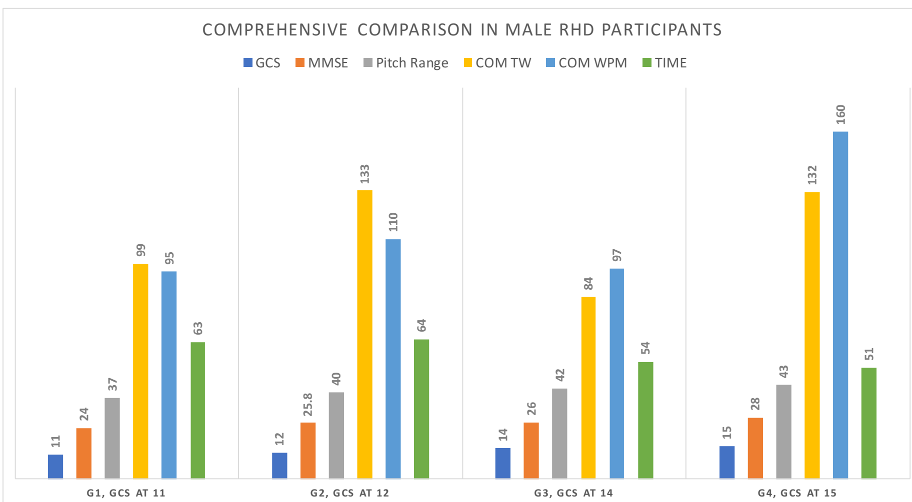


Fig 4.49: The bar graph above comprehensively compares the 4 groups of male RHD participants, made on the basis of common GCS scores.

We can discern the following from fig 4.49: G1 has a GCS score of 11 and an MMSC score of 24. G2 has a GCS score of 12 and an MMSE score of 25.8. G3 has a GCS score of 14 and a MMSE score of 26. G4 has a GCS score of 28 and an MMSE score of 28. From GCS at 11 to GCS at 15, the pitch ranges in discourse have subsequently gone up, following the GCS scores of the groups. The COM TW in G3 is lower than G2 but we must remember that a person can speak lesser than another person and still convey the same message faster. COM WPM in G1 and G3 are almost similar and G2 has a higher wpm than G3 but notice that G3 has taken 10 seconds lesser than G2 and that is a definite sign of improvement.

We can see a gradient in the average scores correlating to the GCS and MMSE scores of the participants.

The next chapter gives us an overview of the present research and then lists down the main findings of the present research. It also lists down the limitations of the present research as well as the future projections which might stem from the present research.

5. SUMMARY AND CONCLUSION

The present research on 'Pitch Variations in Bangla Speaking Cases of Right Hemisphere Damage (RHD)' studied right hemisphere damaged Bengali participants and compared them to age and gender matched normal controls. This study discerned the variations in pitch, as in fundamental frequency at the level of sentences, at the level of words and at the level of discourse. This is a neurolinguistic and empirical study. This was not a longitudinal study but a cross sectional one.

The previous chapter 'Analysis and Discussions' compared all the variables studied in the present research in the RHD group with the control group. In chapter 3, 'Case Studies' we compared every RHD participant with an individual age and gender matched control but in chapter 4, we have taken the means of all the RHD participants (males and females seperately) and compared them to the means of the control group. This enabled us to take a bird's eye view into the performance and severity of all the RHD participants. We also included the GCS and MMSE scores of the participants and compared them to the way the participants performed with the other variables. The GCS and MMSE scores provided us further insight into the performance of the participants.

The present chapter has been divided into two sections. The first part of this chapter will precisely summarize all the chapters in the present research. The latter part will summarize the conclusions reached after studying the participants, in chapter 4.

5.1. THE STUDY : AN OVERVIEW

The first chapter began by introducing the topic of the present research 'Pitch Variations in Bangla Speaking Cases of RHD' to the readers and explained how it studies pitch variations at three levels of communication, namely, discourse, sentence and vowels. It also explains how the right hemisphere of the brain is responsible for primarily controlling the contralateral functions of the left hemisphere. It also gives us our personalities, makes us unique and novel and different from each other. The right hemisphere of the brain is also responsible for helping us comprehend the theme of situations, in particular, of discourses. It helps in understanding what is being spoken about, so that we can speak relevant things. The right hemisphere further helps with understanding metaphors and imageries. The right hemisphere is responsible for giving us the sense of perception and when it is damaged the subjects affected can lose the sence of perception. Left side of the body neglect is very common among subjects with right hemisphere damage. The right hemisphere helps use recognise tones in voices as well as other para-linguistic cues in voice which help us understand conversations better. The right hemisphere also gives us the ability to use the frequency modulations, we do, in normal conversations to express various para-linguistic messages along with normal speech. (Springer, Deutsch, 1993, Weisenberg, 1935, Rachel and Crow, 2005, Metcalfe, Funnell and Gazzaniga, 1995, Moor, 1982, Robinson, Kubos, Starr, Rao, Price, 1984, Vallar, Perani, 1986, Bihrlea, Brownell, Powelsona and Gardnerc, 1986, Ozonoff, Miller, 1996, Gordon, Hewer, Wade, 1987, Narang, 2009). The next section dives into the journey of how the study of the human brain began with Marc Dax and how the torch was handed over to Paul Broca, Wernicke and so on. It also studies how cerebral dominance and leading hemisphere as concepts eveolved and how we have come to know the brain today, with scientifif discoveries making it much more clearer. Concepts like aphasia and its types, dysarthria have also been discussed in detail in this section. Further stroke and its types have been discussed. The chapter then discusses RHD in details and mentions what previous literature says about how RHD affects communication at the level of discourse, sentence and vowels. We have also touched upon emotion and prosody. We finally arrive at the research scopes and objectives as well as the research questions; reiterated from the first chapter, below.

RESEARCH QUESTIONS

1. How does RHD affect the use of pitch in verbal communication and fluency?
2. How does RHD affect the use of pitch at the level of segments (primarily vowels), at the level of words and sentences?
3. How does RHD affect pitch at the level of discourse in connected speech?

OBJECTIVES OF THE PRESENT RESEARCH

At the level of vowels, as in words, the recordings would include all the vowels of the Bangla language, so that the formant 1 and formant 2 can be used to find out the acoustic spaces of vowels and the vowel durations. Three types of sentences would be recorded in the present study, namely, declarative, imperative and interrogatives. At least two samples of each kind would be recorded thrice. At the level of discourse, the pitch range (maximum f0 - minimum f0), mean and Standard Deviation would be found out, to check the effect of RHD.

The second chapter helped the research progress by getting the methodologies to be used for the present reearch, ready. It started off by introducing various kinds of general research methodologies existing, like the inductive and deductive methods; the empirical and rational research approaches; the qualitative and quantitative research approaches and the cross sectional and longitudinal research approaches. It then speaks about the paradigm shift from empirical to rational approach and then introduces us to working with human participants, the hurdles and the formalities associated with them. In the same context, section 2.3.4 describes the ethical clearance procedure in details. Section 2.2 deals in research methods which are associated with general linguistics, phonetics, syntax, socio and field linguistics, applied, clinical, cognitive and neuro linguistics. Section 2.2.3 sums up all the research methodologies which can be used for the present research (from the previously mentioned methods and methodologies) and adds methodologies which were previously not mentioned under any heading, but are necessary.

This is followed by section 2.3.3 which lists down the procedural steps taken in the present research, at the level of discourse, sentences and vowels (acoustic spaces).

Section 2.4 onwards deals in the elicitation procedures and steps taken in the present research. It starts by giving us the participant and language selection details and then talks about the primary inclusion and exclusion criteria details. Section 2.4.2.1 introduces the participants in the present research. We studied 4 female RHD participants, 19 male RHD participants, 9 female control participants and 11 male control participants. We also learn about the method of coding the participants, in order to keep their identity confidential in the present research. Further, we took a look at the format in which the case studies in chapter 3 would be presented. The next section 2.4.3 talks about language selection, tools and equipments in the present research. Section 2.4.3.3 details out the actual recording procedure which began from the process of random sampling at Bangur Institute of Neurosciences and then went on to visiting the homes of the participants who signed the ICF forms. Section 2.5 describes the analytical procedures used to stratify the data and use them with statistical tools. It describes in intricate details how Praat has been used to extract the f0, f1, f2 values from sound samples at the levels of discourse, sentence and vowels and how we arrived at the values of the variables we are studying in the present research. The following flowchart best sums up chapter 2.

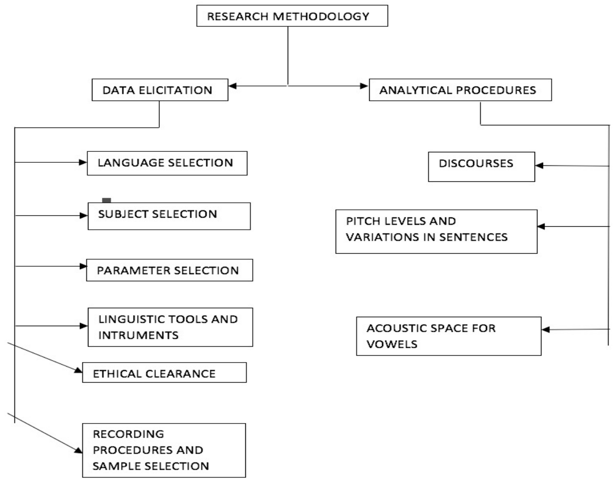


Fig 5.1: A flowchart depicting the research methodology employed in the present research.

The third chapter introduces us to the case study of the participants and the variables which are being studied in the present study. The following flowchart sums up all the variables being studied in the present research.

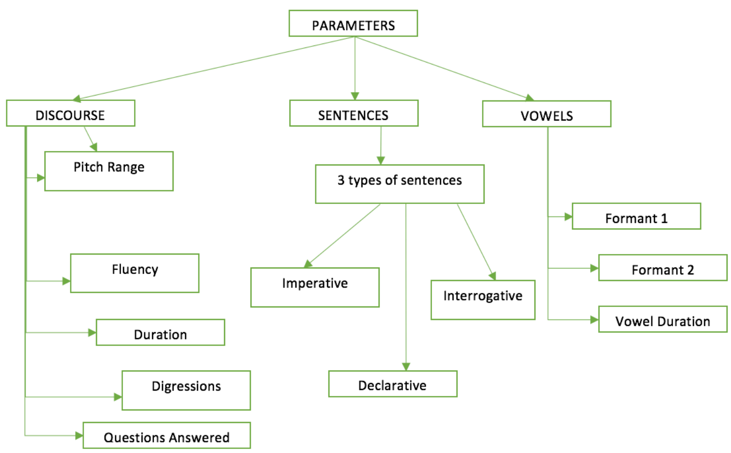


Fig 5.2: A flowchart depicting all the parameters researched in the present study.

Section 3.3 of chapter 3 summarizes the organization of the case studies. The following flowchart summarizes the organization of the case studies.

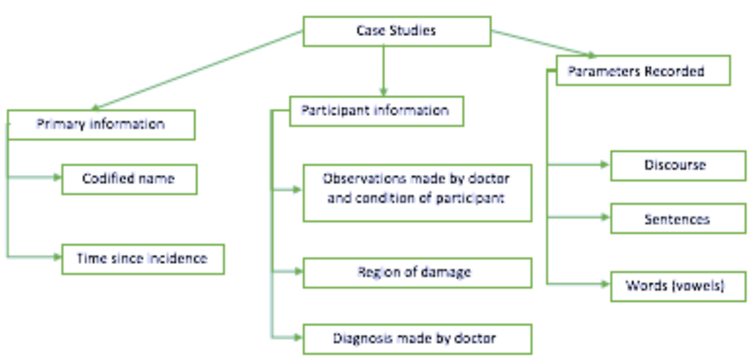


Fig 5.3: A flowchart depicting the organization of individual case studies.

9 female control group participants and 12 male control group participants were first compared to the mean of the male and female control groups respectively in order for us to have ready information to compare the RHD participants to, when we started dealing with them. After this 23 case studies, 4 female RHD participants and 19 male RHD participants were discussed in details and compared individually to age and gender matched controls. Each case study started by providing primary information about the participants and went on describing all the doctors described their condition. Each case study is divided into 3 parts grossly. The first part on discourse compares the individual RHD participants with age and gender matched control on the basis of pitch range, fluency, duration, digressions and questions answered. The next part on sentences compared the RHD participants with the controls on the basis of pitch variations in sentences and 4 types of sentence curves. The third section on vowels compared RHD participants with controls on the basis of vowel space diagrams and acoustic space area, as well as vowel durations.

The **fourth chapter** summarizes the case studies, previously discussed in details in the third chapter. The following means were looked into:

At the level of discourse: In the male and female RHD group - **Pitch Variation**, **Fluency** (words per minute), **Duration**, **Thematic Digressions**, **Questions Answered**. **At the level of sentences:** Pitch variations in the 9 sentences from male and female RHD participants. **At the level of words:** the formant values of vowels in words, the vowel durations in words, recorded from female RHD participants, in comparison with female control participants.

Section 4.2 displays the research questions and then we revisit the research questions along with the data from the present research. The three research questions have been revisited along with data based examples from the present research. The first question discussed how RHD affects pitch range in discourse and fluency levels. The second question discusses how RHD affects pitch variation at the level of sentences for the RHD participants and how RHD affects the vowel spaces in individuals. The third and the final question looks into if RHD might cause digressions. This question also helps us create a table, which sums up the RHD participants in order of their severity under each of the variables being studies in the present research, as well as their GCS and MMSE scores. We shall sum up each parameter studied in the present research, in details in the section following named **Conclusion**. It is worth reminding the reader here that the present research only focusses on pitch variations at the level of discourse, sentences and vowels in words; and fluency at the level of discourse. Other parameters studied in the present research were only to add to a clearer understanding of the main parameters being studied.

5.2. THE MAIN FINDINGS

The previous section gave us a brief overview of the present research and we took a look at all the chapters in brief. In this section, we shall summarize the findings of all the major parameters being studied in the present research, along with the parameters, which help us understand the major parameters better. Since, we have already discussed all the case studies in details in the third chapter, along with the means of all the major parameters in the fourth chapter along with making a comprehensive review of all the major variables in the previous chapter, we shall stick to concise and short conclusions reached in each major parameter. We shall study the following parameters:

1.2.1. At the level of discourse: Pitch Variation**.** Fluency – Total words, Words per minute, Mean of the total time taken to narrate the two stories. Thematic Digressions**.** Questions Answered

1.2.2. At the level of sentences: Pitch variations in the 9 sentences, recorded from 4 female RHD participants and from 18 male RHD participants

1.2.3. At the level of vowels in words: Vowel spaces**.** Vowel Durations.

DISCOURSE

PITCH RANGE

FEMALE PARTICIPANTS

The female RHD group has a mean pitch variation of 30 Hz in the first story in comparison with the female control group, with a mean of 61 Hz. There is a difference of 29 Hz. The female RHD group has a mean pitch variation of 33 Hz in the first story in comparison with the female control group, with a mean of 57 Hz. There is a difference of 24 Hz, which is significant. The female RHD group has a mean pitch variation of 31 Hz in the mean of both the stories in comparison with the female control group, with a mean of 59 Hz. There is a difference of 28 Hz, which is significant. The female RHD participants have a much smaller pitch range in discourse, in comparison with the female control group participants. 22CS62FR displays minimum pitch range in both the stories at 15 Hz and 17 Hz and is the most severe case noted, under pitch variations. 23GD65FR, who has better performance than 22CS62FR in the severity scale has a pitch range of 29 Hz and 26 Hz. 24NB50FR has a pitch range of 32 Hz and 43 Hz, which is much nearer to the pitch range of the control group. 25UG58FR is the least severe case study and has a pitch range of 43 Hz and 45 Hz. What we have found here, also pertain to the overall comprehensive comparisons index tables (table 4.20 to 4.22). 22CS62FR has the lowest GCS and MMSE scores while 25UG58FR has the maximum MMSE and GCS scores.

MALE PARTICIPANTS

The male RHD group has a mean pitch variation of 40 Hz in the first story in comparison with the female control group, with a mean of 53 Hz. There is a difference of 13 Hz. It is a significant difference considering the number of participants being calculated in the mean. The male RHD group has a mean pitch variation of 39 Hz in the first story in comparison with the male control group, with a mean of 55 Hz. There is a difference of 16 Hz, which is significant, considering the number of participants being calculated in the mean. The male RHD group has a mean pitch variation of 39 Hz in the mean of both the stories in comparison with the female control group, with a mean of 54 Hz. There is a difference of 15 Hz and it is significant. The male RHD participants have a smaller pitch range in discourse, in comparison with the male control group participants. Starting with 37SH31MR, who has a pitch range of 40 Hz, every participant has a pitch range, which is more than the mean of the RHD group. Participants like 39SR34MR, 36SB47MR, 34SR36MR and 33NB42MR have close to control group mean pitch range, which would also mean that they would have communication capabilities, which are very similar to that of the control group. We have noticed monotonous speech in participants like 22CS62FR and 30HD50MR due to diminished pitch range in their speech. 22CS62FR, 25UG58FR, 26AS60MR and 30HD50MR were noticed to display very less emotions while speaking. It was difficult to understand whether they were happy or sad, angry or frustrated or any other emotion otherwise. Other participants like 24NB50FR, 33NB42MR, 34SR36MR, 39SR34MR and 36SB47MR were found to converse naturally and there were no problems in understanding their speech or emotions or expressions whatsoever.

FLUENCY

FEMALE PARTICIPANTS

59MEANFR has 95 words in story 1 in comparison with 57MEANFC who has 156 words and the NARRATOR who has 182 words. 59MEANFR has a fluency rate of 119 wpm in story 1 in comparison with 57MEANFC who has a fluency rate of 141 wpm. 59MEANFR has 85 words in story 2 in comparison with 57MEANFC who has 138 words and the NARRATOR who has

157 words. 59MEANFR has a fluency rate of 128 wpm in story 1 in comparison with 57MEANFC who has a fluency rate of 137 wpm. 59MEANFR has a combined mean of 90 words for the combined mean of both the stories with a fluency rate of 123 wpm and took 50 seconds to complete the stories. In comparison, 57MEANFC has 148 words and took 64 seconds and has a fluency rate of 139, whereas, the NARRATOR has 174 words and took 63 seconds and has a fluency rate of 166 wpm. The female RHD group took the least amount of time to speak the least amount of words, in comparison with the other two means. The RHD group has a fluency figure, which is close to that of the control group mean but, the RHD group has spoken for much lower amount of time, in comparison with the control group and hence much lower number of total words, even if they have a good fluency rate. 22CS62FR with 98 words in story 1 and 81 words in story 2, is the participant with the minimum number of total words and spoke for a time of almost 85 seconds on an average for both the stories. 24NB50FR, the participant who seems to be the least severe, has 104 words in story 1 and 106 words in story 2 and took 39 seconds.

MALE PARTICIPANTS

60MEANMR has 116 words in story 1 in comparison with 58MEANMC who has 142 words and the NARRATOR who has 182 words. 60MEANMR has a fluency rate of 116 wpm in story 1 in comparison with 58MEANMC who has a fluency rate of 124 wpm. 60MEANMR has 101 words in story 2 in comparison with 58MEANMC who has 141 words and the NARRATOR who has 157 words. 60MEANMR has a fluency rate of 111 wpm in story 1 in comparison with 58MEANMC who has a fluency rate of 127 wpm. 60MEANMR has a combined mean of 113 words for the combined mean of both the stories with a fluency rate of 115 wpm and took 58 seconds to complete the stories. In comparison, 58MEANMC has 142 words and took 68 seconds and has a fluency rate of 125, whereas, the NARRATOR has 174 words and took 63 seconds and has a fluency rate of 166 wpm. The male RHD group took the least amount of time to speak the least amount of words, in comparison with the other two means. The RHD group has a fluency figure, which is close to that of the control group mean but, the RHD group has spoken for much lower amount of time, in comparison with the control group and hence much lower number of total words, even if they have a good fluency rate. The male RHD participant with the minimum number of total words was 27BD57MR and 39SR34MR with 72 total words in the combined mean; whereas the maximum number of total words was spoken by

35SA58MR with 160 words. The difference between the minimum and maximum is massive. In comparison with the actual number of words which was 174, both fall short, but 35SA58MR comes pretty close. The male with the minimum fluency rate was 32KD72MR with 75 wpm and the maximum was 34SR36MR with 202 wpm, which is abnormally high. The control group has a fluency figure of 139 wpm and this means that 34SR36MR has a fluency rate which is more than the control group but lesser than the NARRATOR at 166 wpm. Below is a table which arranges the participants in order of their severity. The participant with the minimum number of total words has been placed at the top, and the participant with the maximum number of words has been placed at the bottom.

THEMATIC DIGRESSIONS

FEMALE PARTICIPANTS

The female RHD participants made 1.3 digressions in the first story, in comparison with the female control group, with 0.4 digressions. The female RHD participants made 1.3 digressions in the second story, in comparison with the female control group, with 0.3 digressions. The female RHD participants made 1.3 digressions in the mean of both the stories, in comparison with the female control group, with 0.4 digressions. We can notice that the RHD group participants had way more digressions in their story recordings, in comparison with the control group participants. This can be attributed to the fact that RHD causes the affected to sometimes have thematic digressions while speaking.

MALE PARTICIPANTS

The male RHD participants made 3 digressions in the first story, in comparison with the male control group, with 0 digressions. The male RHD participants made 2 digressions in the second story, in comparison with the male control group, with 0 digressions. The male RHD participants made 2.7 digressions in the mean of both the stories, in comparison with the male control group, with 0.3 digressions. We can notice that the RHD group participants had way more digressions in their story recordings, in comparison with the control group participants. This can be attributed to the fact that RHD causes the affected to sometimes have thematic digressions while speaking.

QUESTIONS ANSWERED

FEMALE PARTICIPANTS

The female RHD group participants could answer all 5 questions in the first story, in comparison with the female control group participants, who answered 4.8 questions. The female RHD group participants could answer 4 questions in the second story, in comparison with the female control group participants, who answered 4.9 questions. The female RHD group participants could answer 4.4 questions in the mean of the two stories, in comparison with the female control group participants, who answered 4.8 questions. Here we can notice that the RHD group answered almost the same number of questions, as the control group participants.

MALE PARTICIPANTS

The male RHD group participants could answer all 5 questions in the first story, in comparison with the male control group participants, who also answered 5 questions. The male RHD group participants could answer 4 questions in the second story, in comparison with the male control group participants, who answered 5 questions. The male RHD group participants could answer 4.7 questions in the mean of the two stories, in comparison with the male control group participants, who answered 5 questions. Here we can notice that the RHD group answered almost the same number of questions, as the control group participants.

5.1.1. SENTENCES

FEMALE PARTICIPANTS

DECLARATIVE SENTENCES (Refer to figure 4.12)

Sentence 1 (marked in dashed blue) in the female RHD group is a type B sentence, while sentence 1 (marked in blue) in the female control group is a type C sentence. Every RHD participant has a type C sentence except 23GD65FR, who has a type B curve. Sentence 2 (marked in dashed grey) in the female RHD group is a type D sentence, while sentence 2 (marked in grey) in the female control group is also a type D sentence. We find one exception in the second sentence by 25UG58FR who has produced a type B sentence. Sentence 3 (marked in dashed orange) in the female RHD group is a type C sentence, while sentence 3 (marked in orange) in the female control group is a type C sentence (but with a much steeper gradient. There is a lot of pitch difference between its pitch points). 22CS62FR, has a type A sentence and 25UG58 has a type B sentence. We notice a much steeper gradient in the curves of the control group mean in the three sentences individually, as well as the individual sentences showing much less range in the articulation of the sentences of the RHD participants.

IMPERATIVE SENTENCES (Refer to figure 4.13)

Sentence 4 (marked in dashed blue) in the female RHD group is a type D sentence, while sentence 4 (marked in blue) in the female control group is also a type D sentence. The pitch difference between the pitch points are much more than in the RHD participant. We found one exception in the sentence 22CS62FR who has a type C curve. Sentence 5 (marked in dashed grey) in the female RHD group is a type D sentence, while sentence 5 (marked in grey) in the female control group is also a type D sentence. The pitch difference between the pitch points are much more than in the RHD participant. Every RHD participant has a type C sentence except 23GD65FR, and the mean of the RHD group also has a type D curve but there are two exceptions in found in 24NB50FR and 25UG58FR, who have both displayed type A sentences. Sentence 6 (marked in dashed orange) in the female RHD group is a type C sentence, while sentence 6 (marked in orange) in the female control group is also a type C sentence. We found one exception in the sentence 25UG58FR who has a type B curve. It is worth noticing that all the control group curves are high above in the pitch range while the RHD curves lack proper contoured curves, which in turn translates to lesser pitch range in the sentences.

INTERROGATIVE SENTENCES (Refer to figure 4.14)

Sentence 7 (marked in dashed blue) in the female RHD group is a type C sentence, while sentence 7 (marked in blue) in the female control group is a type B sentence. 22CS62FR and 24NB50FR have type D curves while, 23GD65FR has a type C curve. 25UG58FR is the only participant who has a type B curve but the curve is so flat, i.e., it lacks pitch range and looks like a flat curve. Sentence 8 (marked in dashed grey) in the female RHD group is a type D sentence, while sentence 8 (marked in grey) in the female control group is a type B sentence. The pitch difference between the pitch points are much more than in the RHD participant. 22CS62FR has a type C curve, while 23GD65FR has a type A curve and 24NB50FR and 25UG58FR have type D curves. Sentence 9 (marked in dashed orange) in the female RHD group is a type D sentence, while sentence 9 (marked in orange) in the female control group is also a type D sentence (but with a much steeper gradient. There is a lot of pitch difference between its pitch points). We find only one exception in 23GD65FR who has a type A curve. It should be noted here, again, that the control group curves have much more contour and pitch range in their sentences in comparison with their RHD group counterparts, which lack pitch range and are located in the lower part of the graph, proving that they operate at a lower pitch point as well have much lesser pitch range in their sentences.

MALE PARTICIPANTS

DECLARATIVE SENTENCES (Refer to figure 4.15)

Sentence 1 (marked in dashed blue) in the male RHD group is a type C sentence, while sentence 1 (marked in blue) in the male control group is a type C sentence. Exceptions include 35SA58MR and 27BD57MR who have type A curves and 30HD50MR and 44ZS64MR, who have type B curves. Sentence 2 (marked in dashed grey) in the male RHD group is a type D sentence, while sentence 2 (marked in grey) in the male control group is also a type D sentence. Exceptions include 29DS55MR who has a type C curve, 27BD57MR who has a type A curve, 33NB42MR who has a type A curve, 40SB82MR who has a type A curve and 30HD50MR who has a type B curve. Sentence 3 (marked in dashed orange) in the male RHD group is a type B sentence, while sentence 3 (marked in orange) in the male control group is a type B sentence. Exceptions include 29DS55MR, 31SH31MR, 42SR44MR, 39SR34MR, 40SB82MR, 32KD72MR and 43SK55MR with type C curves, 35SA58MR, 41SK55MR and 26AS60MR with type D curves.

IMPERATIVE SENTENCES (Refer to figure 4.16)

Sentence 4 (marked in dashed blue) in the male RHD group is a type D sentence, while sentence 4 (marked in blue) in the male control group is a type D sentence. Exceptions include 44ZS64MR with a type C curve and 33NB42MR with a type A curve. Sentence 5 (marked in dashed grey) in the male RHD group is a type D sentence, while sentence 5 (marked in grey) in the male control group is also a type D sentence. Exceptions include 37SH31MR, 35SA58MR and 27BD57MR with type A curves. Sentence 6 (marked in dashed orange) in the male RHD group is a type C sentence, while sentence 6 (marked in orange) in the male control group is a type C sentence. Exceptions include 29DS55MR, 31KM80MR and 35SA58MR with type D curves, 27BD57MR with a type B curve. Here, again, we must notice that the RHD group curves exist under the control group curves graphically, proving that they have lesser pitch range in the respective sentences.

INTERROGATIVE SENTENCES (Refer to figure 4.17)

Sentence 7 (marked in dashed blue) in the male RHD group is a type D sentence, while sentence 7 (marked in blue) in the male control group is a type D sentence. Exceptions include 36SB47MR, 33NB42MR, 43SK55MR and 30HD50MR with type C curves, 27BD57MR with a type B curve and 39SR34MR with type A curve. Sentence 8 (marked in dashed grey) in the male RHD group is a type D sentence, while sentence 8 (marked in grey) in the male control group is also a type D sentence It is surprising to notice here, that the control group has a much flatter curve than the RHD group. Exceptions to the RHD group include 27BD57MR with a type B curve, 40SB82MR with a type A curve and 39SR34MR and 26AS60MR with type C curves. Sentence 9 (marked in dashed orange) in the male RHD group is a type D sentence, while sentence 9 (marked in orange) in the male control group is a type D sentence. Here, the control group has a much higher operating pitch range in the sentences. The RHD group mean curve is located under the control group curve, meaning lesser pitch range. Exceptions include 27BD57MR with a type A curve and 43SK55MR with a type C curve.

5.1.2. VOWELS IN WORDS

FEMALE PARTICIPANTS

ACOUSTIC SPACE OF VOWELS

The vowel /i/ (f1=-404, f2-f1=-2181) in 53MEANFR is almost at the same place as vowel /i/ (f1=-355, f2-f1=-2200) in 55MEANFC. The vowel /e/ (f1=-433, f2-f1=-1946) in 53MEANFR is more backed and a bit lower than vowel /e/ (f1=-458, f2-f1=-1887) in 55MEANFC. The vowel /æ/ (f1=-767, f2-f1=-945) in 53MEANFR is almost at the same place as vowel /æ/ (f1=-822, f2-f1=-1158) in 55MEANFC. The vowel /ɑ/ (f1=-831, f2-f1=-683) in 53MEANFR is slightly fronted and lower in comparison with vowel /ɑ/ (f1=-887, f2-f1=-745) in 55MEANFC. The vowel /ɔ/ (f1=-711, f2-f1=-532) in 53MEANFR is slightly fronted and higher, in comparison with vowel /ɔ/ (f1=-749, f2-f1=-464) in 55MEANFC. The vowel /o/ (f1=-457, f2-f1=-514) in 53MEANFR is slightly lower and fronted in comparison with vowel /o/ (f1=-476, f2-f1=-613) in 55MEANFC. The vowel /u/ (f1=-403, f2-f1=-485) in 53MEANFR is a slightly higher and fronted in comparison with vowel /u/ (f1=-365, f2-f1=-487) in 55MEANFC. The area of the acoustic space chart for 53MEANFR is 363352.5 and for 54MEANFC is 521601.5. The area of 56MEANMR is 30% smaller than that of 55MEANFC. The female RHD group is only **71%** of the control acoustic space. We can also discern that the high low capabilities of the RHD group are lower than the control group. But we found multiple instances of exceptions like 24NB50FR who has a vowel space 30.8% smaller than the control mean vowel space and 25UG58FR who has a vowel chart 37.5% bigger than the control vowel chart. The female RHD group has decreased high/low capabilities but the front/back capabilities of the female RHD group seems almost similar to that of the female control group.

VOWEL DURATIONS

The RHD group took 0.183 seconds to articulate the vowel /i/ in comparison with the control group, who took 0.104 seconds. The RHD group took 0.083 seconds to articulate the vowel /e/ in comparison with the control group, who took 0.056 seconds. The RHD group took 0.103 seconds to articulate the vowel /æ/ in comparison with the control group, who took 0.076 seconds. The RHD group took 0.073 seconds to articulate the vowel /ɑ/ in comparison with the control group, who took 0.063 seconds. The RHD group took 0.107 seconds to articulate the vowel /ɔ/ in comparison with the control group, who took 0.091 seconds. The RHD group took 0.058 seconds to articulate the vowel /o/ in comparison with the control group, who took 0.059 seconds. The RHD group took 0.068 seconds to articulate the vowel /u/ in comparison with the control group, who took 0.071 seconds. Except for vowels /o/ and /u/ the RHD group took more time to articulate the vowels, in comparison with the control group. Vowel /i/ in the RHD group has the longest duration.

MALE PARTICIPANTS

ACOUSTIC SPACE OF VOWELS

The vowel /i/ (f1=-329, f2-f1=-1909) in 56MEANMR is almost at the same place as vowel /i/ (f1=-335, f2-f1=-1880) in 54MEANMC. The vowel /e/ (f1=-423, f2-f1=-1517) in 56MEANMR is more backed and a bit lower than vowel /e/ (f1=-408, f2-f1=-1617) in 54MEANMC. The vowel /æ/ (f1=-683, f2-f1=-1102) in 56MEANMR is almost at the same place as vowel /æ/ (f1=-676, f2-f1=-1080) in 54MEANMC. The vowel /ɑ/ (f1=-769, f2-f1=-622) in 56MEANMR is slightly fronted and lower in comparison with vowel /ɑ/ (f1=-749, f2-f1=-591) in 54MEANMC. The vowel /ɔ/ (f1=-579, f2-f1=-427) in 56MEANMR is slightly fronted and higher, in comparison with vowel /ɔ/ (f1=-618, f2-f1=-391) in 54MEANMC. The vowel /o/ (f1=-452, f2-f1=-582) in 56MEANMR is slightly lower and fronted in comparison with vowel /o/ (f1=-432, f2-f1=-554) in 54MEANMC. The vowel /u/ (f1=-347, f2-f1=-481) in

56MEANMR is a slightly higher and fronted in comparison with vowel /u/ (f1=-357, f2-f1=-472) in 54MEANMC. The area of the acoustic space chart for 56MEANMR is 334580 and for 54MEANMC is 342454.5. The area of 56MEANMR is 3% smaller than that of 54MEANMC. We have participants like 34SR36MR with an area 74.1% larger than the control chart and 40SB82MR with an area 54.2% larger than the control vowel space area. But in all fairness, we also need to name the cases which had acoustic space areas much lower than that of the control mean. 30HD50MR has a vowel space 38.5% smaller than the control vowel space. 32KD72MR has an area which is 31.9% smaller than the control mean-vowel space. Rest of the participants have vowel spaces which are plus or minus 10% area of the control mean vowel space. We can discern from the vowel space graph above that the low/high, front/back capabilities of the male RHD group seems almost similar to that of the male control group, in spite of case studies who have much smaller vowel spaces, in terms of area and high/low, front/back capabilities.

VOWEL DURATIONS

The RHD group took 0.096 seconds to articulate the vowel /i/ in comparison with the control group, who took 0.096 seconds. The RHD group took 0.070 seconds to articulate the vowel /e/ in comparison with the control group, who took 0.071 seconds. The RHD group took 0.172 seconds to articulate the vowel /æ/ in comparison with the control group, who took 0.106 seconds. The RHD group took 0.102 seconds to articulate the vowel /ɑ/ in comparison with the control group, who took 0.058 seconds. The RHD group took 0.097 seconds to articulate the vowel /ɔ/ in comparison with the control group, who took 0.088 seconds. The RHD group took 0.056 seconds to articulate the vowel /o/ in comparison with the control group, who took 0.057 seconds. The RHD group took 0.059 seconds to articulate the vowel /u/ in comparison with the control group, who took 0.066 seconds. Vowel /æ/ in the RHD group has the longest duration.

5.3.LIMITATIONS OF THE PRESENT RESEARCH

Although we could reach some good results during the present research, we also came across a few limitations for the present study:

1. The number of male and female participants could not be controlled because of the fact that the field work was conducted at a hospital and the RHD participants had to be studied as received from the hospital. In short, because of the huge disparity in the number of male and female participants, we could not compare the male participants with the female participants.

2. The present study is a cross sectional study and a cross sectional study needs more number of participants than is studied in the present research. This is because of the damage type of the participants chosen in the present research, which makes it harder to find such patients with the exact damage, which is right hemisphere damaged stroke patients. We also needed more time and more cases from other hospitals.
3. We had no time for a longitudinal study which would in turn reward us with the knowledge of how much a participant gets better with time, therapy and support after a stroke both with formal communication skill training and without.
4. We also have no data on how the participants would have performed in any of these speech tests, used in the present research, before they suffered a stroke. Because we do not have data from them prior to stroke, we have to depend on control data instead of the participants' longitudinal data. There is also no way to know if they speech and communication habits of an individual has changed after suffering a stroke because of the same reason. A person might have developed a specific habit of speaking and display a reticent nature even before suffering a stroke. We have no way to separate such habits from the effects of RHD in such participants, without individual data about their speech from before they suffered a stroke.
5. At the level of discourse, we have very little data. Basically, this is a study strictly on pitch and production of vowels. This is a study on speech rather than on language. At the level of discourse, sentence and vowels in words the major feature studied were pitch, pitch range and fluency, along with a few other variables like thematic digressions and questions answered at the level of discourse. We had structured tests for pitch, pitch variations and fluency but we had no planned and structured tests for thematic digressions. The tests were not planned, so as to reveal thematic digressions but to make it easier to elicit data on pitch and pitch range.
6. It is not possible to conduct a full-fledged discourse analysis for linguistic nuances. The focus of the present research was on speech output, rather than on language. We also made observations on parameters like thematic digressions and questions answered at the level of discourse but the present study is not a structured study on the same.
7. Although we were looking primarily for monolingual Bangla participants, but it is difficult to find monolingual speakers. It is hard to find pure monolinguals. In most cases monolinguals are passive bilinguals because of their exposure to the various forms of media and technology. Most of the participants studied here were workers, tenants, farmers or

laborers. They were noticed to be code mixing and code switching freely, as well as using loan words from other languages in contact, including some English loan words.

5.4. FUTURE PROJECTIONS

After a look at the limitations for the present research, we can take a look at the future projections stemming from the present research:

1. The same study can be repeated with a parity in the number of male and female participants, as well as a much higher number of participants, which might require us to study participants from more than one hospital.
2. In further studies, language should also be focused on, along with speech. One should also do a full-fledged discourse analysis and thematic digression study, along with the other variables studied here.
3. One can also study the morpho-syntactic variations at the level of sentences as well as digressions made, if any, at the level of sentences. This was not possible here.
4. There were no standardized tools, procedures and equipment in the present study to elicit data on language, as well as longitudinal data of the participants. Developing new tools to study the speech and language of bilingual individuals should be a primary priority.
5. The same study can be repeated on bilinguals with a much more structured approach to study bilinguals and with input from the results from the present study. In that case the effect of RHD on both monolinguals and bilinguals can be studied.

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APPENDIX

THE ETHICAL CLEARANCE FROM IERB, JNU.

INSTITUTIONAL ETHICS REVIEW BOARD
Jawaharlal Nehru University
New Delhi-110067

Name of the Ethics Committee: IERB-JNU IERB Ref. No.2014/Student/56

Title of the Project Proposal: "Language and Speech of the RHD"

Principal Investigator: Mr. Agniva Pal c/o Prof. Vaishna Narang(Supervisor &PI)
Centre for Linguistics/SLL&CS/JNU

Sponser: NA

Telephone: Email: agniva.jnu@gmail.com

Collaborators' Name:

FOR OFFICIAL USE

The proposal was reviewed in a meeting held on 23rd September, 2014 at 4:30 PM.
The following members were present:

1. Professor Shiv K. Sarin, Chairperson
2. Professor Madhuri Behari, Member
3. Professor Vijay Kumar, Member
4. Professor Ramesh Juyal , Member
5. Professor Ravinder Gargesh , Member
6. Advocate Bulbul Das , Member
7. Advocate Omika Dubey , Member
8. Professor Amita Singh, Member
9. Professor Rajiv Bhat , Member
10. Professor Vaishna Narang, Member Secretary

The committee resolved to

[ ] Approve - indicating that the proposal is approved as submitted;
[ ] Approve – after clarifications – indicating that the proposal is approved if the clarifications Requested are provided to the satisfaction of designated committee members;
[✓] Approve after amendment/s – indicating that the proposal is approved subject to the incorporation of the specified amendments verified by designated committee members;
[ ] Defer – indicating that the proposal is not approved as submitted but it can be reassessed after revision to address the specified reason/s for deferment;
[ ] Disapprove – indicating that the proposal is not approved for the reason specified.

Comments:

RECOMMENDED

Member Secretary,
IERB, Ethics Committee

Date of Approval: 19-11-2014
*(1st part to be filled in by PI and presented at the time of Review (Periodic, Continuing, Interim)).

INFORMED CONSENT FORM

Institutional Ethics Review Board
Jawaharlal Nehru University

(PIS – ICF)

Part I PARTICIPANT INFORMATION SHEET (PIS)

Title of the Project: Pitch Variations in Bangla Speaking Cases of RHD
Investigators: Agniva Pal
Collaborators:
Potential Funding Agency: Self-funded

INFORMED PATIENT/GUARDIAN CONSENT FORM

	Topic	Explained in Detail	Researcher's Comments
1.	Purpose of the Study গবেষনার উদ্দেশ্য	[ ]	RHD participants would be studied to discern the level of deviations at the level of words, as in vowels; at the level of sentences and at the level of discourse. Healthy individuals would be studied for controls. এই গবেষনার উদ্দেশ্য মানুষের প্রাত্যহিক ভাব ও ভাষার আদান-প্রদানে মস্তিষ্কের দক্ষিন গোলার্ধের অনবস্তা বা অসুস্ততার প্রভাব নির্ণয় ।
2.	Study Procedures গবেষনার পদ্ধতি	[ ]	First the signing of the ICF has to be done. Second, case history will be recorded. Language recordings at the level of words, sentences and discourse would be made with the help of the doctor. There are no invasive procedures involved. ১৫ থেকে ২০ মিনিট সাধারণ কথাবার্তা অডিও বা রেকর্ডিং করার পর অংশগ্রহনকারীর অসুবিধা না থাকলে তাঁকে একটা নির্দিষ্ট বাক্যের তালিকা পড়তে দেওয়া হবে, যার পর একটা নির্দিষ্ট শব্দের তালিকা দেওয়া হবে। সব মিলিয়ে মোটামুটি ৩০ মিনিট লাগবে।
3.	Risk of the Study অংশগ্রহনের ঝুঁকি	[ ]	Practically, there are no risks in the study but if the participants suffer any sort of emotional breakdown, they would be given time to recover. It would be best, if they are interviewed on another day. There are no risks to the healthy controls. এই গবেষণায় কোন ঝুঁকি নেই
4.	Benefits from the Study অংশগ্রহনের সুবিধা	[ ]	No monetary benefits shall be presented to any participants, nor would be any schemes or prizes. This research might only be of some therapeutic value from linguistic

			intervention with me. This research will benefit future generations. এই গবেষনার মাধ্যমে পাওয়া ফলাফল এক্ষুনি না দেখা বা বোঝা গেলেও ভবিষ্যতে একটু হলেও সাহায্য হবে| ভবিষ্যত প্রজন্ম উপকৃত হবে আশা করা যায়|
5.	Complications জটিলতা	[ ]	There are no complications in the study. এই গবেষণায় কোনো জটিলতা নেই
6.	Compensations অংশগ্রহনের ক্ষতিপূরণ	[ ]	There are no monetary rewards or incentives involved. এই গবেষণায় অন্গসগ্রহন্কার্তিদের জন্যে কোনো আর্থিক সাহায্য হবে না এবং কোনো আর্থিক পুরস্কার ও দেব হবে না।
7.	Confidentiality অংশগ্রহনের গোপনীয়তা	[ ]	The identity of every participant would be kept confidential under the confidentiality rule of working with human participants. এই গবেষনার অন্গসগ্রহন্কার্তিদের পরিচয়, তথ্য দেওয়ার সময় কোনো ভাবেই কারোর কাছে জানানো হবে না ।
8.	Rights of Participants অংশগ্রহণকারীদের অধিকার	[ ]	The participants can withdraw from the study at any point of time. There is no compulsion whatsoever. অন্গসগ্রহন্কার্তিরা যেকোনো সময় গবেষণা ছেড়ে যেতে পারে, যার ফলে তার চিকিত্সাতে কোনো রকমের ব্যাঘাত হবে না ।
9.	Alternatives to Participation in the Study অংশগ্রহনের বিকল্প	[ ]	None না।
10.	Others	[ ]	

PART II INFORMED CONSENT FORM

Title of Project: Pitch Variations in Bangla Speaking Cases of RHD
Investigators: Agniva Pal

Brief Description of Study

The present research is working with participant with damage to the Right Hemisphere of the brain, which can cause deviations at the level of words, as in vowels, at the level of sentences and at the level of discourse, in individuals. The right hemisphere of the brain is responsible for a significant part of human communication, namely, the ability to understand the theme of a discourse and holding on to it, the fundamental frequency or pitch and the actual pronunciation of the vowels they use. This research involves an audio recording, so that the individuals with RHD can be analyzed for cues of damage in the Right Hemisphere of the brain. This research can provide valuable insight into better ways of understand such disorders. Your participation in this research is entirely voluntary. It is your choice whether to participate or not. Whether you choose to participate or not, all the services you receive at this clinic will continue and nothing will change. You may change your mind later and stop participating even if you agreed earlier. Participants would be given a word list, for vowel recordings and they have to read the words aloud, thrice. Participants would also be given a list of sentences which they would have to read aloud, thrice. The third step involves free conversation with the participant for around 10-15 minutes. The whole process involves the following:

1. Explaining the research (10 mins)
2. The Glasgow Coma Scale test to be given (5 mins)
3. The mini mental state exam would be administered (6 mins)
4. A list of words to be read out aloud. (3 mins)
5. A list of sentences to be read out aloud (4 mins)
6. A discourse with specific reading lists (30 mins)

There will be no direct, visible benefits to you but as we understand today, linguistic interaction can increase neural activity in the patients affected by RHD and the whole process might have therapeutic value. This information being collected can greatly benefit in the domain of research and future generations are likely to benefit from it.

The identities of each individual who takes part in this research will be kept secret with utmost confidentiality. Any sort of language usage which would hint at any specific individual will be also avoided. The data received from the participants would also be anonymized. The information only, will be used for research purposes, being attached to no individual identities.

You do not have to take part in this research if you do not wish to do so and refusing to participate will not affect your treatment at this clinic in any way. You will still have all the benefits that you would otherwise have at this clinic. You may stop participating in the research at any time that you wish without losing any of your rights as a patient here. The whole study would require a maximum of 2 hours. The participants would be approached on a per sitting basis and not more than one hour would be required per sitting, although if the participants want the whole thing to be done in one sitting, that would be entertained.

সংক্ষিপ্ত বিবরণ

এই গবেষণার উদ্দেশ্য মানুষের প্রাত্যহিক পারস্পরিক ভাব ও ভাষার আদান-প্রদান মস্তিষ্কের দক্ষিণ গোলার্ধের অনবস্তা বা অসুস্থতার প্রভাব নির্ণয়। গবেষণার জন্য সেই ব্যক্তিদের সাক্ষাৎকার প্রয়োজন যাঁরা মস্তিষ্কের দক্ষিণ গোলার্ধে কোনো রকম আঘাত পেয়েছেন বা শারীরিক অসুস্থতার জন্য তাঁদের মস্তিষ্কের এই অংশে আঘাত হয়েছে। অন্যমটি সাপেক্ষে সাক্ষাৎকারের সময় তাঁদের শ্রাব্য মাধ্যমে নথিবন্ধ করা হবে। প্রথম এ একটি শব্দের তালিকা তিন বার পড়ার পর একটি বাক্যের তালিকা পড়ার জন্য দেয়া হবে। এর পর অনুমতি থাকলে ১০-১৫ মিনিট কথোপকথন করা হবে যা নথিবন্ধ হবে।

এই গবেষণায় যাঁরা অংশগ্রহণ করবেন তাঁদের পরিচয় গোপন থাকবে এবং কোনো অবস্থাতেই এমন কোনো ইঙ্গিতও করা হবে না যাতে তাদের পরিচয় প্রকাশ এর সম্ভাবনা থাকে। এই গবেষণায় কোনো অংশগ্রহণকারীর কোনো ঝুঁকির ও সম্ভবনা নেই।

এই গবেষণা প্রত্যক্ষভাবে দক্ষিণ গোলার্ধের অনাবস্থা বা অসুস্থতার কোনো আশু প্রতিকারের ব্যবস্থা এই মুহূর্তে দিতে অক্ষম হলেও গবেষণালব্ধ তথ্য ভবিষ্যতে এই অসুস্থতার প্রতিকারে সামান্য হলেও সাহায্য করবে এবং ভবিষ্যত প্রজন্ম উপকৃত হবে এই আশা করা যায়।

দক্ষিণ গোলার্ধের অনাবস্থা বা অসুস্থতা যুক্ত কোনো ব্যক্তি সাক্ষরে অক্ষম হলে তাঁর বাঁ হাতের বৃদ্ধাঙ্গুলির ছাপ সম্মতি নেয়া হবে। যিনি এর কোনোটিতেই সক্ষম হবেন না তাঁর ক্ষেষেন আইনি অভিভাবকদের অনুমতি সূচক স্বাক্ষর নেয়া হবে।

অংশগ্রহণকারী গবেষণায় সময় প্রত্যাহার করতে পারেন এবং এর ফলে চিকিত্সা কেন্দ্রের সহায়তা ও চিকিত্সার পরিবর্তন হবে না অর্থাৎ তাঁর কোনো ক্ষতি হবে না।

CONSENT FORM

The advantages and disadvantages of the research in which I am expected to participate, for which my speech or language will be recorded, been explained to me.
I willingly, under no pressure from the researcher-

(i) agree to take part in this research, and agree to participate in all investigations which will help acquire knowledge for the benefit of the mankind,
(ii) agree to let the researcher record my language and speech.
(iii) My consent is explicitly not for disclosing my personal identity.
(iv) I understand that I can withdraw from the study at any point of time.

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Participant/patient Witness Principle Investigator
Date…………………………………………

সম্মতি পত্র

এই গবেষণায় অংশগ্রহণ এর সুবিধা, অসুবিধা এবং ঝুঁকি সম্মন্ধে আমাকে / আমাদের সম্যকভাবে অবহিত করা হয়েছে | গবেষকের তরফে কোনো বাধ্য-বাধকতার ছাড়া আমি স্বেচ্ছায় জানাচ্ছি যে

১) গবেষকে গবেষণায় সমস্ত ক্ষেষেন যথাসাধ্য সাহায্য করবো যাতে এই গবেষণালব্ধ তথ্য ভবিষ্যতে মানুষের প্রয়োজনে সাহায্য করতে পারে।

২) গবেষণার পদ্ধতি ও পরিস্থিতি অনুযায়ী শ্রাব্য মাধ্যমে আমার সাথে সাক্ষাৎকার ও পরীক্ষা নথিবদ্ধ করতে দেব।

৩) গবেষণালব্ধ তথ্যের সাথে আমার পরিচয় কোনোভাবেই প্রকাশ করা যাবে না।

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অংশগ্রহণকারী সাক্ষী প্রধান গবেষক
তারিখ ………………………

Research Participant/ Parent/ Guardian/ Legal Guardian Consent
গবেষণা অংশগ্রহণকারী/ মা বাবা/ অভিভাবক/ আইনত অভিভাবক সম্মতি

INVESTIGATOR'S STATEMENT:

I, the undersigned have explained to the parent/guardian in a language she/he understands the procedures to be followed in the study and risks and benefits.

Name of the Participant অংশগ্রহনকারীর নাম		Sign :
Name of the Parent/Guardian অভিভাবক / অভিভাবিকার নাম		Sign :
Relationship to Participant সম্পর্ক		Sign :
Name of Investigator গবেষকের নাম	**Agniva Pal**	Sign :
Name of the Witness সাক্ষীর নাম		Sign :

CONTACT DETAIL:

Details of Principle Investigator:	Agniva Pal
Address :	Room Number 331E, Brahmaputra Hostel, JNU, New Delhi. (Hostel) Amaralaya, 197, Gorosthan Road, Chinsurah, Hooghly- 712101, West Bengal. (Residence)
Mobile Number :	09871845958
Details of Researcher / Student :	Researcher. Centre for Linguistics, JNU.
Mobile Number :	09871845958