LATERALITY IN CHILDREN WITH AND WITHOUT STUTTERING

Deepika D

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CERTIFICATE

This is to certify that this dissertation entitled "**Laterality in children with and without stuttering**" is a bonafide work submitted in part fulfillment for the Degree of Master of Science (Speech Language Pathology) of the student (Registration No.: 12SLP007). The study has been carried out under the guidance of a faculty of this institute and has not been submitted earlier to any of the University for the award of any Diploma or Degree.

Dr. S. R. Savithri
Director

Mysore

May, 2014

All India Institute of Speech and Hearing
Manasagangothri, Mysore -570 006

CERTIFICATE

This is to certify that this dissertation entitled "**Laterality in children with and without stuttering**" has been prepared under my supervision and guidance. It is also certified that this has not been submitted earlier in other University for the award of Diploma or Degree.

Mysore

May, 2014

Dr. Y.V.Geetha
Guide

Professor of Speech Language Sciences
All India Institute of Speech and Hearing
Manasagangothri, Mysore - 570 006

DECLARATION

This is to certify that this dissertation entitled "**Laterality in children with and without stuttering**" is the result of my own study under the guidance of Dr.Y.V.Geetha., ProfessorofSpeech Language Sciences, Department of Speech Language Sciences, All India Institute of Speech and Hearing, Mysore, and has not been submitted earlier in other University for the award of Diploma or Degree.

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Dedicated to never ending inspiration of my life, my first teacher, my "amma"

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CHAPTER 1

INTRODUCTION

The speech and language functions have their representations in both the hemispheres with left hemisphere being dominant for these functions in majority of the normal individuals. Both right and left hemispheres are highly coordinated with bilateral neuro-motor control for speech production at each speech sub-system level, including respiratory, phonatory, articulatory and resonatory systems. However, dominance of one hemisphere over the other for various integrated functions is very essential for the production of fluent speech. If there is any disturbance or problems in these highly coordinated activities, there can be breakdown in the speech production, including the finest aspect of it, the speech fluency. Stuttering or stammering is one such disorder of speech fluency.

Many research findings have shown that, persons with stuttering (PWS) have bilateral speech and language representations, resulting in lack of hemispheric dominance (or equal dominance), leading to incoordination between the hemispheres, which results in stuttering. In few persons with stuttering, it has alos been reported that they have reversed dominance (right hemisphere dominance) for speech and language functions.

Many theories have been put forth by various researchers to explain the cause of stuttering. Few theories of stuttering explain that children are predisposed to stutter due to conflict between the two halves of the cerebrum for control of the

activity of the speech organs. In the 1920s, reports suggested that individuals who stutter are more likely to be left-handed or ambidextrous than those without stuttering and the onset of stuttering had occurred in conjunction with attempts to change their handedness in some way (Bloodstein, 1993). The theory which offers this account of the etiology of stuttering or onset of stuttering is 'Cerebral Dominance theory' proposed by Orton and Travis in 1927.

The Cerebral Dominance theory is well known as 'handedness theory' or 'Orton-Travis theory of Cerebral Dominance'. Based on the concept of left hemisphere dominance for language and speech, Orton proposed the "Cerebral Dominance" theory which states that because the muscles of the speech mechanism receive nerve impulses from both the left and right hemispheres of the brain, one hemisphere should be dominant over the other in order for the speech to be properly synchronized. If one hemisphere is not dominant, both will function independently and the actions of two halves of speech musculature would be poorly synchronized**,** leading to stuttering.

Rosenfield and Goodglass (1980) studied dichotic listening in individuals with stuttering and controls using dichotic presentations of CVs (consonant-vowel) and melodies on two occasions. The right ear advantages were obtained for CVs and left ear advantages for melodies, without significant differences between groups. However, a significantly greater number of individuals with stuttering than controls consistently failed to show the expected ear laterality for either type of material.

Cimorell, Gilbert and Frick (1983) compared dichotic speech perception between children with and without stuttering. 90 right-handed boys, 30 in each age group of 5, 7, and 9 years [Half in each group were children with stuttering (CWS) and half children with no stuttering (CWNS)] underwent a stop consonant-vowel dichotic listening task. Two and a half times as many CWS as those without were found to display either a left-ear advantage (LEA) or no ear advantage (NEA). This finding suggested a greater tendency on the part of CWS, as opposed to CWNS, for reversed or bilateral representation of the auditory speech areas of the brain.

Brosch, Haege, Kalehne and Johannsen, (1999) did a prospective study considering 79 children with stuttering (CWS) aged 3–9 years with a control group of 18 children of kindergarten age, to investigate the relationship between hearing and central processing of acoustic stimuli, cerebral dominance and the clinical course of the stuttering. The subjects were tested for their cerebral dominance by administering various tests of laterality, their peripheral hearing and their ability to discriminate sound using the dichotic discrimination test. No significant results were found for peripheral hearing and dichotic discrimination test in relation to stuttering. But, it was found that left handed children had a significantly poorer chance of attaining speech fluency, when relationship between handedness and stuttering was investigated. The handedness appeared to be related to the probability that stuttering will become chronic.

Szaflarski, Binder, Possing, McKiernan, Ward and Hammeke (2002) studied language lateralization in left-handed and ambidextrous people using fMRI (functional Magentic Resonance Imaging) data. The language distribution in 50

healthy, non-right-handed subjects was evaluated based on the relationships between personal handedness, family history of sinistrality, and a language laterality index (LI) measured with fMRI. The incidence of atypical language lateralization in normal left-handed and ambidextrous subjects was higher than in normal right-handed subjects (22% vs 4-6%). The associations that were observed between personal handedness & LI and family history of handedness & LI may indicate a common genetic factor underlying the inheritance of handedness and language lateralization.

Cerebral (hemispheric) dominance/language lateralization in stuttering, have been studied using various techniques, since the time cerebral dominance theory was proposed. The techniques such as testing for laterality (hand, eye), dichotic listening tests, Wada test, functional magnetic resonance imaging (fMRI), Positron emission tomography (PET), Event related potentials (ERPs) and Cerebral blood flow are being used mostly.

1.1 Need for the study

Many recent studies using various methods have provided support to the lack or inadequate cerebral laterality or dominance associated with stuttering. Recent neuro-imaging studies have re-emphasized the right hemisphere laterality/mixed dominance in significant proportion of children and adults with stuttering. Further, pre and post therapy comparisons of imaging findings have given support to the change in laterality status (from mixed or right dominance to left dominance) in significant number of individuals who demonstrated therapeutic benefits.

In the recent past, studies have used either only the invasive techniques or the combination of both invasive and non-invasive techniques to investigate the hemispheric dominance in persons with stuttering. The invasive techniques are expensive and not easily feasible and have certain amount of difficulty during interpretation of the results. Hence, there is need for using the non-invasive techniques that are easy to administer & interpret and to identify the hemispheric dominance in children with and without stuttering.

The present study tries to use non-invasive methods to study hemispheric dominance in children with stuttering and to compare the findings with normal control group.

1.2 Aim

The aim of the study was to understand the hemispheric dominance through laterality measures in children with and without stuttering.

1.3 Objectives

The main objectives of the study:

a) To investigate, if children with stuttering differ in the lateralization for hand, ear, eye and foot compared to children without stuttering

b) To investigate, if there are ear laterality differences in children with and without stuttering based on Dichotic Consonant Vowel (CV) test scores

CHAPTER 2

REVIEW OF THE LITERATURE

Stuttering is a developmental speech disorder that usually appears between 3 and 8 years of age and often remits before puberty. When it persists beyond the period of developmental plasticity, around puberty, it becomes a chronic adult speech disorder throughout the life span (Andrews, Craig, Feyer, Hoddinott, Howie, & Neilson, 1983). Stuttering has been investigated for centuries and yet, it remains a puzzle in understanding its nature, etiology, onset, development, recovery and management issues.

2.1 Definitions of stuttering

According to Wingate (1964), stuttering has been defined as "disruption in the fluency of verbal expression; characterized by involuntary, audible or silent pauses, repetition or prolongations in the utterance of short speech elements, namely: sounds, syllables, and words of one syllables, and words of one syllable; usually occur frequently or are marked in character; not readily controllable; disruptions are accompanied by accessory activities involving the speech apparatus, related or unrelated body structures, or stereotyped speech utterances. These activities give the appearance of being speech related struggle, indications of the presence of an emotional state, ranging from a general condition of excitement or tension to fear, embarrassment or irritation, immediate source of stuttering is some in-coordination expressed in the peripheral speech mechanism".

According to WHO (1977) stuttering is a “disorder in the rhythm of speech in which the individual knows precisely what he wishes to say, but at the time is unable to say it because of an involuntary, repetitive prolongation or cessation of a sound”.

Peters and Guitar (1991), defined stuttering as a “disorder of neuro-motor control of speech, influenced by the interactive process of language production, and intensified by complex language process”. This definition incorporates the physiological capacities of the speaker as well as the adaptive learning that take place.

The stuttering foundation of America (1997), defined stuttering as a communication disorder characterized by excessive involuntary disruption in the smooth and rhythmic flow of speech, particularly when such disruptions consist of repetition or prolongation of a syllable and when they are accompanied by emotions such as fear and anxiety and behaviors such as avoidance and struggle.

The above definitions highlight the nature of understanding about stuttering, where authors try to focus on different aspects of the problem in terms of etiology, characteristics and mostly from the listeners’ perspective. The standard definition of stuttering by Wingate is more a description of characteristic feature & etiology and runs to half a page, indicating the complexity of its nature.

2.2 Incidence and prevalence of stuttering

Mansson (2000) did a pilot study on the incidence and development of early childhood stuttering. A survey of the entire population of children born within a 2-

year span was done in Danish island of Bornholm. Their findings revealed that there was a increase in the level of stuttering to 5.19%. After the original survey within two years, around 71.40% of the children stopped stuttering, and rest of the children stopped stuttering during later period.

Yairi and Ambrose (2013) did a review on epidemiological advances in stuttering. The review was organized in six sections: onset, incidence, prevalence, developmental paths, genetics and subtypes. They concluded that: by age 5 most of the risk for stuttering onset is over; the lifespan incidence of stuttering in the general population may be higher than the 5%; the average prevalence over the lifespan may be lower than the commonly held 1%; the effects of race, ethnicity, culture, bilingualism, and socioeconomic status on the incidence/prevalence of stuttering remain uncertain; longitudinal, as well as incidence and prevalence studies support high levels of natural recovery from stuttering. They have also given results pertaining to the genetic background for stuttering onset.

2.3 Characteristics features of stuttering

The three components of stuttering are: core behaviors, secondary behaviors and feelings and attitudes towards stuttering. The three core behaviors are repetitions, prolongations and blocks. Each of these three categories comprise of subgroups of disfluencies.

The primary stuttering behaviors are the overt, observable signs of speech fluency breakdown, which includes repeating sounds, syllables, words or phrases, silent blocks and prolongation of sounds. These differ from the normal disfluencies

i.e., stuttering disfluencies may last longer, occur more frequently, and are produced with more effort.

The severity of a stuttering is often not constant, even for people who have severe stuttering. There is an increased fluency in speech, while talking in unison with another speaker, whispering, when talking to pets, young children, or themselves. Other situations, such as public speaking and speaking on the telephone, are often greatly feared by people who stutter, and increased stuttering is reported.

2.4 Onset and development of stuttering

The onset occurs mainly at the beginning of speech development, or in early childhood, or between 5 and 8 years of age i.e., it often begins when a child enters a period of intense language development. The onset of stuttering depends upon developmental factors, the demands of speech and language, precipitating factors and increased complexity of language.

Stuttering behaviours often *change and develop* over time. The development of stuttering is heterogeneous and non-linear in nature; it can be grouped to form developmental trends. These developmental courses have been broken down or classified into stages/phases/tracks. Few such common classifications systems are: Bluemel's (1913, 1932) "primary" and "secondary" stuttering, Froeshel's (1964) tonic and clonic stuttering, Van Riper's (1973) 4 tracks of development of stuttering, Conture's (1991) four patterns of stuttering development (alpha, beta, gamma and delta) and Bloodstien's (1995) four phases of development. These classifications highlight on the development of different aspects of stuttering characteristics on a

long term basis except for VanRiper's developmental tracks which propose 4 different tracks in which stuttering could develop.

2.5 Causative factors of stuttering

No single, exclusive cause of developmental stuttering is known, but multiple factors are reported to lead to stuttering. Among these, strong evidence has been provided for that stuttering having genetic basis. The children who have first-degree relatives who stutter are three times as likely to develop a stuttering whereas twin and adoption studies suggest that genetic factors interact with environmental factors for stuttering to occur, and many people who stutter have no family history of the disorder. The stuttering is more common in children who also have concomitant speech, language, learning or motor difficulties. For some people who stutter, congenital factors such as physical trauma at or around birth, as well as cerebral palsy and intellectual disability play a major role. An impact due to stressful situations such as the birth of a sibling, moving or relocating, or a linguistic load also leads to stuttering (Demands and capacity model). Auditory processing deficits have also been proposed as a cause of stuttering. Hence, it can be said that stuttering does not have specific causative factor, it can be due to combination of multiple causes.

In order to explain causative factors for stuttering many theories have been proposed which mainly explain the onset, development and recovery of stuttering; causative factors; moments of stuttering and management principles.

2.6 Theories of stuttering

Bloodstein (1973) tried to group theories as belonging to 3 types: “theories of the etiology of stuttering” that offer an account of the etiology, or “onset of stuttering”; “theories of the moment of stuttering”, that are “concerned with the nature of discrete instances of stuttering behaviors” and “theories that shift the frame of reference”, whose basic contribution lies in “ reformulation of a previous theory, either of the etiology or of the moment of stuttering, in terms of a new frame of reference”.

The etiology of stuttering is based on breakdown hypothesis, repressed need hypothesis and anticipatory struggle hypothesis. Basically there are three view points in the theories of stuttering: Organic/Physiological theories/Breakdown theories, Functional/Psychological theories and Nature-nurture/Physiological-Psychological/Organic-functional or Combined theories.

Functional/psychological theories include learning theories continuity theory, diagnosogenic theory, anticipatory struggle hypothesis, personality theory and personal construct theory. Organic/physiological/breakdown theories are the theories which are based on breakdown hypothesis (etiology) and represent the stuttering block as a temporary failure in the smooth integrated performance of a complex neuromuscular activity in certain individuals who are emotionally or constitutionally predisposed to such breakdown under conditions of stress. The breakdown theories include- Perseveration theory, Cerebral Dominance Theory, Biochemical theory, Hormonal theory and genetic theories.

More recently combined theories are proposed which highlight the role of both organic and functional basis for stuttering.

The theory that was proposed as one of the oldest and prime theories, which was researched a lot (even currently), and which tried to explain the etiology of stuttering is ***Cerebral dominance theory***.

2.7 Cerebral dominance theory (CDT)

The Cerebral dominance theory is well known as 'handedness theory' or 'Orton-Travis theory of Cerebral Dominance. Initially the theory was proposed by Dr. Samuel. T. Orton, and later it was studied by Prof. Lee Edward Travis extensively. Based on the concept of left hemisphere dominance for language and speech, Orton (1927) proposed the Cerebral Dominance theory which states that because the muscles of the speech mechanism receive nerve impulses from both the left and right hemispheres of the brain, one hemisphere should be dominant over the other, in order for the speech to be properly synchronized. The function of non-dominant hemisphere is to accept the temporal rhythm of innervations established by dominant hemisphere. If one hemisphere is not dominant, both will function independently and the actions of two halves of speech musculature would be poorly synchronized**.** The nervous systems of individuals who stutter are reported to have not matured sufficiently to attain hemispheric dominance. This can be due to hereditary influences, disease, injury or even emotional arousal and fatigue.

According to the Orton- Travis theory, it was this very same side of the cerebrum that was dominant for the purpose of "Motor lead control". This was an

essential element of the theory because it made it possible to explain: the relation between handedness and stuttering; children who were innately ambidextrous were lacking by heredity a safe margin of cerebral dominance and training such left handed children to use their right hand meant reducing this margin of cortical dominance by exercising the minor hemisphere at the expense of the major one. And this also explains that left handed persons might become predisposed to stuttering even when not deliberately shifted because they are subject to so many pressures exhibited by a right handed society to use the right hand. This theory had some obvious implications such as: strict unilaterality should not be forced in all of the PWS's (person with stuttering) activities and if right handed PWS seemed to be natively left sided as determined from case history or by certain types of laterality tests they would need to learn to exercise brain's natural dominance.

The cerebral dominance theory gave impetus to a wide scope of research to establish its role in answering questions pertaining to the etiology and nature of stuttering by different groups of researchers from many different disciplines.

2.8 Methods to study cerebral /hemispheric dominance

A wide range of invasive and non-invasive methodologies have been adopted by researchers to study the cerebral dominance issues and following are some of them.

2.8.1. Invasive methods

Wada test, Positron emission tomography (PET), Cerebral blood flow are some of the invasive methodologies for studying cerebral dominance.

a) WADA test

Wada and Rasmussen (1960) conducted WADA test on 4 persons with stuttering (PWS), which showed transient aphasia regardless of either right or left side injection suggesting a lack of cortical dominance for speech in PWS.

In 1966, Jones reported a study of four adult patients (three males, one female) who had stuttered severely since early childhood and who underwent brain surgery for intracranial pathology unrelated to their speech problem. As a part of surgical procedure, the Wada technique (Wada & Rasmussen, 1960) was used to inject sodium amytol directly into the right carotid artery followed by left carotid artery while the patient was conscious and talking. It was found that all four persons with stuttering (PWS) developed transient aphasia when the drug was injected into either the right or the left carotid artery. This suggests that PWS have bilateral control of speech-that there were speech centers in both hemispheres indicating mixed dominance. When the surgery was done on only one cerebral hemisphere, the stuttering ceased in all 4 patients and did not return over the long period of time. After surgery on repeating the Wada test, it was found that the PWS became aphasic only when the artery serving the non-operated hemisphere was injected. On the basis of these findings, it was concluded that there was a substantial bilateral cortical representation of the speech function in four patients with stuttering before surgery

and that the operation for unrelated lesions transferred the dominant speech influence to one hemisphere only. Further, under dominant control of just one hemisphere speech became normal.

Andrews and others (1972) studied four right hand adult with stuttering with the knowledge from previous studies that persons with stuttering (PWS) have bilateral motor and auditory speech areas. All four participants underwent injection to individual carotid artery, first to the right and then to left carotid artery. Three adult PWS showed left cerebral dominance for speech on the sodium amytal test and one PWS had bilateral cortical speech representation.

b) Positron emission tomography (PET)

PET studies during speech have indicated a failure to show the normal activation of auditory cortical areas in persons with stuttering.

Fox, Ingham, Zamarripa, Xiong and Lancaster (2000) did a study using PET imaging, to see the brain correlates during stuttered productions and syllable productions in 10 right-handed persons with stuttering and 10 right-handed, age- and gender matched non-stuttering controls. 90 PET blood flow images were obtained in each cohort and were computed. The brain correlates of stutter rate and syllable rate showed significant differences in both laterality and sign (i.e., positive or negative correlations). The principal difference between syllable-rate and stutter-rate positive correlates was hemispheric laterality. An exception was that cerebellar positive correlates for syllable rate was seen extensively in stuttering group than in the control group, which suggests a specific role of the cerebellum in enabling fluent utterances

in persons who stutter. The persons with stuttering (PWS) were negatively correlated with right-cerebral regions (superior and middle temporal gyrus) associated with auditory perception and processing, regions which were positively correlated with syllables in both the stuttering and control groups. These findings support long-held theories that the brain correlates of stuttering are the speech-motor regions of the non-dominant (right) cerebral hemisphere, and extend this theory to include the non-dominant (left) cerebellar hemisphere. These findings also indicate a specific role of the cerebellum in the fluent utterances of PWS and support theories that implicate auditory processing problems in stuttering.

De Nil and Kroll (2000) investigated the lateralization and functional distribution of cortical and sub cortical activity involved in single word reading by individuals with and without stuttering using PET scan. 10 right handed male adults with stuttering and matched non-stuttering individuals were instructed to read individually presented single words either silently or out loud. Increased activation in the left anterior cingulate cortex (ACC) was observed during silent reading in the persons with stuttering (PWS) but not in persons with no stuttering (PWNS). The results showed greater activation of left hemisphere in the PWNS, and proportionally greater activation of right hemisphere in the PWS, i.e., adult PWS showed atypical lateralization of language processes**.**

c) Cerebral blood flow studies

Braun, Varga, Stager, Schulz, Selbie and Maisog (1997) assessed dynamic brain function in adults who had stuttered since childhood, measuring regional

cerebral blood flow (rCBF) with H_2O and PET during a series of speech and language tasks designed to evoke or attenuate stuttering. The CBF patterns in subjects with stuttering differed markedly during the formulation and expression of language, showing absence of left hemispheric lateralization typically seen in controls, instead, regional responses were either absent, bilateral or lateralized to the right hemisphere. The activation of right hemispheric regions appeared to be related to the production of stuttered speech, while activation of left hemispheric regions may represent compensatory processes associated with attenuation of stuttering symptoms.

2.8.2 Pre and post therapy related studies

Many studies have found the before and after therapy changes for shift in hemispheric dominance, specifically after therapeutic management of stuttering.

Wood (1980) analyzed 2 subjects (1 male & 1 female adult) using SPECT before and after trial of Haloperidol (used in treatment of motor control disease). The results before treatment revealed severe stuttering and significant differences in cerebral blood flow (right greater than left) in the reading-aloud condition, whereas after treatment there was less severe stuttering and a reversal of comparative cerebral blood flow (left greater than right) for both subjects in the reading-aloud condition.

Sassi, Matasa, Zanotto de Mendonc and Furquim de Andradea (2011) investigated possible effects of behavioral treatment on the pattern of signal amplitude and latency between waves using P300 event-related potentials. In order to compare variations in P300 measurements, a group of PWS (12) and a control group

(12) matched for age and gender, was included in the study. The P300 measurements in PWS and controls presented results within normal limits in all testing situations and no significant statistical variations between pre and post treatment testing was found. When comparing individual results between the testing situations, PWS presented a higher average decrease in wave latency for the right ear following treatment.

Neumann, Euler, Preibisch and Gudenberg (2004) investigated fMRI variations of 9 male persons who stutter after intensive fluency therapy and compared it with the findings of 16 PWNS. Before therapy, distributed and predominantly right-hemispheric over-activations was found in PWS during overt reading, whereas left-sided activations were seen after fluency shaping therapy. After 2 years of therapy withdrawal, the activations again reverted back to right-side. Thus, fluency-inducing techniques might synchronize a disturbed signal transmission between auditory, speech motor planning, and motor areas.

2.8.3 Non – invasive methods

Some of the non-invasive techniques include, testing for laterality (hand/eye/foot), dichotic listening tests, functional magnetic resonance imaging (fMRI), event related potentials (ERPs), and EEG (electroencephalography).

a) Testing for laterality (hand, eye, foot)

Individual hand preference has not been studied extensively in developmental stuttering despite the long standing hypothesis that developmental stuttering may be

associated with atypical cerebral laterality. Atypical hand preference may be a marker of atypical cerebral laterality or atypical brain dominance. There is recent research evidence that individual footedness is also important to study and may help in examining individual laterality Foundas (2003).

The Stuttering Foundation distributed handedness questionnaires in 2003 to over 1000 PWS. In this sample, 56% of the participants reported that they were currently stuttering, and 44% had previously stuttered. In the group with persistent stuttering, the proportion of men to women was 5 to 1, a finding that is consistent with results as reported in the literature. As far as handedness, overall the proportion of right and left handers, defined by writing hand, was similar to that of general population i.e., about 90% of the participants were right-handed and 10% were left-handed.

Based on responses derived from the questionnaire, individuals could be grouped as consistently right-handed, mixed (right or left-handed) and consistently left-handed. The study found an interaction of handedness and gender that is, the women with developmental stuttering were more mixed in handedness compared to the men with stuttering, who were more left-handed. The responses to the footedness questionnaire did not show any group differences.

Greiner, Fitzgerald and Cooke (1986) study supported the hypothesis that disorganization in the integration of left- and right-hemisphere inhibitory and excitatory processes may be an integral component of stuttering. They studied left and right handed persons with stuttering (PWS) and persons with no stuttering

(PWNS) on bimanual writing of digits and letters. The right-handed PWS performed more poorly with their non-dominant hand on bimanual writing of digits and letters and also made more non-dominant hand mirror reversals than did PWNS. Left-handed PWS and PWNS differed only in the incidence of mirror reversals with the non dominant hand.

Strub and Black (1987) studied two left-handed siblings with developmental stuttering comprehensively including speech and language evaluation, neurological and neuropsychological examinations, dichotic listening, auditory evoked responses, electroencephalogram, and CT scan asymmetry measurements. The CT scan measurements showed atypical asymmetries in both siblings, especially in the occipital regions. These findings supported the theory that stuttering may be related to anomalous cerebral dominance (functionally and structurally).

Webster (1988) compared the performance of left- and right-handed male and female PWS with fluent speakers on a bimanual handwriting task. On each trial four words were read to the subjects and were made to repeat them and write the initial letters as quickly as possible using the two hands simultaneously and without visual guidance. As a group, PWS (both males & females) were slower, made more mirror-reversed letters (indicating reversed dominance), and formed letters of poorer quality than fluent speakers.

Webster (1988) also compared the performance of right- and left-handed male and female PWS with that of PWNS on a bimanual coordination task that involved tapping a key twice with one hand for each single tap of a key by the other hand. The

right-handed PWNS performed this 2:1 tapping better when it was the right hand that tapped twice (R2/L1 condition) rather than the left hand (L2 / R1 condition). The left-handed PWNS and right-handed PWS showed similar performance for R2/ L1 and L2/R1 conditions. The left-handed PWS showed asymmetrical performance on both conditions. This indicates that individuals with stuttering have anomalous inter-hemispheric connections.

Szelq, Herman and Stasiekl (1993) studied cerebral lateralization in visual perception in individuals between the age of 14 and 16 years. The subjects included were 9 with severe stuttering, 11 with mild stuttering and 48 fluent speakers. The subjects were asked to identify 3 letter nouns presented in the left or right visual field of a fixation point for 20 ms, by pointing to the exposed test word on a response card which contained four different words. The errors committed in both visual fields were analyzed. The data showed left hemisphere superiority in the processing of words in both persons with mild stuttering and the fluent speakers, but a right hemisphere advantage in the persons with severe stuttering. The results suggest a close relationship between the severity of stuttering and functional brain organization.

There are a few studies exploring the distribution of right, left and ambidexterity in handedness of children and adults with stuttering which show equivocal results. Although handedness is one obvious inference of cerebral laterality, there are also concepts of footedness, eye laterality and ear laterality. There are many studies pertaining to ear preference or dominance and other audiological

findings in individuals with stuttering but studies on eye preference and footedness are scanty. The findings on these laterality measures are mixed and inconclusive.

b) Dichotic listening tests

Curry and Gregory (1969) administered dichotic listening test on persons with stuttering and results showed 75% of the PWNS demonstrated a right ear advantage (REA), whereas 55% of the participants who stuttered demonstrated an left ear advantage (LEA).

Brady and Berson (1975) studied PWS based on the hypothesis that they have incomplete cerebral lateralization or reversed lateralization of speech function, or both. The participants were right-sided PWS (35) and right-sided PWNS (35), who underwent a dichotic listening task. An assumption of the procedure was that right-ear preference indicates left-cerebral dominance for speech. It was found that 6 PWS and PWNS showed a reversal, i.e., a left-ear preference. But as a group, the remaining PWS showed no such reversal and other PWNS showed right-ear preference. This study suggested that a subset of PWS may have an anomaly in the lateralization of speech functions i.e., they have incomplete cerebral lateralization or reversed lateralization of speech functions.

Foundas, Corey, and Hurley (2004) divided 18 adults who stutter into three subgroups: 10 right-handed men, 4 right-handed women, and 4 left handed men (but no left-handed women). The 28 controls were divided on the same laterality basis. All received dichotic presentation of consonant-vowel stimuli in three attention conditions: non directed attention, attention directed right, and attention directed left.

From previous findings, controls and right-handed men who stutter had the expected right-ear advantage (REA) in the non directed attention condition whereas left-handed men who stutter had a left ear advantage (LEA). The right-handed women who stutter did not have a lateral ear advantage in the same condition and were relatively unable to selectively shift left–right attention. The left-handed men who stutter were able to make such shifts better than any other group. It was concluded that left-handed men and right-handed women who stutter have atypical auditory processing and, in this respect, differing from right-handed men who stutter.

Gauri (2004) investigated the perception of musical rhythm and ear preference in PWS, with the hypothesis that stuttering is a disorder of rhythm and can be attributed to lack of or reversed cerebral dominance. Two groups of subjects participated in the experiment. Group 1 with10 adult PWS and Group 2 with10 adult non musician normal individuals in the age range of 18-30 years. The rhythm structures selected were four ta:las from catusra, tisra, misra and khanda. The melodies were hummed by a trained singer which was stored in computer memory. The subjects were presented with the ta:las in monaural condition and in dichotic condition. They were instructed to tap the ta:la perceived by them which were recorded and analyzed. The data was analyzed to find out the rhythm to which tapping pattern resembled and ear advantage if any in the perception of various rhythmic structures. The results indicated that the identification of rhythm was different in PWS compared to normal individuals and that there was right hemisphere dominance or mixed laterality in PWS.

c) Functional magnetic resonance imaging (fMRI)

Many studies have shown differences in linguistic processing between PWS and PWNS. Brain scans of adult people who stutter have found increased activation of the right hemisphere, which is associated with emotions, than in the left hemisphere, which is associated with speech.

Szaflarski, Rajagopal, Altaye, Byars, Jacola, Schmithorst, Schapiro, Plante and Holland (2012) studied handedness and language lateralization in children. This fMRI study investigated the development of language lateralization in 81 left-handed and right handed children between 5 and 18 years of age. Left-hemispheric language lateralization was found to increase with age in both groups but somewhat different lateralization trajectories were observed in girls when compared to boys. The incidence of atypical language lateralization in left-handed children in this study was similar to that of adults. They also found similar rates of increase in left-hemispheric language lateralization with age between groups (i.e., independent of handedness) indicating the presence of similar mechanisms for language lateralization in left- and right-handed children.

d) ERPs (Event related potentials)

A study was done by Christine, Amanda and Heyley (2013) on stuttering and electrophysiological indices of language processing in early childhood. They examined neural activity mediating semantic and syntactic processing in 27 preschool-age children who stutter (CWS) and 27 preschool-age children who do not stutter (CWNS) matched for age, nonverbal IQ and language abilities. All participants displayed language abilities and nonverbal IQ within the normal range. Event-related

brain potentials (ERPs) were elicited while participants watched a cartoon video and heard naturally spoken sentences that were either correct or contained semantic or syntactic (phrase structure) violations. ERPs in CWS, compared to CWNS, were characterized by longer N400 peak latencies elicited by semantic processing. In the CWS, syntactic violations elicited greater negative amplitudes for the early time window (150–350 ms) over medial sites compared to CWNS. Additionally, the amplitude of the P600 elicited by syntactic violations relative to control words was significant over the left hemisphere for the CWNS but showed the reverse pattern in CWS, a robust effect only over the right hemisphere. Both groups of preschool age children demonstrated marked and differential effects for neural processes elicited by semantic and phrase structure violations; however, a significant proportion of young CWS exhibited differences in the neural functions mediating language processing compared to CWNS despite normal language abilities. These results are the first to show that differences in event-related brain potentials reflecting language processing occur as early as the preschool years in CWS and provide the first evidence that atypical lateralization of hemispheric speech/language functions previously observed in the brains of adults who stutter begin to emerge near the onset of developmental stuttering.

e) EEG studies

Moore and Haynes (1980) examined alpha hemispheric asymmetries of normal males & females and male PWS using electroencephalographic (EEG) techniques during exposure to connected speech and connected nonlinguistic stimuli. All subjects were selected based on family history of right handedness. The PWS showed

significantly less alpha in their right hemispheres for both verbal and nonverbal tasks in opposition to normal individuals.

Hence, from the above discussed invasive and non-invasive studies, it can be inferred that individuals with stuttering either have atypical (reversed/left hemisphere) dominance (lateralization) or lack (mixed) of dominance. Also, the therapy related studies, have shown the shift in laterality of brain functions, which gives an inference that it is essential to know the laterality aspects in PWS for better understanding of the problem to answer various issues related to it.

CHAPTER 3

METHOD

This study was undertaken to investigate the laterality or cerebral dominance in children with and without stuttering using Laterality index and Dichotic CV test.

3.1 Participants

Two groups of participants were considered for the study. The first group comprised of 10 children diagnosed by experienced Speech language pathologists (SLPs) as having moderate to severe stuttering (based on SSI) in the age range of 7 to 11 years. The second group comprised of 30 typically developing children in the age range of 7 to 11 years.

3.1.1 Participants selection criteria

The subjects were selected for the study based on the following criteria: all the children were screened to rule out any associated speech, language, hearing and intellectual problems, except for group one who had stuttering. All the children were native speakers of Kannada.

3.1.2 Participant Details

The children with stuttering (CWS) group consisted of 10 participants (9 boys & 1 girl) within the age range of 7 to 11 years (mean age = 8.7 years), 9 diagnosed to be having ***moderate stuttering*** and 1 as having ***severe stuttering.***

The group of children with no stuttering (CWNS) consisted of 30 participants (14 boys & 16 girls) within the age range of 7 to 11 years (mean age = 8.3 years).

3.1.3 Ethical standards used for the participant selection

The parents/ caregivers of the participants were explained about the purpose and procedure of the study. The informed consent proposed by AIISH (All India Institute of Speech and Hearing) ethical guidelines for bio-behavioral research using human participants (2009) was used for obtaining written consent from the parents of the participants.

3.2 Materials

The materials used for the study included:

3.2.1 General information checklist

This consisted of the demographic details, language used, educational background, hand preferred by the participants of both children with no stuttering group (CWNS) and children with stuttering group (CWS). In addition, for children with stuttering (CWS), onset and development of stuttering, family history of stuttering, situational variations of stuttering, severity of stuttering etc., were also included. General information checklist has been given as Appendix A.

3.2.2 Stuttering Severity Instrument (SSI-3; Riley, 1994)

This test gives the severity of stuttering, which was administered on each participant with stuttering, before administration of Modified Laterality Preference Schedule and Dichotic consonant-vowel (CV) test.

3.2.3 Modified Laterality Preference Schedule

This checklist was developed by Dr. Venkatesan, S, (1992) as a part of thesis, on adults with multiple disabilities. It has a series of tasks that has to be performed by the individual and it checks for the hand, foot, eye and ear preferred by the individual, while doing the tasks. This checklist was used, since it gives preference for foot and eye which are not mainly used to study laterality along with preferred hand and ear. Also, it is simple, non-invasive, cost-effective and less time consuming to measure laterality. The checklist has been given in Appendix A.

Scoring: The checklist consists of 30 tasks (18 hand related, 6 foot related, 4 eye related, 2 ear related tasks). In the checklist, a score of 1 is given with respect to the preferred side (right/left/both) to perform each task and scores are totaled and percent is calculated to get the laterality index.

3.2.4 Dichotic consonant-vowel (CV) test (Asha & Vanaja, 2012)

This test was used to find the ear preference of children with stuttering (CWS) and children with no stuttering (CWNS). The stimulus (CV combinations) was presented to both the ears simultaneously (0 milli second difference) and each participant was made to write the stimulus coming from both ears, below respective columns provided. A pair of 30 stimuli was presented, scores for each ear was

obtained and lateralization index was calculated using the formula. Instructions, procedure, scoring and interpretation as given by the authors were used. The response sheet of Dichotic CV test has been given in Appendix A.

3.3 Procedure

3.3.1 Pre-data collection phase

Prior to the data collection informed consent was obtained from the parents/caretakers of the participants using AIISH ethical guidelines for bio-behavioral research using human participants (2009). General information related to hearing and vision, any persisting neurological/psychological illness etc, about the participants, was collected.

3.3.2 Data collection phase

Baseline assessment was carried out for children with stuttering (CWS) to assess for dysfluencies and the severity of the problem. The Modified Laterality Preference Schedule which checks for laterality of hand, foot, eye and ear through a list of activities, was administered on each subject of experimental and control group individually. The Dichotic CV test was also carried out to check for ear laterality and its scores were obtained.

3.3.3 Testing environment

Testing was carried out in an electrically shielded, sound treated room complying with ANSI S3.1 1999 standards for noise levels.

3.3.4 Analysis

The obtained data from Modified laterality preference schedule and dichotic CV test were subjected to appropriate statistical measures. SPSS software version 16.0 was used for the data entry and statistical analysis. The scores obtained from both the groups were tabulated and were used to obtain the mean (X), median (M) and standard deviation (SD) and further analyses were performed.

3.3.5 Research Design

A standard group comparison research design was employed for the present study.

CHAPTER 4

RESULTS & DISCUSSION

The participants belonging to the stuttering group (CWS) as well as the control group (CWNS) were subjected to Dichotic CV test and Modified Laterality Preference Schedule (MLPS) tasks and scores were obtained. The obtained scores were tabulated and subjected to statistical analysis. The results of the study were discussed under two main sections based on the scores obtained from MLPS and Dichotic CV tests namely:

1. Comparison of MLPS scores obtained from CWS and CWNS groups

2. Comparison of the Dichotic CV test scores between CWS and CWNS groups

4.1 Comparison of MLPS scores obtained from CWS and CWNS groups

The Modified Laterality Preference Schedule (MLPS) scores obtained from both the CWS and CWNS groups were compared for their means. Table 1 depicts the mean scores of MLPS obtained for both the experimental as well as the control groups.

Table 1

Mean scores obtained from MLPS for CWS and CWNS groups

Groups	Hand (18)			Foot (6)			Eye (4)			Ear (2)		
	R	L	M	R	L	M	R	L	M	R	L	M
CWS	16.70	-	1.3	4.7	1.3	-	2.9	1.1	-	2.0	-	-
CWNS	16.9	-	1.1	4.6	1.4	-	3.0	1.0	-	2.0	-	-

R=right, L=left, M=mixed
Number of tasks (in brackets)

The results from Table 1 reveals that there were no differences obtained from the scores on Modified Laterality Preference Schedule between the CWS and CWNS group i.e., both the groups lateralized the tasks to right side with >50% criteria. Hence, no specific statistical analysis was carried out.

The scores from table 1, depicts the mean scores obtained for hand (18), foot (6), eye (4) and ear (2) lateralization tasks across CWS and CWNS group. Here, the values are similar for both the groups. In other words, it is seen that most tasks across both groups are lateralized to right side and only few tasks have mixed lateralization (for handedness) and left sided lateralization (footednees & eye preference).

In terms of hand preference, both the groups preferred right hand and few both hands with no significant difference between both the groups. The mean values are indicative that majority of the children from both the groups lateralized to right hand.

For foot preference, both the groups preferred right foot and few left foot with no significant difference between both the groups. The mean values are indicative that majority of the children from both the groups lateralized to right foot.

With respect to eye preference, both the groups preferred right eye and few left eye with no significant difference between both the groups. The mean values are indicative that majority of the children from both the groups lateralized to right eye.

In case of ear preference, both the groups preferred right ear with no significant difference between both the groups.

Though the checklist did not give any significant differences between the groups and right side preference was seen in both the groups, it gives an inference that due to practice effect from childhood, children tend to lateralize to right side on all tasks. Hence, in addition to a subjective checklist, an objective test is also essential to obtain reliable results for assessing laterality. In this study, the objective test that has been used was, Dichotic CV test and findings are given below.

4.2 Comparison of the Dichotic CV test scores between CWS and CWNS groups

In order to find laterality effects in CWS and CWNS groups, the test scores obtained from Dichotic CV test for both CWS and CWNS groups was subjected to a pairwise comparison using Mann Whitney Test. Table 2 depicts the mean, median and SD scores of the Dichotic CV test of both the experimental and control group.

Table 2

Comparison of scores of CWS and CWNS groups

Dichotic CV (LI scores)			
Groups	Mean	Median	SD
CWNS	0.30	0.12	0.38
CWS	0.017*	0.00	0.95

*shows significance at .01 level

As shown in table 2, there were significant differences observed between scores of CWS group and CWNS group, which indicates that there is a notable difference in the laterality patterns between CWS and CWNS groups.

In addition, a pair-wise comparison of the scores of Dichotic CV test obtained from both the groups was checked for the level of significance using the Mann Whitney test.

Table 3

/Z/ value and significance value for Dichotic CV test results of both groups

Dichotic CV	**/Z/ Value**	**Significance**
CWS & CWNS	2.989	0.003**

As shown from table 3, there was a highly significant (0.003**) difference observed in the median scores between the CWS & CWNS groups for Dichotic CV test [/Z/ = 2989, $p < 0.001$].

The results imply that majority of CWS heard the stimulus presented to the left ear (Left ear advantage) more accurately than right ear, indicating right hemisphere dominance or reversed dominance, while CWNS exhibited right ear

advantage and left hemisphere dominance. Many studies also supported these results having left ear advantage and right hemisphere dominance using Dichotic CV test [Curry & Gregory (1969), Brady & Berson (1975), Foundas, Corey, & Hurley (2004)].

The current study aimed at investigating laterality in CWS and CWNS groups. The tests considered for the study were Modified laterality preference schedule (MLPS) tasks and Dichotic CV test. All the participants were made to listen to Dichotic CV stimulus and perform tasks of MLPS.

The results indicated that children with stuttering showed left ear advantage and right hemisphere dominance with a high level of significance on Dichotic CV test. On the other hand, there was no differences seen on tasks of Modified laterality preference schedule (MLPS) i.e., all subjects from both the groups lateralized towards the right side with >50% criteria on all the tasks (hand, ear, eye and foot).

Even though there were no differences seen in laterality checklist (MLPS), differences were seen in Dichotic CV test, indicating that the CWS may lateralize to right side on hand/eye/ear preferences because of practice from childhood. But in Dichotic CV test, few CWS showed left ear advantage, as an actual response, since there is no practice effect, indicating right hemisphere dominance. The left ear advantage was not seen in all CWS, may be because dominance is atypical in these individuals.

These findings are found to be supported by Brady and Berson (1975) study where it was found that 6 PWS and non-stutterers PWNS showed a reversal, i.e., a left-ear preference. However as a group, the remaining CWS showed right ear preference and other CWNS showed right-ear preference suggesting that a subset of CWS may have an anomaly in the lateralization of speech functions i.e., they have incomplete cerebral lateralization or reversed lateralization of speech functions.

CHAPTER 5

SUMMARY AND CONCLUSION

The study aimed at comparing the performance of children with stuttering and typically developing children on Dichotic CV test and modified laterality preference schedule tasks. The scores of 10 participants with moderate to severe stuttering (CWS) between 7 to 11 years were compared with 30 typically developing children (CWNS) of same age range.

The performance of all the participants were tabulated and subjected for statistical analysis. The analysis was performed with respect to groups. Statistical analyses was done using SPSS Software 16.0 version. The Mann Whitney test was applied to compare and contrast between the groups and to investigate the differences among the groups.

The following conclusions were drawn from findings of the present study.

- There was no difference observed between children with stuttering and children with no stuttering groups on Modified laterality preference schedule in terms of hand, eye, ear and leg preferences.
- There was a significant difference observed between children with stuttering and children with no stuttering groups on Dichotic CV test, CWS showed more left ear advantage compared to CWNS who showed typical right ear advantage, implying laterality differences.

5.1 Clinical implications

This study tried to find the lateralization using non-invasive methods, which helps in theoretical understanding of laterality issues in CWS compared to normal controls. Although differences were observed only on dichotic CV test and not on MLPS, it still shows that there could be differences in lateralization in CWS, especially the ear preference which could have serious theoretical implications. This could provide some practical implications with modified approaches in the management of stuttering.

5.2 Limitations

- The present study had very less sample size in clinical group and hence generalization of the findings cannot be done.
- Only 0 milli second lag was considered between the stimulus presentations in Dichotic CV test.
- Test-retest reliability was not performed due to time constraints and non availability of participants for the re-testing.

5.3 Future directions

- Further studies considering larger number of participants in the clinical group need to be carried out for better understanding of the skills.
- The findings on the tests could be compared with different sub groups like children and adults with stuttering, different severity, age and gender.
- In Dichotic CV, other lags (30 ms, 90 ms) can be used to study laterality.

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APPENDIX A

General information checklist (Questions related to stuttering were excluded for control group)

1. History of speech and language difficulties, if any (specify):

2. History of stuttering, if yes (specify):

3. Age of onset of stuttering: <2 yrs; 2-3 yrs; 3-4 yrs; 4-5 yrs; 5-6 yrs; >6 yrs.

4. Nature of onset: Sudden / Gradual.

5. Status of the condition: Static / Increasing / Decreasing / Fluctuating.

6. Chronicity: Acute / Chronic (<6 months; >6 months).

7. Awareness about the problem: Not aware / Aware.

8. Concern about problem: Not concerned / Somewhat concerned / Highly concerned.

9. Stuttering variability: Not variable / Somewhat variable / Highly variable.
   a) Situations: Not variable / Somewhat variable / Highly variable.
   b) Language: Not variable / Somewhat variable / Highly variable.
   c) Person: Not variable / Somewhat variable / Highly variable.

10. Cause of stuttering: Unknown / Heredity / Organic / Psychological / Any other (specify).

11. Associated problems, if any (specify):

12. Family history of stuttering: Nil / In distant relatives / In close relatives (specify).

13. Handedness: Right / Left / Ambidextrous.

14. Any history of change of handedness? No / Yes.
    - If yes, when and how? Specify.

15. Any family history of left handedness? No / Yes.
    - If yes, specify.

Modified Laterality Preference Schedule

Activities	Laterality		
	Right	**Left**	**Ambidextrous**
Tasks for hand			
Wipe a table with cloth			
Hold a glass when drinking			
Put a coin into a box			
Raise when called out			
Write			
Brush teeth			
Catch			
Comb or Brush hair			
Open a drawer or dresser			
Points to objects			
Pick an object kept on the table			
Switch on light			
Has the greatest strength			
Hold a pair of scissors while cutting			
Use first while putting on shirt			
Erase a pencil mark with eraser			
Hurl a ball			
Hold an umbrella while walking			
Tasks for foot			
Kick a ball			
Hop			
Put on footwear first			
Stand the longest			
Extend first when asked to stand & walk			
Has the greatest strength			
Tasks for eye			
Look through a small hole			
Aim while hitting a marble / ball			
See through a tube / Kaleidoscope			
Spontaneously see when asked to close one eye			
Tasks for ear			
Listen to telephone			
Listen to faint sound from a distance			

Interpretation

Laterality	**Total left**	**Total right**	**Total mixed**
Handedness			

Footedness			
Eye			
Ear			
Overall			

The lateralization is towards (50% criteria):

Dichotic CV response sheet

Sl no	Response		Scoring	
			SCS (R)	SCS (L)
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				
16				
17				
18				
19				
20				
21				
22				
23				
24				
25				
26				
27				
28				
29				
30				

Double correct score		
Single correct score	**Right ear**	
	Left ear	
Interpretation		

Lateralization Index: LI = (npr – npl) / (npr + npl)
npr – detected right stimuli
npl – detected left stimuli

If values are positive -> right ear & left hemisphere dominance

APPENDIX B

ALL INDIA INSTITUTE OF SPEECH & HEARING

Naimisham Campus
Manasagangothri, Mysore 570 006

Title of study: Laterality in children with and without stuttering

CONSENT FORM

I have been informed about the aims, objectives and the procedure of the study. I understand that I have a right to refuse participation or withdraw my consent at any time. I have the freedom to write to head of the Institute in case of any violation of these provisions without the danger of my being denied any rights to secure the clinical services at this institute. I am interested in allowing my child to participate for the study and hereby give my written consent for the same.

I, _____, the undersigned, give my consent for my child to be participant of this investigation/study/program. I have no objection in my child participating in the program.

Signature of Participant Name and Address:

Date: