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Dichotic ear preferences of stuttering adults

by

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CHAPTER 1. INTRODUCTION

Background Information

The speech disorder termed "stuttering" is a complicated speech problem which has intrigued man throughout the ages because the cause was unknown and continues to remain a mystery today. The observable nature of the problem is fascinating and presents some interesting characteristics for the researcher to contemplate. For instance, stuttering has been shown to have a rather insidious onset, beginning gradually and progressing toward more advanced states of severity. It is considered a childhood disorder with few individuals suffering onset of the impediment at the adult stage in life.

The nature of the disorder is further outlined by leading authorities (Bloodstein, 1975; Eisenson, 1958; Johnson, 1959; Sheehan, 1970; and Van Riper, 1972). They report that stutterers will not stutter while singing, talking and reading in unison. Stutterers will usually not stutter when talking with a pet or a baby, when talking aloud in private, when whispering, or when assuming a character role in a theatrical play. On the other hand, stutterers do tend to develop a pattern of stuttering on specific sounds and words. Stutterers usually stutter more frequently while conversing with authority figures. They can usually predict their moment of stuttering with fairly good accuracy. Furthermore, stutterers may undergo periods of perfect speech fluency with remission lasting for hours, days, weeks, months, and occasionally years.

The incidence of stuttering tends to be uniform throughout the world with approximately one percent of the population suffering from the speech defect. The prevalence of stuttering, however, shows a less stable pattern than the incidence of the disorder. There is considerable evidence to support a sex ratio difference among the stuttering group. According to Van Riper (1972), there appear to be four male stutterers for every one female stutterer. The prevalence of stuttering is not evenly distributed with respect to age either. There is a noticeable increase in prevalence for preschool-age children. Van Riper estimates that approximately four percent of the children between the ages of three to seven years stutter. About 75 percent of these cases recover from the difficulty as they mature. Fewer cases of stuttering onset are reported for the adult age group. In fact, it is quite uncommon for stuttering onset to occur beyond the teen-age years. The prevalence of stuttering is much higher among the mentally retarded. Gottsleben (1955) has reported 33 percent of institutionalized mongoloids stutter, whereas 14 percent of institutionalized non-mongoloid retardates have the same speech disorder. The familial incidence of the disorder is quite high, ranging from 15 to 39 percent (Van Riper, 1972). Moreover, the incidence figures among twins shows a variation from 1.9 to 24 percent (Graf, 1955). Figures are also high for the brain-injured population, including those with cerebral palsy and epilepsy. In contrast, the incidence of stuttering among the diabetic population is almost nonexistent.

Statement of the Problem

The libraries are replete with voluminous writings on the subject, but the cause for the disorder continues to perplex many investigators. There are, however, hundreds of theoretical viewpoints concerning the etiology. Most of these theories speculate on a single cause for the problem. More recently, support has mounted for the multicausal concept (Andrews and Harris, 1964; Perkins, 1971; and Van Riper, 1972). That is, stuttering may actually involve more than one cause, and this may vary according to the physical predisposition, psychological make-up, and/or the environmental background of the person. Whatever the case, one is still limited to theorizing only about a cause for the disorder.

At the present time, this writer is willing to speculate that some cases of stuttering may result from physical or organic factors. Moreover, the specific nature of this cause may somehow be linked to a neurological difference, such as reversed, or mixed dominance for speech control. This is not a completely new idea, but originated with Orton (1927) and Travis (1931). In the present investigation, however, the researcher wishes to study the relationship between auditory processing and stuttering. Auditory processing patterns, as determined by dichotic listening, are thought to be closely related to cerebral dominance for speech (Kimura, 1961).

Some interesting facts about stuttering lead one to suspect a connection between the functioning of the auditory system and the problem of stuttering. For instance, the incidence of stuttering reported among the congenitally deaf population is almost nonexistent

(Backus, 1938). Also, when a stutterer becomes deaf, after a period of normal hearing, he commonly will cease to stutter. Masking noise directed to both ears of the stutterer will also usually result in fluent speech. It is interesting to note that under both of these conditions, hearing loss and masking noise, the stutterer does not hear his own voice while talking. Furthermore, when auditory feedback is delayed by a fraction of a second, and then presented to the stutterer's ear, he will usually not stutter at the time. These, and many other examples of auditory difference, serve to illustrate the possibility of a relationship to stuttering. While the existence of such patterns have long been recognized, and well-substantiated, an understandable explanation for their presence is clearly lacking (Van Riper, 1972).

The dichotic listening technique is a relatively recent, but promising means for exploring the nature of auditory processing and perception. In dichotic listening, the person hears two different signals presented simultaneously. Each signal is directed to a different ear, resulting in competing stimuli. An ear preference is a reflection of the person's dominance pattern for speech control. The following chapter, concerned with a review of the literature, will include a summary of the major research in this area, and present the controversial issues involved with interpretation of findings from dichotic listening studies.

Purposes

The primary objective of the study was to determine the ear preference of both stuttering and nonstuttering adults, as revealed by their performances on a dichotic word and digit test. The research findings would help substantiate patterns of cerebral dominance for adult stutterers. Hence, the theory of mixed or reversed cerebral dominance for stutterers could be tested. The specific questions to be answered by this study include:

1. Do both stutterers and nonstutterers demonstrate a right ear preference for dichotic word and digit tasks?

2. Do both dichotic tasks yield the same pattern of ear preference for subjects?

3. Does interaction occur on ear preference for group and task?

4. Do stutterers for the four different levels of severity demonstrate a right ear preference?

5. Do stutterers demonstrate a right ear preference for both dichotic tests?

6. Does interaction occur between test and severity of stuttering for the experimental group?

Hypotheses

The six research null hypotheses were:

1. There is no significant difference between the ear preference for the experimental and control group.

2. There is no significant difference between the ear preference for the dichotic word and ear preference for the dichotic digit tasks.

3. There is no significant interaction effect on ear preference for group and task.

4. There is no significant difference in ear preference and level of stuttering severity for the experimental group.

5. There is no significant difference in dichotic tests for the experimental group.

6. There is no significant interaction effect on ear preference between test and stuttering severity among the experimental group.

Definitions

Cerebral Dominance—Refers to a tendency for one brain hemisphere to assume control for various sensory, motor and language functions.

Dichotic Listening—The person hears two different signals presented simultaneously. Each signal is directed to a different ear, resulting in competing stimuli.

Ear Preference—In this study, it refers to the proportion of right ear responses for dichotic words and digits.

Handedness—Refers to the preferred hand used in motor skills, and is sometimes referred to as sidedness.

Laterality—Refers to cerebral dominance control of various functions primarily by a single hemisphere of the brain. It may also refer to handedness or sidedness.

LEP—Left ear preference; it is usually determined by one's performance on a dichotic listening task.

REP—Right ear preference; it is usually determined by one's performance on a dichotic listening task.

Stuttering—Definitions of stuttering vary on several dimensions. One type focuses on a direct statement of speech characteristics, another defines on the basis of etiology, and others outline a description of the full range of behaviors associated with stuttering. Wingate (1964) suggests that a good definition should include the following features:

> identifies and emphasizes discriminative features, is amenable to general application, and accords with our current state of knowledge of stuttering.

He proposed the following widely accepted definition of stuttering:

> The term "stuttering" means:
> 1. (a) Disruption in the fluency of verbal expression, which is (b) characterized by involuntary, audible or silent, repetitions or prolongations in the utterance of short speech elements, namely: sounds, syllables, and words of one syllable. These disruptions (c) usually occur frequently or are marked in character and (d) are not readily controllable.
>
> 2. Sometimes the disruptions are (e) 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.
>
> 3. Also, there are not infrequently (f) indications or report of the presence of an emotional state, ranging from a general condition of "excitement" or "tension" to more specific emotions of a negative nature such as fear, embarrassment, irritation, or the like. (g) the immediate source of stuttering is some incoordination expressed in the peripheral speech mechanisms; the ultimate cause is presently unknown and may be complex or compound.

Limitations

This study was limited to 25 stuttering and 25 nonstuttering right-handed subjects ranging from 19-51 years of age. The population was drawn primarily from the student and faculty body at Iowa State University. Randomization procedures were not followed in selecting the experimental population, since so few subjects were available to participate in the study. The control subjects consisted primarily of students selected from the basic public speaking course in the Department of Speech. These subjects were selected and matched on the basis of age and handedness with the experimental group.

CHAPTER 2. REVIEW OF THE LITERATURE

Introduction

The previous chapter outlined some of the general aspects regarding the nature of stuttering, and presented a statement of the problem, purposes, hypotheses, and limitations of this study. In the present chapter, the writer will not attempt to summarize the massive number of experiments involving stutterers. Instead, the focus will be on those studies concerned with the topics of cerebral dominance and dichotic listening among the stuttering population.

Cerebral Dominance Studies

Extensive research findings have firmly supported the notion that the left hemisphere of the brain assumes dominant control over language functions among the majority of right-handed persons (Broadbent, 1954 ; Gazzaniga and Hillyard, 1971; Geschwind and Levitzky, 1968; Kimura, 1975; Hecaen and Sauguet, 1971; Branch, Milner and Rasmussen, 1964; Penfield and Roberts, 1959; and Zangwill, 1967). Most of our knowledge about hemispheric specialization comes from the study of brain-injured subjects (Milner, 1971; Mountcastle, 1972; and Sperry, 1974). Sperry and Gazzaniga (1967) in notable split brain studies have demonstrated that the right hemisphere is apparently incapable of producing speech. These same studies have shown the right hemisphere is able to process spoken and printed commands at various levels of complexity, however, the motor control of speech is generally strictly unilateral in its organization. While the left hemisphere of the brain is thought to be largely responsible for language processing, the right hemisphere also shows superior control over certain tasks. These include such aspects as spatial relations, tactile processing, and automatic speech (Krashen, 1976).

A faulty assumption is frequently made concerning the relationship between cerebral dominance and handedness. That is, some persons assume all right-handers will show a left dominance and all left-handers will show a right dominance for speech control. The former statement is more likely to be true than the latter statement. In other words, right-handers are more likely to show speech dominance on the left than on the right hemisphere. The same pattern is true for left-handers. However, it is possible for dominance to occur on either right or left hemispheres regardless of sidedness. Mixed dominance for speech control has been shown to exist in a smaller number of cases (Goodglass and Quadfasel, 1964; Penfield and Roberts, 1959; Wada and Rasmussen, 1960; Branch, Milner and Rasmussen, 1964; and Zangwill, 1960). All in all, researchers conclude that most people have left hemispheric dominance for speech control, fewer have right hemispheric dominance and still less have bilateral dominance. Quinn (1972) notes the probable relationship between cerebral dominance and handedness in the general population is roughly as follows:

> Right-handers - more than 90 percent left cerebral dominant, less than ten percent right dominant, less than one percent bilateral representation. Left-handers and ambidextrous subjects - 70 percent left cerebral dominant, 15 percent right dominant, and 15 percent bilateral representation.

The Wada Test to determine cerebral dominance has yielded data confirming these estimates. It has been proposed that the probability of a right-handed individual without cerebral pathology having bilateral speech dominance is very slim indeed; about one chance in 300. Therefore, findings of mixed dominance in right-handed stutterers would be rather significant (Branch, Milner and Rasmussen, 1964; Serafetinides, Hoare and Driver, 1965).

This brief introduction to the extensive literature concerning cerebral dominance for speech has provided the basic theoretical construct from which the present study has emerged. It has been proposed via the Cerebral Dominance Theory that stuttering is etiologically related to bilateral cerebral dominance. Accordingly, stuttering occurs because of mistiming of motor impulses to the bilaterally paired muscles controlling speech. This concept gained wide acceptance after the turn of the century through the writings of Orton (1927) and Travis (1931). Bryngelson (1935) provided support to the theory when he found a high percentage of ambidexterity and left-handedness among the stuttering population. His findings suggested the possibility of an imperfect, or bilateral control for stutterer's speech production. The lack of techniques to assess speech dominance ended the popularity of the Cerebral Dominance Theory. One of the research problems revolved around the investigators hypothesis that a direct relationship existed between handedness and dominance for speech control. In retrospect, present day researchers acknowledge the fact that sidedness, by itself, does not provide clear-cut evidence of laterality. Fortunately, we now have new and more reliable methods involving visual and auditory senses for determining speech dominance. However, the most reliable measure of dominance is the sodium amytal test.

The following discussion will show how recent research studies have brought about a resurgence of interest in the Cerebral Dominance Theory of stuttering. Jones (1966) reported the case histories of four patients who had stuttered severely since childhood. They had each developed intracranial brain pathology in the presumed speech area (Broca's Area) requiring surgical correction. Before operating, Jones employed Wada testing, which consisted of alternately injecting sodium amytal into the patient's right and left carotid arteries to determine cerebral dominance. The test has an estimated three percent mortality risk. It was originally designed to diagnose neurological deficits following surgery for temporal lobe epilepsy. The conclusive findings from this test showed that all four stutterers had bilateral speech dominance. Furthermore, after surgical correction, Jones was surprised to note that the stuttering completely remissed in all of his patients and remained extinguished at follow-up intervals of 15 months, 18 months, 27 months, and three years. Startling results were also observed when postoperative Wada testing revealed a shift to unilateral speech dominance. The results of this experiment suggest mixed dominance as an etiological factor in stuttering. Luessenhop, Boggs, LaBorwit, and Walle (1973) comment:

> The Jones study introduces the possibility of deliberately creating a critically localized lesion, now a relatively simple and safe procedure in neurosurgery, to convert bilateral

> motor speech dominance to unilateral dominance for the treatment of stuttering.

The authors conclude that before seriously considering this possibility, additional supportive findings of bilateral speech representation is needed.

Andrews, Quinn, and Sorby (1972) in a similar study using four stutterers were not able to confirm Jones' earlier findings. Three of the subjects who lacked brain pathology were found to have unilateral dominance for speech as determined by the sodium amytal test. The fourth subject, however, was found to have bilateral speech representation. He also had a history of cerebral injury resulting in dysphasia, or loss of language. The researchers presumed that he had unilateral speech dominance prior to the brain pathology, since only one case of bilateral speech has been reported among right-handed individuals who have no cerebral pathology (Rossi and Rosadini, 1967). Therefore, this fourth subject probably shifted to bilateral speech representation after the cerebral damage, but one cannot be absolutely positive of this occurrence.

A study by Andrews and Harris (1964) found that stuttering did not show an increase in incidence when investigating a group of sinistral and ambidextrous subjects. One should keep in mind that there is normally a 15 percent incidence of mixed dominance with the left-handed and ambidextrous group.

Andrews, Quinn and Sorby (1972) cite two unpublished studies, Rasmussen (1971) and Rossi (1971) who failed to note any incidence of stuttering in a group of left handers shown to have bilateral dominance as revealed by Wada testing. Andrews, Quinn and Sorby (1972) also cited a study by Walle and Luessenhop (1971) also reporting no evidence of bilateral speech representation among three stutterers undergoing sodium amytal testing at the Catholic University. These findings, along with others have failed to confirm Jones' research findings, and shed serious doubt on the possibility that stutterers, as a group, have mixed dominance for motor speech control. Although, mixed dominance may eventually prove to be an etiological factor with a subgroup of stutterers.

The answer is not clear-cut, however, as pointed out by Van Riper (1972) in his review of research in this area. He notes that Guillaume, Mazars and Mazars (1957) reported a complete recovery from stuttering in an epileptic after surgical removal of an epileptogenic focus in the right temporal lobe. He also cites a case study from Russia whereby Shtremel (1963) witnessed sudden onset followed by remission of stuttering after surgical removal of a tumor. The 51-year-old subject presented no history of stuttering prior to the pathology, however, once the pathology formed the patient suffered both aphasia and stuttering. Aphasic symptoms did remain after the surgery. Van Riper (1972) adds the following comments concerning brain injury and cerebral dominance:

> If the brain damage occurs before the onset of speech, it does not seem to matter whether the injury is in either the left or right hemispheres so far as the later acquisition of speech is concerned. After the onset of speech, however, and especially in adulthood, injuries to the left hemisphere disturb speech greatly. Damage to the right hemisphere does not.

This leads one to suspect that establishment of cerebral dominance for speech control is developmental. Moreover, there may be hereditary traits predisposing the process.

Measures, other than the Wada testing technique, have been employed in determining cerebral dominance. Using a visual fusion test with stutterers, Selzer (1933) discovered poor performance by the group. Jasper (1932) in a classic study to investigate the phi phenomenon (the apparent movement between intermittent visual stimuli) with stutterers, ambidextrous, right-handed and left-handed subjects, found some rather interesting results. The phi phenomenon movement was reported as going to the right for right-handers, to the left for left-handers, and moving in inconsistent directions for both the ambidextrous and the stutterers. Jasper concluded:

> These results seem to indicate in general that neural organization is expressed in the field of perception as well as in the field of manual preference. The phi phenomenon test of both peripheral and central dominance clearly demonstrated the lack of unilaterality on the part of stutterers, and a tendency on the part of stutterers to have more ambilaterality than the ambidextrous normal speakers.

A more recent study (Moore, 1976) utilized bilateral tachistoscopic procedures to investigate the visual half-field preferences of stutterers and nonstutterers. The control group was found to have a significant right visual half-field preference, whereas a significant visual half-field preference was not revealed for stutterers. However, a larger proportion of stutterers, as compared to nonstutterers, were found to have a left visual half-field preference. The authors interpreted this finding to indicate reversed cerebral dominance for the stuttering group.

The following section of this chapter will report on the efficacy of dichotic listening as a modern technique employed in determining cerebral dominance for speech.

Dichotic Listening Studies

Background Information

The literature concerning dichotic listening is much too extensive to present in detail here. In summarizing the more than 300 reported studies, it is apparent that a right ear preference (REP) prevails for most right handers in the normal population. A left ear preference (LEP) and a mixed ear preference (MEP) occurs to a lesser degree. The REP is thought to be an indicator of left hemispheric dominance, whereas, the LEP reflects the opposite pattern of dominance. The MEP usually indicates bilateral representation of dominance.

The earliest dichotic study was reported by Broadbent (1954), who was interested in studying selective attention patterns. He found that one ear attended more closely to speech stimuli, than the other ear.

In her classic experiment, Kimura (1961) used Broadbent's earlier procedure to study laterality patterns. She found a right ear advantage (REA), later to be termed right ear preference (REP), for her subjects. Kimura interpreted this REP as reflecting left hemispheric dominance for speech. She hypothesized that the REP was related to a prepotency of the crossed neural auditory pathways.

An interesting conclusion was presented in reviews of over 300 dichotic studies (Berlin, 1972, 1976). Berlin comments:

> In all probability, it would be safe to conclude that such factors as acoustic perception, memory, selective attention and functional asymmetry of the hemispheres probably all interact in some way, as yet unclear, to generate a right ear advantage in dichotic speech perception tasks.

Dichotic listening results can be obscured if certain variables are not controlled (Berlin and Cullen, 1975). The authors point out the importance of acoustic factors in dichotic tasks:

> Many researchers have presented their tapes at "comfort level" without regard for the absolute sound pressure measurements, or the relationship of the consonant-to-vowel energies in their stimuli; few studies specify the signal-to-noise ratio of the tapes used, the nature of the temporal asynchrony, or the monaural intelligibility of the signals without dichotic competition.

In addition, investigators must employ procedures to assure repeatable calibration of absolute levels and channel balance. Moreover, signal-to-noise ratio must be kept the same for both channels of the tape recorder and recorded material (Cullen, Thompson, and Samson, 1974). As indicated by these authorities, interpretation of results becomes difficult when care is not exercised with regard to tape preparation and presentation.

The following section will be concerned with the more pertinent literature concerning this study. A review of dichotic listening research with stutterers will be presented.

Stuttering-Auditory Studies

The few studies which are specifically concerned with the auditory processing patterns of stutterers have yielded contradictory conclusions. Some dichotic listening experiments have shown a REP, while others have failed to reveal this same pattern.

Curry and Gregory (1969) reported one of the earliest dichotic research studies involving stutterers. They compared 20 stutterers and 20 nonstutterers on one monotic verbal listening task, and three dichotic listening tasks. No differences were found in scores between ears for the two groups on three of the tasks. However, 55 percent of the stutterers attained higher left ear scores, whereas, 75 percent of the nonstutterers achieved higher right ear scores. The authors concluded that these results may reflect a smaller difference between ipsilateral and contralateral auditory pathways for the stutterers than for the nonstutterers. They speculate if the between-ears difference scores reflect laterality, then their findings may be interpreted as supporting the Cerebral Dominance Theory of stuttering.

A similar dichotic listening experiment reported by Perrin and Eisenson (1970) found a significant difference existed between the stuttering and nonstuttering groups. Stutterers' demonstrated a LEP for two-syllable words and rhyming words. They demonstrated no ear preference for nonsense syllables, but the nonstutterers showed the expected REP.

In the same year, Mattingly (1970) presented his findings of no significant differences in ear preferences between ten right-handed stutterers and ten matched nonstutterers in two dichotic verbal listening tasks involving meaningful, and meaningless stimuli. In comparing the groups, both the right-handed stutterers and nonstutterers showed a REP on these dichotic tasks. Although, the same finding failed to hold true for ten left-handed stutterers. In this instance, the stutterers demonstrated a LEP on the dichotic tasks. These results point out the need for investigators to exercise vigilance when assessing handedness among their research populations. Otherwise, interpretation of one's data may be impossible and meaningless.

Findings from another dichotic study (Sommers, Brady and Moore, 1975) revealed a less clear-cut unilateral dominance pattern for speech among the experimental group. Subjects included, 39 stuttering and 39 nonstuttering right-handed children and adults. The control group of nonstutterers demonstrated a REP for both dichotic words and digits. In contrast, 11 of the 39 nonstutterers failed to show a REP on the dichotic word test. This compared to 23 of 39 stutterers failing to show a REP. In other words, 13 of 39 stutterers showed the typical REP for dichotic words and 22 of 39 showed the REP for dichotic digits. Furthermore, nine stutterers showed a LEP for dichotic digits. The study, however, confirmed the hypothesis that stuttering children show less laterality for speech than adult stutterers. The authors speculated that spontaneous remission of stuttering in the early years may be related to a slower rate in establishing laterality among stutterers.

Prins and Walton (1971) compared the disruptive effects of monaural and binaural delayed auditory feedback (DAF) on speech rate and sound syllable repetition disfluencies with ear preference patterns for nine stutterers. The researchers reported there were mixed laterality differences in the disruptive effects of DAF on speech rate. A LEP for the dichotic task was reported for five of the stutterers.

Sussman and MacNeilage (1975) reported findings from a study employing pursuit auditory tracting, a new listening technique which yields an index of laterality for the speech production mechanism. In explaining the nature of the technique, the authors comment:

> This index is provided by a pursuit auditory tracting task in which subjects match the frequency of a continuously varying pure tone presented to one ear with a second tone presented to the other ear and controlled by unidimensional movements of part of their motor system. This task can be used on normals without raising medical questions and has shown in normal right handers significantly better performance when the tone whose frequency is controlled by a speech articulator (tongue or jaw) is presented to the right ear, rather than the left, but not if the tone is hand-controlled. The right ear advantage (REA) in articulatory tracking suggests the presence in the left hemisphere of an auditory sensorimotor integration mechanism related to speech control.

The 25 right-handed stutterers in this study failed to demonstrate a REP for overall laterality. The opposite trend was reported, however, for the 31 right-handed nonstutterers. Findings from this experiment indicated that stutterers had less distinct lateralization of speech-related auditory sensorimotor integration than nonstutterers.

A second experiment reported by the same authors was performed and involved a dichotic listening task with 19 of the original 25 stutterers. An additional stutterer was added to increase the number to 20. Findings revealed 17 subjects with REP and three with LEP.

It is important to recognize that not all dichotic studies involving stutterers have shown a trend toward LEP's or MEP's. For example, Quinn (1972) found no significant differences between 60 stutterers and 60 nonstutterers in ear preference scores. Both groups demonstrated a REP for dichotic words. A significantly large minority of the stutterers (20 percent) showed a reversed dominance pattern.

Slorach and Noehr (1973) reported their findings from a study involving 15 stuttering, 15 nonstuttering, and 15 dyslalic children. Employing a dichotic digit test, the investigators were able to confirm Quinn's earlier results. All three groups demonstrated a REP for dichotic digits.

Finally, two dichotic experiments supported the notion of a REP existing among stutterers. Cerf and Prins (1974) found no differences between the stuttering and nonstuttering groups in their ear preferences. In fact, these researchers found that 17 of 19 stuttering subjects showed the REP typically found in the normal population. Dorman and Porter (1975), in a recent study involving 16 stutterers and 20 nonstutterers, reported a REP for both groups of adult subjects on a dichotic syllable test.

Summary of Literature Review

In the foregoing review, the writer has attempted to provide a sound theoretical basis for this study. It has been clearly established that dominance for speech and language is most typically found in the left hemisphere of the brain. Furthermore, there is reason to suspect some stutterers have confused dominance patterns which may be somehow linked to the etiology of the disorder. It is obvious the reported research findings to test this hypothesis are often equivocal and contradictory. Thus, the nature of hemispheric specialization for speech in stutterers has not yet been fully established. A more plausible conclusion may exist, which would limit the etiological factor of mixed cerebral dominance to a subgroup rather than the entire population of stutterers.

The dichotic REP for linguistic stimuli has been reported in numerous research studies involving a variety of populations during the past 15 years. In short, the REP is thought to be an indicator of left hemispheric dominance, whereas, a LEP appears to reflect the opposite pattern of dominance. Mixed ear preference (MEP), of course, is thought to indicate bilateral dominance for speech control. Interpretation of dichotic ear preference scores should be guarded and tentative until more is learned about hemispheric specialization, auditory processing, and selective attention. Furthermore, it has been shown that the REP can be manipulated to some extent by varying factors such as: presentation level of stimuli, signal-to-noise ratio, channel balance of the tape recorder, and type of stimuli presented.

Dichotic studies involving stutterers have yielded confused and mixed findings. That is, stutterers as a group, do not always demonstrate a REP on dichotic listening tasks. Slightly more than half of the studies have failed to show the REP among the stuttering groups tested. There may be other factors interacting with the main effects of these dichotic experiments. For instance, the nature and severity of the stuttering may be found to be variables related to the subject's ear preference. Further dichotic research with stutterers is warranted and should attempt to explore areas which will help explain the previous mixed findings among this population.

CHAPTER 3. METHODOLOGY

Introduction

The primary objective of this experiment was to test the Cerebral Dominance Theory of stuttering by determining the dichotic ear preferences of adult stutterers. The Cerebral Dominance Theory, advocated by Orton (1927) and Travis (1931), suggests that the cause of stuttering is related to mixed or reversed hemispheric dominance. Moreover, this condition is thought to result in confused and imprecise timing of neural impulses to the paired speech musculature. As pointed out in the second chapter, investigators suspect the ear preference score yielded by dichotic listening measures is an indicator of language dominance.

This experimental study was designed to answer the six research questions posed by the null hypotheses. These were:

1. There is no significant difference between the ear preference for the experimental and control group.

2. There is no significant difference between the ear preference for the dichotic word and ear preference for the dichotic digit tasks.

3. There is no significant interaction effect on ear preference for group and task.

4. There is no significant difference in ear preference and level of stuttering severity for the experimental group.

5. There is no significant difference in dichotic tests for the experimental group.

6. There is no significant interaction effect on ear preference between test and stuttering severity among the experimental group.

In order to answer these questions, 25 adult stutterers in the experimental group were matched by age and sex variables with 25 adult nonstutterers in the control group. Each group was administered the same dichotic listening measures to determine their right ear response pattern. Specific information concerning the methodology employed in this experiment will be presented under the following sections of this chapter: Design and Analysis; Subjects; Materials and Equipment; and Test Administration.

Design and Analysis

A 2 X 2 X 2 full factorial design, as shown in Figure 1 below, was employed (Winer, 1962). The main sources of variation included: experimental versus control group; dichotic word versus dichotic digit test and first time versus second time tested. The secondary sources of variation included; sex; and four levels of stuttering severity for the experimental group. The variable of time was reduced from the factorial design after early analysis revealed that it provided no contribution to the results. The design, then, changed to a 2 X 2 full factorial model.

2 X 2 X 2 Factorial Design

GROUP	STUTTERING				NONSTUTTERING			
TEST	WORD		DIGIT		WORD		DIGIT	
TIME	1st	2nd	1st	2nd	1st	2nd	1st	2nd

Figure 1. Factors included in the experimental design

Ear preference scores were determined by summing the actual number of preferred responses per ear. No more than 36 total responses were possible for each dichotic test. Thus, the two dichotic tests accounted for a total of 72 ear preference responses for each subject. Only right ear responses were analyzed. These responses were treated statistically as count, proportion, and arcsin transformation data. However, the researcher elected to report the proportion data in this study. Thus, allowing for uniform presentation of data and ease in interpretation. The Analysis of Variance (ANOVA) statistical procedure was used to determine the F-values for the sources of variation. Regression analysis was selected to test those hypotheses related to stuttering severity (numbers 4, 5 and 6). Statistical comparisons were patterned after Winer's (1962) ANOVA model (pp. 317, 320). The procedure for coding is outlined below:

Column	Card	Coding Description
1-2	1	Student identification ie. 01, 02, 03
3	1	Experimental group = 1; Control group = 2
4	1	Word test = 1; Digit test = 2
5	1	Right ear = 1; Left ear = 2
6	1	First time tested = 1; Second time tested = 2
7	1	Severity; 0 = Normal or control group 1 = Slight 2 = Mild 3 = Moderate 4 = Extremely severe
8	1	Sex; Male = 1; Female = 2
9-10	1	Ear preference score for appropriate ear and task

The Statistical Analysis System (Barr and Goodnight, 1972) was employed to compute the data at the Iowa State University Computation Center.

Subjects

The stuttering subjects consisted primarily of students and faculty seen at the Iowa State University Speech and Hearing Clinic. Three subjects had not received treatment at this center. Nonstuttering subjects were obtained primarily from the basic public speaking course (Speech 211) at the same university. Random selection procedures were not followed in securing the experimental stuttering group, since only a small and limited population was available. A modified randomization procedure was used, however, in selecting the control group of non-stutterers. In this instance, sections of the basic course were randomly selected and students within each section were asked to participate in the study. Twenty-five control subjects were selected from a group of more than 150 students. These persons were matched with the experimental group on age and sex variables. The older stuttering and nonstuttering subjects were secured primarily from the faculty body at Iowa State University.

Subjects were required to meet the following selection criteria:

1. Were right-handed, as determined by observational data, informal case histories, and self reports.
2. Had normal hearing acuity, as determined by audiometric testing at an intensity level of 20 decibels (dB) for the frequency range of 125 to 6,000 Hertz (ANSI, 1969).
3. Had a negative history of cerebral pathology, or brain damage.

4. Had normal intelligence, as surmised by their educational backgrounds.
5. Had a confirmed stuttering disorder, as determined by a certified speech pathologist (experimental group).
6. Had no background of stuttering, as determined by a certified speech pathologist (control group).
7. Had to be over 18-0 years of age, as determined by self reports.
8. Were speakers of the English language, as determined by observation.

Materials and Equipment

The dichotic word and digit tapes were borrowed from Dr. Ronald K. Sommers, Director of the Speech and Hearing Clinic at Kent State University (See list of words and digits in Appendix C. Starkey and Sommers (1974) prepared the dichotic word test, and Sommers, Brady and Moore (1975) prepared the dichotic digit test. The word test was originally employed as a dichotic word pointing test with accompanying visual stimuli, and were intended for use with young children. The visual stimuli was not utilized in this experiment. Johnson, Sommers and Weidner (1977) described the preparation and nature of the tape:

> The stimulus material consisted of 10 CVC words (stop + vowel + stop) chosen for their high frequency of occurrence in the English language and low vocabulary strength requirements. The words were initially selected for use with young children and were believed to be well within the recognition vocabularies of most normal three-year-old children. The 10 words were arranged into five pairs. For each pair, only the initial stop plosives differed. The nature of the difference consisted of place of articulation, or voicing, or both. Each pair was presented six times,

> with each element of the pair being presented to each ear three times, for a total of 30 pairs. The arrangement of the pairs on the tape was randomized to control for the potentially biasing effect of order. Tape preparation involved the use of an Ampex, Model 602, two-channel tape recorder equipped with a movable playback head. Each member of the pair was first recorded on separate channels of the recorder. Onset times were manually aligned by shifting the playback head and monitoring onsets with a dual beam storage oscilloscope. Alignment was obtained with ± 2 msec. Each pair was recorded onto a master tape. All words were recorded at 90 dB SPL with ± 2-dB variation as monitored on a Bruel and Kjaer sound level recorder. The pairs were separated by a 10-second interval.

A similar procedure was followed in preparation of the dichotic digit test (Sommers, Brady and Moore, 1975). The following digit pairs were presented: 1-8, 2-3, 4-5, and 9-10.

As reported in the previous chapter, Berlin and Cullen (1975) suggest that methodology in dichotic experiments must consider procedures to assure repeatable calibration of absolute intensity levels and channel balance. Berlin and Cullen comment:

> The right-ear superiority is maintained for as much as 10 dB difference near 80 dB. However, if the pivotal sound pressure is near 50 dB SPL, this is not the case. The right-ear superiority is maintained only so long as the difference between the channels does not exceed 5 dB. This highlights the importance of channel balance, as well as absolute intensity, in presenting dichotic signals.

In the present experiment, channel balance and absolute intensity level were measured for both word and digit tapes by a Bruel and Kjaer precision sound level meter, Model 2203. Calibration tones of 750 Hz and 1000 Hz were included on the word and digit tapes respectively. In accordance with procedures suggested by Berlin and Cullen (1975), a criterion level of no greater than 2 dB difference between channels was adopted for this study. Measurements revealed a 4 dB difference in calibration tones between channels on the dichotic word tape. This meant that the tape was not suitable for this experiment. A second problem was also encountered. The tapes had been recorded on a half-track, stereo recorder and no similar instrument was available at Iowa State University for use in this study. Therefore, in order to resolve both problems, the Media Resource Center duplicated the two tapes from A Revox, Model A 77, half-track recorder, onto a SONY, Model TC 353, 2-track, 4-channel stereo recorder. While duplicating the test materials onto Scotch Professional Chromium Dioxide Tape # 206, the calibration tones on the two channels were balanced within 2 dB of each other. Now the tapes were compatible for playback on equipment which was available for the study. The investigator used a SONY, Model TC 270, 2-track, 4-channel stereo recorder for playback purposes.

Attempting to further adhere to the suggestions offered by Berlin and Cullen (1975), the next step was to establish peak sound pressure values for the calibration tones and speech signals. The precision sound level meter and 1/3 octave filter were set on 800 Hz. The tape recorder volume control was adjusted to read 54 dB SPL. This resulted in a peak sound pressure value of 72 dB for the dichotic word test. The same procedure was followed for the digit test with the 1/3 octave band filter set at 1000 Hz. The peak sound pressure values for both the calibration tone and the speech signals were 74 dB. In retrospect, Berlin's recommendation to measure peak sound pressure values for both the calibration tone and the speech signals was a wise procedure to follow in this study. Had the 800 Hz tone on the tape been used to calibrate the speech signal to 74 dB, a serious problem would have resulted. That is, the speech signals would have actually been presented at 92 dB; considerably above the recommended playback level for reliable dichotic testing.

TDH-39, (ANSI Standard, 1969) earphones were selected for use in this experiment. A 20 dB T-pad attenuator was coupled to the sound system to provide a wider volume adjustment control on the tape recorder. This facilitated the researcher in his repeatable calibration procedures.

The sound level meter was equipped with a one-inch condenser microphone, Type 4131 which was capable of measuring sound levels on A, B, or C scales from 10 to 140 dB SPL. It was also equipped with a Model 1613 one third passive octave filter set, capable of measuring sound in octave intervals of center frequencies from 32 Hz through 16,000 Hz. A special collar was employed to hold a 6 cc standard audiometer earphone coupler with a 500 gram (nonmagnetic) weight to simulate headband pressure.

The Beltone portable audiometer, Model 10-D, was employed to test the hearing sensitivity of subjects for the pure tone frequencies ranging from 125 to 6,000 Hertz.

Testing equipment was arranged in a quiet room. Ambient room noise levels were measured with the Bruel and Kjaer sound level meter and found not to exceed 45 dB on the external filter.

Test Administration

The following test administration procedures were adhered to for each of the 50 subjects participating in this experiment.

1. Apparatus and materials were arranged, inspected and prepared for use prior to each testing session. Equipment included the following items:

A. Bruel & Kjaer precision sound level meter
B. Sony, 2-track, 4-channel stereo tape recorder
C. Beltone portible audiometer
D. 20 dB T-pad attenuator
E. Passive octave filter set, Model 1613
F. 500 gram aluminus (nonmagnetic) weight

2. Subjects were not informed about the purpose of the study until after all testing was completed. The examiner did provide an explanation of the type of stimuli employed.

3. Seating was arranged in such a manner that the researcher could easily operate the equipment, give verbal instructions and observe the subject's responses.

4. After seating the subjects and briefly explaining the nature of the task, the following questions were presented to determine handedness:

A. What hand do you use in writing?
B. What hand do you use in scissoring?
C. What hand do you use in combing?
D. What hand do you use in throwing?
E. What hand do you use when holding a spoon?
F. What hand do you use in threading a needle?
G. What hand do you use in snapping your fingers?
H. What hand do you use in winding a watch?
I. What hand do you use when dealing and holding playing cards?

If the subject showed any sign of left-handedness or ambidexterity, he was not included in the study. Subjects were required to show a strong preference for the right hand. One subject was excluded from the study because he showed signs of ambidexterity.

5. Subjects were asked whether they had suffered from any type of brain damage, concussion or disease. A report of any history of neurological dysfunction resulted in dismissal from the study.

6. The ambient room noise was measured with the B & K sound level meter. The noise level was checked before each testing session and was found to not exceed 45 dB. The criterion level set by the researcher for discontinuing testing in the room was 50 dB.

7. A hearing screening test was administered at 20 dB (ISO) for the pure tone frequencies of 125, 250, 500, 1,000, 2,000, 4,000, and 6,000 Hz. Subjects were not included in the study unless their hearing thresholds for these frequencies was 25 dB or better. Five subjects were excluded from the study after testing revealed hearing losses for each of them.

8. Once the nature of the task and instructions for responding had been explained, subjects were required to listen to some dichotic words and digits, in order to become familiar with the type of test materials employed in the experiment. The testing commenced when the examiner was sure the participant understood the task. Subjects were given the following instructions:

> You will hear two different (words, digits) at precisely the same time. Listen to them carefully and tell me which (word, digit) you heard the most clearly. At times, the signals may sound so similar in terms of clarity that you will need to make a decision concerning which is the most clear. Remember, report the (word, digit) which seems to have the best clarity.

The examiner listened to the verbal responses of the subject and recorded them on a prepared answer form (see test forms in Appendix A).

9. The order of testing was randomized among subjects. That is, the dichotic word test was the first test administered 50 percent of the time and on a random basis. The same held true for the dichotic digit test.

10. After completing half of each dichotic test, the earphones were reversed, in order to counterbalance the effect of a channel imbalance.

11. Before each dichotic test was administered, the earphones were calibrated using the B & K sound level meter. They were also rechecked periodically after the test was completed. Calibration measures from the recheck were found to not exceed a 2 dB difference from the initial check. Therefore, the intensity output levels for both earphones were shown to fluctuate by an insignificant amount. Calibration procedures were as follows:

> The calibration tone for the dichotic word test was 750 Hz. The sound level meter, A-scale was set on 800 Hz. The intensity level was adjusted to read 54 dB for both right and left earphones on the meter. The dichotic digit test used a calibration tone of 1,000 Hz. Therefore, the sound level meter was set on A-scale, 1,000 Hz. The intensity level for both ears was adjusted to read 75 dB on the meter.

12. The calibration of the sound level meter was checked both before and after it was used in this experiment. Also, batteries were checked each time before using it. Extensive care was exercised in handling all equipment, especially the sound level meter which was on

loan from the Area Education Agency-11.

13. The tape recorder heads were periodically cleaned, but failed to show much sign of wear.

14. One session of approximately 50 minutes was required for completing the entire test with one subject. The dichotic word test and retest accounted for approximately 18 minutes and the dichotic digit test and retest consumed an estimated 12 minutes. Subjects were given a three-minute rest period while the investigator calibrated the equipment. Hearing testing and debriefing accounted for another ten minutes.

15. The factor of stuttering severity was included in the experiment as a secondary source of variation, only after it became apparent to the investigator that an interesting trend seemed to exist. As the experiment progressed, it appeared that the ear preference was not as pronounced for the more severe stutterers.

There is considerable lack of agreement among speech pathologists, concerning how different variables should be weighted in determining severity ratings for stutterers. In this experiment, however, the examiner made an arbitrary and subjective judgment concerning each subject's level of stuttering severity. The examiner's judgement in assigning severity ratings was influenced, in part, by his clinical experience in treating more than 150 stutterers.

A rating of severity was determined for each stutterer using information collected from informal case histories, therapy reports from the Iowa State University Speech & Hearing Clinic, and general observations by the examiner. The rating of zero was assigned to all members of the nonstuttering control group. The following severity scale was used in assigning ratings to the experimental group of stutterers:

1 = slightly severe
2 = mildly severe
3 = moderately severe
4 = markedly severe

The examiner clearly recognized the limitations and faults in employing this source of variation without control of biasing effects. For instance, it would be difficult to generalize any definite conclusions from the data since intra-judge reliability could not be determined. Moreover, an inherent problem existed in assessing exactly what criteria were actually used by the examiner in making judgments of severity, and whether these same criteria were used to rate all subjects. The examiner attempted to follow the same subjective guidelines in making judgments of severity for all stutterers. Nevertheless, it was reasoned that any tentative findings regarding the severity variable would be of some value, and serve as impetus to investigators planning future dichotic research with the stuttering population.

The following chapter will report the findings from this experiment.

CHAPTER 4. FINDINGS

The purpose of this study was to investigate the dichotic ear preferences for words and digits among a right-handed adult population of 25 stutterers and 25 nonstutterers. A 2 X 2 X 2 full factorial design included the classes of group, task, and time tested. Two other variables: sex and severity of stuttering, were included in a second level of analysis. The F-test of significance for the analysis of variance was used to statistically analyze the data. Regression analysis and the Pooled T-test were also employed to test hypotheses three, four and five.

Subjects were matched on the basis of sex and age factors. There were 21 males and four females in each group. The ages ranged from 18 to 51 years with an overall mean of 25.94 for the experimental group and 25.73 for the control group. The Pooled T-test was employed to compare ages among the two research groups and confirmed the suspicion that there was no statistical difference between them, as tested at the 01. level of significance. The calculated T-value for 24 degrees of freedom was .11 (see Appendix A for the raw data concerning age).

Full Model Analysis

Since there were an unequal number of male and female subjects included in this experiment, 21 males and four females in each group, no separate and detailed statistics could be performed on this variable. However, by computing a separate ANOVA on male subjects only, a comparison was made possible with earlier findings which did employ both male and female subjects. Close inspection of the findings revealed that no noticeable change in means and F-values had taken place. Therefore, inclusion of the female subjects in this study was found to have little effect on the group means and ANOVA findings.

The original 2 X 2 X 2 model was also reduced by eliminating the variable of time-tested. Subjects had been presented a first and second administration of the dichotic word and digit tasks. Inspection of early ANOVA findings, using the full model, revealed that the time-tested factor was not statistically significant as a main effect, nor did it contribute much toward significance in any interaction effects. Negligible differences were apparent when comparing the ANOVA findings for both the full and reduced models. Consequently, by eliminating the time factor, the experimental model was changed from a 2 X 2 X 2 to a 2 X 2 full factorial design. The ANOVA and means tables for the full model (including the variable of time-tested) can be found in Appendix B.

Tests of Hypotheses

The first three null hypotheses were:

1. There is no significant difference between the ear preference for the experimental and control group.

2. There is no significant difference between the ear preference for the dichotic word and ear preference for the dichotic digit tasks.

3. There is no significant interaction effect on ear preference for group and task.

Null hypotheses one, two and three were tested by the F-test of significance for the analysis of variance using proportion data. The ANOVA findings in Table 1 are displayed as follows:

Table 1. Analysis of variance for right ear responses on group, test, and interaction between group and test

Source of variation	df	Sum of squares	Mean squares	F-test Computed F-value	F-test Prob > F
Group	1	193.210	193.210	4.213	0.043
Std (Grp)	48	2200.800	45.850		
Test	1	30.250	30.250	1.816	0.181
Residual	48	799.360	16.653		
Group X Test	1	10.890	10.890	.653	0.571
Residual	48	799.360	16.653		
Corrected Total	99	3234.510	32.671		

As evidenced by the ANOVA findings, the proportion data were sufficient to reject null hypothesis number one at the .05 level of significance. This same conclusion was reached when the hypothesis was tested by ANOVA using count and arcsin transformed data. Therefore, a significant difference was found to exist in ear preference for the experimental and control groups. The means, reported as proportions in Table 2 below, illustrate the direction of this difference.

Table 2. Right ear response means for group and test

	Test 1	Test 2	
Stutterers	.599	.550	.574
Nonstutterers	.658	.645	.651
	.628	.598	

The nonstuttering group demonstrated a significantly greater proportion of right ear responses than did the stuttering group. Thus, the major hypothesis was supported by the findings of this study. That is, stutterers were found to be more mixed than right hemispheric dominant for speech. This conclusion is true insofar as the technique of dichotic listening is an accurate indicator of cerebral dominance.

The data were insufficient to reject null hypotheses two and three at the .05 level of significance. Therefore, these null hypotheses were tenable, indicating that there were no significant differences in ear responses for the dichotic word and digit tests. Furthermore, no significant interaction occurred between group and test. The means of proportion in Table 2 illustrate the similarity of responses for stutterers on the two tests, as well as for nonstutterers on the same measures. Finally, negligible differences were noted when the same hypotheses were tested by ANOVA using count, and arcsin transformed data.

Null hypotheses four, five and six are restated below:

4. There is no significant difference in ear preference and level of stuttering severity for the experimental group.

5. There is no significant difference in dichotic tests for the experimental group.

6. There is no significant interaction effect on ear preference between test and stuttering severity among the experimental group.

Null hypotheses four, five and six were tested by regression procedures which generated dummy variables for the unequal cell numbers. The findings from the regression analysis using proportion data are reported in Table 3 below:

Table 3. Regression findings for right ear responses on severity, test and interaction between severity and test

Source of variation	df	Sum of squares	Mean squares	F-test Computed F-value	F-test Prob > F
Severity	3	.223	.074	01.72	> 0.100
Std(Severity)	21	.912	.043		
Test	1	.034	.034	3.622	0.0678
Test X Severity	3	.023	.007	0.819	0.5002
Residual	21	.199	.009		
Corrected Total	49				

As supported by the regression findings, the proportion data were sufficient to reject null hypothesis number four above the .25 level of significance. This same conclusion was found when the hypothesis was tested with two other regression procedures which employed count and arcsin transformed data. Therefore, a significant difference was found to exist for the experimental group between ear preference and stuttering severity. The means, displayed as proportions in Table 4, illustrates the direction of this difference.

Inspection of the means table indicates that level one stutterers demonstrated a significantly greater proportion of right ear responses than did stutterers in levels two, three and four. A Pooled T-test was employed to test the differences between the overall means of level one versus levels two, three and four combined. The calculated T-value for 21 degrees of freedom was 2.252. The probability level(two-tailed test) was 2.080 at the .05 level of significance. Therefore, the T-test supported a significant difference between severity level one and levels two, three and four combined on overall right ear responses. Thus the least severe stutterers responded similarly to the nonstuttering group, but the other stutterers failed to show a strong right ear preference typical of nonstutterers. This is one of the most interesting findings of the study and supports the Cerebral Dominance Theory of stuttering. Furthermore, these results have not been reported in earlier studies of dichotic listening with stutterers. It would appear, then, that mixed dominance is related to the level of stuttering severity. As the level of severity increases, the right ear preference weakens and moves toward a mixed ear preference.

Table 4. Right ear response means for level of stuttering severity

Severity	Word Test	Digit Test	
Level 1	.6630	.6736	.6684
Level 2	.5992	.5079	.5536
Level 3	.5278	.4778	.5028
Level 4	.5667	.4833	.5250
	.5989	.5500	

The proportion data were not sufficient to reject null hypotheses five and six at the .05 level of significance. This same conclusion was reached when the hypotheses were tested with two other regression analysis procedures employing count and arcsin data. Thus, the null hypotheses five and six were tenable and it appears that there is no significant overall difference between word and digit test, and interaction effect for Severity X Test among the experimental group. However, a .0678 probability level was found for the variable of test (hypothesis five). This finding, close to being statistically significant at the .05 alpha level, indicates a difference existed at the .10 alpha level between stutterers' right ear responses to the dichotic word and digit tests. Inspection of the means reveals that level one stutterers responded in approximately the same manner for both dichotic tests. However, level two, three and four stutterers demonstrated a higher proportion of right ear responses to the word than the digit test.

A Pooled T-test was employed to test the difference between the overall means for the word and digit tests. Word test means were compared for level one stutterers versus level two, three and four stutterers combined. The calculated T-value for 21 degrees of freedom was 1.506. The probability level(two-tailed test) was 2.080. Therefore, the T-test finding was not significant at the .05 alpha level. Digit test means were compared in the same way and resulted in a calculated T-value of 7.799 for 21 degrees of freedom. The probability valu. for a two-tailed test at the .05 level was 2.08, indicating a highly significant difference existed between level one stutterers and level two, three and four stutterers on the digit test. Therefore, level one stutterers demonstrated a strong right ear preference for both word and digit tests. However, level two, three and four stutterers, when compared with level one stutterers, were not found to respond significantly different on the word test. They were found to respond significantly different on the digit test. Level two, three and four stutterers demonstrated a weaker right ear preference for digits than did level one stutterers. Therefore, the Cerebral Dominance Theory was upheld primarily by findings from the digit test.

Finally, the proportion data were insufficient to reject null hypothesis number six at the .05 level of significance. This same conclusion was found when the hypothesis was tested with two other regression procedures which employed count and arcsin transformed data. Therefore, the alternative hypothesis was tenable, indicating no significant interaction effects existed between the severity levels of stuttering and the dichotic tests.

CHAPTER 5. SUMMARY AND RECOMMENDATIONS

The cause of stuttering continues to remain a mystery. There have been numerous theoretical explanations postulated, in an attempt to find the answer to this age-old speech disorder. Included among the etiologies espoused is the Cerebral Dominance Theory, originally advocated by Orton (1927) and Travis (1931). The theory proposes that stuttering is caused by a mixed brain dominance for speech control. In other words, it is hypothesized that stuttering results from competition between the two brain hemispheres in controlling speech. This cortical competition leads to imprecise motor timing of neural impulses mediating the paired speech musculature.

The present investigation attempted to test the Cerebral Dominance Theory by utilizing a dichotic listening task to determine hemispheric speech dominance for a group of 25 stuttering and 25 nonstuttering adults. Dichotic listening is a technique whereby two different signals are presented simultaneously with one signal being directed to each ear. More than 300 dichotic listening experiments have rather firmly substantiated a pattern of right ear preference (REP)among the normal right-handed population. Furthermore, it has been hypothesized that the REP is indicative of a left-hemispheric dominance for speech control due to a prepotency of the crossed neural pathways (Kimura, 1961). In order to support the Cerebral Dominance Theory for stuttering, then, one would expect to find a left ear or mixed ear preference for dichotic speech stimuli.

Dichotic listening studies involving stutterers have resulted in mixed findings. Some researchers have not found a REP among the stuttering population tested (Curry & Gregory, 1969; Mattingly, 1970; Perrin & Eisenson, 1970; and Sommers, Brady & Moore, 1975). Other investigators, however, have found a REP among stuttering groups, which would indicate their dominance pattern was no different from the normal population of right-handers (Sussman & MacNeilage, 1975; Quinn, 1972; Slorach & Noehr, 1973; Cerf & Prins, 1974; and Dorman & Porter, 1975).

The present investigation has also yielded findings which support the Cerebral Dominance Theory of stuttering. Stutterers demonstrated a significantly weaker REP than nonstutterers on overall dichotic responses. A repeatable measure utilizing the same groups confirmed these findings. However, the most interesting discovery, not reported in earlier dichotic studies involving stutterers was that the REP weakened as the severity level of stuttering increased. Conversely, the typical REP found among the normal population would be more evident for the less severe stutterers. While it is recognized that the research procedures related to this aspect of the study are subject to criticism, the findings are still of considerable interest. Level two, three and four stutterers demonstrated a significant difference between level one stutterers on the digit test. The more severe stutterers demonstrated a mixed ear preference for dichotic digits, and level one stutterers showed a right ear preference for dichotic digits. Also, level one stutterers had a stronger REP for words than the more severe stuttering subjects.

The question of inconclusive findings among stutterers for dichotic listening tasks is still perplexing. The answer may lie in the control of acoustic variables. Berlin and Cullen (1975) emphasize the importance of controlling acoustic variables when performing dichotic experiments. Moreover, they point out that the REP will vary under certain conditions such as; poor signal-to-noise ratio, tape recorder channel imbalance, high intensity playback level, and so forth. Therefore, the unclear findings of dichotic listening studies employing stutterers may be partially due to improper control of acoustic parameters during testing.

The investigator was extremely careful in this experiment to control for acoustic factors which would bias the results. For instance, the tape recorded materials were carefully prepared and checked for improper channel balance, playback level, alignment of signals, and signal-to-noise ratio. Throughout the study, the researcher vigilantly maintained tight control over acoustic variables. The calibration procedures employed were an inherent strength of the study.

The research model in the present experiment was a 2 X 2 X 2 full factorial design (Winer, 1962). Class variables included were: group (stutterers versus nonstutterers); test (dichotic word versus dichotic digit task); and time (first time versus second time tested). A second level of analysis included the variable of sex (male versus female). The variables of time and sex were found to be insignificant factors in the study and failed to have much effect on the findings. Therefore, they were eliminated from the original 2 X 2 X 2 research model. Analysis of variance, regression analysis and the Pooled T-test were the statistical procedures selected to test the research hypotheses.

In order to test the Cerebral Dominance Theory of stuttering, the following null hypotheses were proposed:

1. There is no significant difference between the ear preference for the experimental and control group.

2. There is no significant difference between the ear preference for the dichotic word and ear preference for the dichotic digit tasks.

3. There is no significant interaction effect on ear preference for group and task

4. There is no significant difference in ear preference and level of stuttering severity for the experimental group.

5. There is no significant difference in dichotic tests for the experimental group.

6. There is no significant interaction effect on ear preference between test and stuttering severity among the experimental group.

Four null hypotheses failed to be rejected at the .05 level of significance. These included hypotheses number two, three, five and six. Null hypotheses number one and four were rejected at the .05 level of significance.

Conclusions

In summarizing the findings from this study, the following conclusions were made:

1. As a group, nonstuttering adults demonstrated a REP for dichotic speech tasks. However, stutterers failed to demonstrate a REP and were found to be mixed ear dominant. This finding adds support

to the notion that stutterers, as a group, have a mixed hemispheric dominance for speech.

2. There was no significant difference between the overall responses to the dichotic word and digit tests. That is, both groups combined failed to show a strong difference on the two measures.

3. The findings failed to reveal a significant interaction effect on ear preference for group and task.

4. A statistically significant difference was found, as revealed by regression analysis, for ear preference and stuttering severity among the experimental group. Level one stutterers demonstrated a stronger REP than level two, three and four stutterers combined. The more severe stutterers showed a weaker REP and conversely a stronger mixed ear preference.

5. Regression analysis failed to reveal a significant difference at the .05 alpha level for ear preferences between the word and digit tests. However, a significant difference was found at the .10 alpha level. In addition, findings from the Pooled T-test indicated a highly significant difference existed between stutterers' responses on the word and digit tests. Level one stutterers responded similarly to the nonstuttering group on both measures by showing a REP. However, level two, three and four stutterers showed a highly significant difference from level one stutterers on the dichotic digit test. In this case, a significantly weaker REP was noted for the more severe stutterers (levels two, three and four). The more severe stutterers demonstrated a mixed ear preference on the digit test and a slight REP on the word test.

6. There were no significant interaction effects on ear preference between test and stuttering severity for the experimental group.

Strengths and Weaknesses of the Study

Strengths

1. Subjects were matched closely on age and sex variables.

2. Acoustic variables were stringently controlled throughout the experiment.

3. A uniform pattern of test presentation was adhered to for each subject.

4. The dichotic test materials were appropriate for testing the hypotheses.

Weaknesses

1. The sample was not drawn from a random population, making generalization of the findings difficult.

2. A standardized measure was not employed to determine handedness.

3. Stuttering severity was rated by a single judge, and the criteria employed for each stuttering severity level was not clearly defined.

Recommendations

Based upon the findings of this experiment, the following recommendations are proposed for future dichotic listening studies involving stutterers:

1. Select a random population of stutterers if possible.

2. Adhere to strict control measures for acoustic variables relevant to the study.

3. Use several standardized instruments to determine handedness, footedness, and eyedness, rather than a single measure.

4. Develop a detailed severity rating system for stuttering, which has a clearly established set of criteria.

5. Sample a population of male and female child stutterers to determine dichotic ear preference for each group. Such a study may shed light on the high sex ratio incidence among the stuttering population.

6. Compare other measures of cerebral dominance with the dichotic listening technique. Possibly, a battery of measures would be even more sensitive in determining the degree of cerebral dominance.

7. Complete a detailed analysis of stuttering development patterns, to determine whether any significant correlation exists between the pattern of stuttering and the degree of cerebral dominance, as measured by dichotic listening.

8. Plan further studies to determine the relationship between the severity of stuttering and ear dominance, while adhering to suggestions outlined in items one through four above.

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APPENDIX A. AGE LEVELS FOR GROUPS

Experimental Group		Control Group	
Subject	Age	Subject	Age
1	21-9	1	21-8
2	20-9	2	35-5
3	35-6	3	19-7
4	18-10	4	22-10
5	26-3	5	22-5
6	51-2	6	18-8
7	34-10	7	26-0
8	20-1	8	20-7
9	22-5	9	25-6
10	19-2	10	19-8
11	22-5	11	23-4
12	31-10	12	21-9
13	23-0	13	22-8
14	36-10	14	49-11
15	19-7	15	36-3
16	25-1	16	27-4
17	28-2	17	26-10
18	23-5	18	23-10
19	23-2	19	26-7
20	27-4	20	18-10
21	25-10	21	20-3
22	19-18	22	22-9

Experimental Group		Control Group	
Subject	Age	Subject	Age
23	21-9	23	25-0
24	22-6	24	31-2
25	27-4	25	34-2

APPENDIX B. MEANS AND ANOVA FINDINGS FOR FULL FACTORIAL MODEL 2 X 2 X 2

Table 5. ANOVA findings for full model (including the time tested factor)

Source of variation	df	Sum of squares	Mean squares	F-test: Computed F-value	F-test: Prob>F
Group	1	0.432	0.432	6.752	0.0119
Std(Grp)	48	3.077	0.064		
Test	1	0.012	0.012	2.590	0.1068
Residual	96	0.464	0.004		
Test	1	0.012	0.012	0.195	0.664
Std(Grp)	48	3.077	0.064		
Time	1	0.0008	0.0008	0.179	0.676
Residual	96	0.4644	0.0048		
Group X Time	1	0.012	0.012	2.590	0.106
Residual	96	0.0464	0.004		
Test X Time	1	0.010	0.010	2.239	0.133
Residual	96	0.464	0.004		
Group X Test X Time	1	0.011	0.011	2.412	0.0119
Residual	96	0.464	0.004		
Corrected Total	199	5.289	0.026		

Table 6. Means for full model 2 X 2 X 2

Group	X	Test	X	Time	N	Means (Proportion)
Stuttering		Word		1st	25	0.598
Stuttering		Word		2nd	25	0.587
Stuttering		Digit		1st	25	0.550
Stuttering		Digit		2nd	25	0.537
Nonstuttering		Word		1st	25	0.657
Nonstuttering		Word		2nd	25	0.647
Nonstuttering		Digit		1st	25	0.645
Nonstuttering		Digit		2nd	25	0.695

Test	X	Time	N	Means (Proportions)
Word		1st	50	0.628
Word		2nd	50	0.617
Digit		1st	50	0.597
Digit		2nd	50	0.616

Group	X	Time	N	Means (Proportions)
Stuttering		1st	50	0.574
Stuttering		2nd	50	0.562

Table 6 (continued)

Group X	Time	N	Means (Proportion)
Nonstuttering	1st	50	0.651
Nonstuttering	2nd	50	0.671

Time	N	Means (Proportion)
1st	100	0.613
2nd	100	0.617

Group X	Test	N	Means (Proportion)
Stuttering	Word	50	0.593
Stuttering	Digit	50	0.543
Nonstuttering	Word	50	0.652
Nonstuttering	Digit	50	0.670

Test	N	Means (Proportion)
Word	100	0.623
Digit	100	0.607

Table 6 (continued)

Group	N	Means (Proportion)
Stuttering	100	0.568
Nonstuttering	100	0.661
Overall means	200	0.615

APPENDIX C. DICHOTIC TEST MATERIALS

NAME________________________________ GROUP: EXPERIMENTAL CONTROL

B/DATE________________AGE____________DATE________________RETEST______________

DICHOTIC LISTENING TEST

RIGHT EAR	LEFT EAR	RIGHT EAR	LEFT EAR
TOP	POP	BUN	GUN
BUN	GUN	CAT	BAT
GOAT	COAT	DIG	PIG
PIG	DIG	CAT	BAT
GUN	BUN	GUN	BUN
COAT	GOAT	COAT	GOAT
PIG	DIG	BALL	DOLL
DOLL	BALL	BAT	CAT
BAT	CAT	PIG	DIG
DIG	PIG	DOLL	BALL
BALL	DOLL	POP	TOP
BAT	CAT	DIG	PIG
POP	TOP	BALL	DOLL
GUN	BUN	GOAT	COAT
CAT	BAT	POP	TOP
DOLL	BALL	BUN	GUN
TOP	POP	COAT	GOAT
GOAT	COAT	TOP	POP

(REVERSE EAR PHONES)

TOTAL RIGHT EAR__________ RETEST ______

TOTAL LEFT EAR __________ RETEST ______

NAME ____________________ GROUP: EXPERIMENTAL CONTROL

DATE OF BIRTH ____________ AGE ________ DATE ________ RETEST ___

DICHOTIC DIGIT TEST

RIGHT EAR	LEFT EAR	RIGHT EAR	LEFT EAR
5-3-8	4-2-1	2-1-10	3-8-9
1-10-2	8-9-3	1-2-10	8-3-9
5-3-9	4-2-10	2-9-5	3-10-4
1-3-9	8-2-10	1-3-10	8-2-9
5-3-4	4-2-5	2-1-4	3-8-5
1-10-5	8-9-4	1-10-5	8-9-4

(REVERSE EAR PHONES)

TOTAL RIGHT EAR ________ RETEST ______

TOTAL LEFT EAR ________ RETEST ______