INFORMATION TO USERS

This reproduction was made from a copy of a document sent to us for microfilming. While the most advanced technology has been used to photograph and reproduce this document, the quality of the reproduction is heavily dependent upon the quality of the material submitted.

The following explanation of techniques is provided to help clarify markings or notations which may appear on this reproduction.

1. The sign or "target" for pages apparently lacking from the document photographed is "Missing Page(s)". If it was possible to obtain the missing page(s) or section, they are spliced into the film along with adjacent pages. This may have necessitated cutting through an image and duplicating adjacent pages to assure complete continuity.

2. When an image on the film is obliterated with a round black mark, it is an indication of either blurred copy because of movement during exposure, duplicate copy, or copyrighted materials that should not have been filmed. For blurred pages, a good image of the page can be found in the adjacent frame. If copyrighted materials were deleted, a target note will appear listing the pages in the adjacent frame.

3. When a map, drawing or chart, etc., is part of the material being photographed, a definite method of "sectioning" the material has been followed. It is customary to begin filming at the upper left hand corner of a large sheet and to continue from left to right in equal sections with small overlaps. If necessary, sectioning is continued again—beginning below the first row and continuing on until complete.

4. For illustrations that cannot be satisfactorily reproduced by xerographic means, photographic prints can be purchased at additional cost and inserted into your xerographic copy. These prints are available upon request from the Dissertations Customer Services Department.

5. Some pages in any document may have indistinct print. In all cases the best available copy has been filmed.
AUDITORY MEMORY OF PERSONS WITH
DOWN'S SYNDROME

DISSERTATION

Presented in Partial Fulfillment of the Requirements for
the Degree Doctor of Philosophy in the Graduate
School of The Ohio State University

By

Phoebe I. Parker, B.Mus.Ed., M.A.

*****

The Ohio State University

1984

Reading Committee:
Henry Leland, Ph.D.
Gary Bernston, Ph.D.
Steven Beck, Ph.D.

Approved by:

[Signature]
Adviser
Department of Psychology
© Copyright by Phoebe I. Parker 1984
ACKNOWLEDGMENTS

I would like to acknowledge the people who have supported and guided me throughout the research process of this dissertation. Thanks go to faculty members, Dr. Peter Costanza, Dr. Steven Beck, Dr. Gary Bernston, and especially to Dr. Henry Leland, my adviser.

Great appreciation is given to Gayle Kranz for her help and belief in my professional abilities and to Doug McElwain for his time and guidance through the final steps of research.

And special affection goes to my parents for instilling a belief in striving toward academic goals and to Greg Fuller for his constant encouragement and patience throughout the whole research process.
VITA

August 9, 1953.............................. Born - Springfield, Ohio

1975...................................... B.Mus.Ed.
The Ohio State University
Columbus, Ohio

1976-1978.............................. Research Assistant
Music Therapy Department
Texas Woman's University
Denton, Texas

1978-1980.............................. Music Therapist
Connecticut Department of
Mental Retardation

1980...................................... M.A.
Texas Woman's University
Denton, Texas

1980-1981.............................. Research Assistant
The Nisonger Center
The Ohio State University
Columbus, Ohio

1981-1982.............................. Psychology Trainee
The Nisonger Center
The Ohio State University
Columbus, Ohio

1982-1984.............................. Psychology Clinic Coordinator
The Nisonger Center
The Ohio State University
Columbus, Ohio

PUBLICATIONS


VITA (cont'd)

FIELDS OF STUDY

Major Field: Developmental Psychology

Studies in Mental Retardation: Henry Leland, Ph.D.
Studies in Behavior Modification: Robert Fox, Ph.D.
Studies in Music Therapy: Donald E. Michel, Ph.D.
# TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>ACKNOWLEDGMENTS</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>11</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>VITA</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>III</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>LIST OF TABLES</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>vii</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>CHAPTER</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

## I INTRODUCTION

<table>
<thead>
<tr>
<th>Statement of the Problem</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>4</td>
</tr>
<tr>
<td>Purpose</td>
<td>5</td>
</tr>
<tr>
<td>Objectives</td>
<td>5</td>
</tr>
</tbody>
</table>

## II REVIEW OF THE LITERATURE

<table>
<thead>
<tr>
<th>Music and Memory</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>7</td>
</tr>
<tr>
<td>Overview of Hemispheric Dominance</td>
<td>11</td>
</tr>
<tr>
<td>Physiological Aspects of Audition</td>
<td>21</td>
</tr>
<tr>
<td>Localization Research of Brain-Damaged Patients</td>
<td>25</td>
</tr>
<tr>
<td>Dichotic Presentations</td>
<td>31</td>
</tr>
<tr>
<td>Monaural Presentations</td>
<td>36</td>
</tr>
<tr>
<td>Implications of Hemispheric Specialization</td>
<td>40</td>
</tr>
</tbody>
</table>

## III METHOD

<table>
<thead>
<tr>
<th>Subjects</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>42</td>
</tr>
<tr>
<td>Apparatus</td>
<td>45</td>
</tr>
<tr>
<td>Procedure</td>
<td>46</td>
</tr>
<tr>
<td>Experiment 1</td>
<td>46</td>
</tr>
<tr>
<td>Experiment 2</td>
<td>49</td>
</tr>
<tr>
<td>Testing Procedure</td>
<td>51</td>
</tr>
</tbody>
</table>

## IV RESULTS

<table>
<thead>
<tr>
<th>Experiment 1</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>52</td>
</tr>
<tr>
<td>Experiment 2</td>
<td>56</td>
</tr>
</tbody>
</table>

## V DISCUSSION

<table>
<thead>
<tr>
<th></th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>59</td>
</tr>
<tr>
<td>Appendixes</td>
<td>Page</td>
</tr>
<tr>
<td>------------------------------------------------</td>
<td>------</td>
</tr>
<tr>
<td>A. Verbal and Written Explanations to</td>
<td>69</td>
</tr>
<tr>
<td>Participants or Guardians of Participants</td>
<td></td>
</tr>
<tr>
<td>B. Consent Form</td>
<td>72</td>
</tr>
<tr>
<td>C. Experimental Phrases</td>
<td>74</td>
</tr>
<tr>
<td>D. Trial Phrases</td>
<td>76</td>
</tr>
<tr>
<td>E. Answer Sheets</td>
<td>78</td>
</tr>
<tr>
<td>F. Raw Data for Experiment 1</td>
<td>82</td>
</tr>
<tr>
<td>G. Raw Data for Experiment 2</td>
<td>85</td>
</tr>
</tbody>
</table>

REFERENCES................................................................. 87
<table>
<thead>
<tr>
<th>Table</th>
<th>Description/Analysis</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Description of Subjects</td>
<td>43</td>
</tr>
<tr>
<td>2</td>
<td>Mean Scores and Standard Deviations of Verbal Sequential Responses</td>
<td>53</td>
</tr>
<tr>
<td>3</td>
<td>Analysis of Variance for Verbal Sequential Responses</td>
<td>54</td>
</tr>
<tr>
<td>4</td>
<td>Mean Scores and Standard Deviations of Verbal Recall Responses</td>
<td>55</td>
</tr>
<tr>
<td>5</td>
<td>Analysis of Variance of Verbal Recall Responses</td>
<td>55</td>
</tr>
<tr>
<td>6</td>
<td>Mean Scores and Standard Deviations of Sorting Responses</td>
<td>57</td>
</tr>
<tr>
<td>7</td>
<td>Analysis of Variance of Sorting Responses</td>
<td>58</td>
</tr>
</tbody>
</table>
CHAPTER I

INTRODUCTION

Many persons who have been diagnosed as having mental retardation, and who are unable to function effectively in public schools or in competitive community employment, attend pre-vocational classes or are employed by sheltered workshops in order to learn vocational skills. These skills may be necessary for acceptance into the work force beyond the workshop setting. The students and employees may be taught a wide variety of skills or jobs to maximize their versatility, and therefore, their marketability. Since many varied tasks are taught, methods to facilitate and expedite the learning process of such tasks could benefit the operation of the classroom or workshop as well as contribute to the knowledge of cognitive processing in the person with mental retardation.

One such method could be the addition of music into the training environment. Music has been a medium used with mentally retarded persons in recreational, educational, and therapeutic modes to accomplish various goals in various settings. A prevalent area of music research has been the use of music as a reinforcer for desirable behaviors (Dorow, 1975; Saperston, Chan, Morpew, & Carsurd, 1980; Underhill & Harris, 1974). Another less studied, but no less important research area, is the performance of persons in
music versus non-music settings. Cotter (1971) found that mentally retarded adolescents increased their work production while listening to music as opposed to periods of silence. Forsythe (1975) found that elementary school students were on-task more frequently in music class than in their regular classrooms. The use of music to facilitate a verbal task is researched less often. However, Isern (1959, 1961) did study the influence of music on the memory of mentally retarded persons and found that her subjects recalled significantly more information from songs than from spoken stories. All of the articles cited above demonstrate an advantage when music is used in conjunction with learning and performing various tasks. Such music research also indicates the advantages that music may provide in the improvement of behavioral or cognitive responses of individuals. Unfortunately, applied music research has seldom explored the cognitive or auditory processes which may be affected or utilized by music, thereby contributing mainly to the behavioral aspects and sparingly to the cognitive aspects of musical stimuli.

One discipline that has studied the cognitive and auditory processing of music has been that of neurology. Within neurology, the research area pertaining to cerebral dominance has especially explored music in relation to cognitive processing. The study of cerebral dominance for music is often tied to the study of cerebral dominance for speech since both are auditory mediums which are specific as to their structure and seem to be processed in the temporal lobe of opposite hemispheres. Studies of individuals with brain lesions of the left or right temporal lobe indicate a left
hemispheric dominance for speech and a right dominance for music (Kimura, 1961, 1964; Milner, 1962, 1967). Subjects who have undergone brain bisections demonstrate a left hemispheric dominance for language but with a capability for some language comprehension in the right hemisphere (Gazzaniga, 1968, 1970, 1974). In studies of non-brain-damaged persons, using dichotic presentations with melodic stimuli in one ear opposing verbal stimuli in the other ear, subjects have demonstrated a right-ear advantage for recall of verbal material, and a left-ear advantage for the recall of music material (Jellison, 1976; King & Kimura, 1972). Dichotic presentations, however, have been found to be unnecessary to produce a right-ear dominance for the recall of speech presentations in normal persons. Burns and Manning (1981) found superior recall when word lists were presented to the right ear regardless of whether or not masking was presented in the contralateral ear. Hartley (1981), however, found that children with Down's Syndrome have reversed dominance from the general population, demonstrating a left-ear advantage for speech.

The current investigation intends to focus on the effects of music and/or single-channel presentations on the recall of verbal material by persons with Down's Syndrome. Music has historically been a positive influence on the behavior of retarded individuals, and recent studies indicate that single-channel verbal input may improve the verbal recall of some persons. If music, or single-channel presentations, are found to improve performance in persons with Down's Syndrome, then a contribution to the education of the retarded will have been made. Utilizing knowledge from the music
and neuropsychology literature may help to determine a means of more effectively delivering verbal stimuli to persons with Down's Syndrome, thereby contributing to applied, as well as more experimental, areas of research.

**Statement of the Problem**

The use of dichotically presented verbal stimuli was previously examined by this author (Parker, 1980) when measuring verbal recall of flattened versus normal speech with normal adult subjects. The results indicated no significant differences between groups receiving normal, flattened, or dichotically presented (normal/flattened) speech, but the study utilized normal subjects with no apparent brain damage and verbal presentations which varied only slightly in melodic content.

Studies using brain-damaged individuals (Assal, 1974; Kimura, 1961a, 1961b, 1964; Milner, 1962, 1967; Milner, Branch, & Rasmussen, 1964; Shankweiler, 1966) indicate a cerebral dominance for language and melody in both dichotic and non-dichotic presentations of stimuli. There is a need for applied research in the area of auditory presentations to retarded persons to determine if such individuals might better be served in training environments by variable forms of auditory input. If music or laterally presented stimuli can affect favorable change in the retarded person's production, then modifying current procedures to include sung presentations or laterally presented verbalizations would seem beneficial to both a training situation as well as to the learner himself.
Purpose

The purpose of this Investigation is to study the effects of music and single-channel verbal stimuli on the verbal memory and task performance of persons who have been diagnosed as having Down's Syndrome. With the exception of Isern (1959, 1961), little research has been performed to investigate music as a means of improving the memory of retarded persons. And, although studies have been performed with brain-damaged individuals to explore the auditory processing of such individuals (Assal, 1974; Kimura, 1961a, 1961b, 1964; Milner, 1962, 1967; Milner, et al., 1964; Shankweller, 1966), to the author's knowledge, these individuals were not diagnosed as mentally retarded nor were they tested on applied musical or single-channel memory tasks.

The major goal of this Investigation is to explore a more effective means of presenting auditory verbal input to a population with Down's Syndrome that could readily be implemented in a training or vocational setting.

Objectives

1. To evaluate the auditory memory of persons with Down's Syndrome by requiring them to repeat three-word phrases heard verbally and melodically.
2. To evaluate the auditory memory of persons with Down's Syndrome by requiring them to sort three objects in the order heard when the names of the objects are presented verbally and melodically.
3. To evaluate the auditory memory of persons with Down’s Syndrome by requiring them to repeat three-word phrases heard in either the right or left ear.

4. To evaluate the auditory memory of persons with Down’s Syndrome by requiring them to sort three objects in the order heard when the names of the objects are presented in either the right or left ears.
CHAPTER II
REVIEW OF THE LITERATURE

Music and Memory

Children who have been diagnosed as having Down's Syndrome, regardless of intellectual functioning, are almost always language delayed unless there is an intense therapeutic intervention at an early age. In particular, auditory memory has historically been described as a primary area of psycholinguistic deficit in persons with Down's Syndrome. Bilovsky and Share (1965) administered the Illinois Test of Psycholinguistic Ability to 24 persons with Down's Syndrome who had varying I.Q. levels, and found overall strengths to be in areas of motor encoding and visual decoding channels with weaknesses in auditory-vocal channels or automatic sequential tasks.

In studying the psycholinguistic abilities of mentally retarded children of varying etiologies (Down's Syndrome, biological brain damage, environmental, and unknown), Rohr and Burr (1978) contrasted the relationships of visual ability with its auditory counterpart and found that, with the exception of association processes, each visual process score was significantly higher than the relative auditory process score. For the subjects with Down's Syndrome, every visual ability score was significantly higher than its auditory counterpart, and all verbal-auditory abilities (except expression) were performed
at a significantly lower level than that performed by any of the other etiological groups. Further exploring cognitive processes of mentally retarded persons with various etiologies, Snart, O'Grady, and Das (1982) studied coding and planning factors in three subgroups (brain damage, Down's Syndrome, and unknown etiology) of moderately retarded individuals. The authors found that both the brain-damaged and unknown etiological groups performed significantly better in the area of successive (versus simultaneous) processing than did the Down's Syndrome group, whose greatest deficit was again in the area of auditory sequential memory.

Such studies as those described above, indicate a need to examine cognitive processes of mentally retarded persons not just in relation to their level of cognitive functioning, but more precisely in relation to specific etiological variables. To facilitate training of the mentally retarded, researchers must explore more fully, the specific cognitive processes of specific etiological groups.

Auditory memory seems to be one cognitive process of importance to study in persons with learning disabilities. Not only is it an overall weakness and necessary consideration when training persons with mental retardation; it is even found to be significantly related to reading achievement (Bruininks, 1969). Music has been one training mode used to improve the auditory memory of handicapped children. Weigl (1959) claims that children who cannot speak a continuous sentence, can sing whole lines of songs. She states that children may remember phrases more clearly within a song as the rhythm "carries them over the hurdles" (1969, p. 56). Unfortunately,
Weigl provides no research nor scientific data to substantiate her assumptions, even though many music teachers and therapists describe case histories which support her claims.

Straum (1974) attempted to research the effects of a music and non-music remediation program on the auditory-vocal automatic level of emotionally disturbed children. Subjects who received music therapy showed an increase from pretest to post-test scores, but the author states that the hypothesis could not be evaluated within the study's limitations. Myers (1979) studied the effect of music on retention in a paired-associate task with educable mentally retarded children. The researcher presented ten paired-associate words in a list, song, and story form, but found no significant differences between the various modes of presentation. Unfortunately, a confounding variable within the study was that of length of presentation. The list presentation was the shortest, with the story and song presentations being progressively longer.

A study of 104 mentally retarded children also compared a song and story presentation on the immediate, recent, and remote recall of the subjects (Isern, 1959, 1961). The author found no significant differences between presentations. Another article (Doepke, 1967) describes an attempt to teach 50 songs to trainable mentally retarded children. The author states that songs with simple melodic and rhythmic patterns were more readily learned but that six out of the nine students were aided by the use of an overhead projector displaying the lyrics (i.e., visual cues). This particular article was descriptive, and none of the above studies were well-controlled.
The music literature continually fails to provide conclusive evidence that music facilitates verbal memory, yet music educators and therapists continue to state that music improves auditory memory.

Deutsch (1977) does not investigate the effects of music on memory, but instead explores the memory of music itself. She states that certain sounds capture attention more than others, such as loud versus soft, high versus low, sharp attack versus gradual onsets, modulating versus smooth sounds. The human voice is defined as being particularly captivating. She also reports that channels of attention are formed by the process of the listener grouping notes into sequential configurations. This same author researched pitch memory (Deutsch, 1970b) and found memory for tonal pitch to be disrupted by other intervening tones, but not by numbers. Any disruption of memory for tonal pitch could not be due to general factors such as prevention of rehearsal, limitation in information-storage capacity, or displacement in a short-term memory store in which all items or components of items are given equal weight (p. 1604). The author states that "It appears that we must rapidly discard absolute pitch information and store musical sequences in a recorded form" (p. 1605). Deutsch, then, emphasizes the importance of sequential memory (an apparent weakness for Down's Syndrome persons) when considering musical memory and assumes that we rapidly discard absolute pitch information (Deutsch, 1970a). Research relating verbal sequential memory with musical sequential memory would be of interest when studying auditory processing and
when studying the benefits or drawbacks of using musical or verbal
modes in educational or therapeutic milieus.

**Overview of Hemispheric Dominance**

Scientists who have investigated hemispheric functioning have
contributed to the information regarding the cognitive processing of
verbal versus musical stimuli. Many authors have subscribed certain
dominant functions to either of the hemispheres, such as the left
hemisphere being more efficient in learning language and the right
being more efficient in learning musical and/or non-language sounds
(Geschwind, 1972; Spellacy & Blumstein, 1970). Descriptions of
hemispheric specialization date back to the early 1860's when
observations of patients with unilateral brain disease suggested a
major role for the left hemisphere of speech processing in
right-handed persons. These observations led to the concept that the
left hemisphere was dominant for most cognitive processes. The right
hemisphere was not discovered to possess any major function until
World War II, when the posterior region of the right hemisphere was
found to be important for spatial functioning (Milner, 1974). Once
the discovery was made that each hemisphere may have specific and
independent specializations, the issue of research came to be how the
hemispheres interact (Teuber, 1974). Hunter (1976) states that the
left hemisphere processes relationships built across time while the
right hemisphere processes relationships perceived across space. The
corpus callosum then transmits messages between the hemispheres to
"produce integrated brain thinking" (p. 45) which results in each hemisphere augmenting information processed by the other.

Overall processing differences are more often described as follows, "the left hemisphere is specialized for propositional, analytic, and serial processing of incoming information, while the right hemisphere is more adapted for the perception of oppositional, holistic, and synthetic relations" (Bever, 1975, p. 251). Bever (1975) concludes that melodies can be a "gestalt" phenomenon in that, even though a melody is composed of a series of isolated notes, naive listeners focus only on the overall melodic contours of the tones. Therefore, naive listeners should most likely process melodies in the right, or "holistic" hemisphere.

Levy (1969) proposes a basis for the evolution of lateral specialization in the brain. The author suggests that gestalt perceptions were lateralized into the non-linguistic or "mute" hemisphere as the consequence of antagonism between functions of language and functions of perception. It was then hypothesized that persons with bilateral language centers (defined as left-handers) should perform poorly on tests of perception. The author tested this hypothesis using the Wechsler Adult Intelligence Scale and found that left-handed subjects scored significantly lower on performance subtests than did right-handed subjects but the two groups' scores did not differ on the verbal subtests. The author concludes from these results that the bilateral language capacity seems to interfere with abilities usually associated with the minor hemisphere.
Whatever the theory regarding the evolution of brain lateralization, there are definite structural asymmetries between the two hemispheres, with the left yielding consistently higher quantitative values than the right (Lenneberg, 1967). Not only does the left hemisphere yield higher quantitative values than the right, but it also is consistently considered to be the "language hemisphere." And although each ear has direct neurological connections with both hemispheres, it is the contralateral connections that are considered to be the functional neurological connections (Bever, 1971).

Luria (1966) suggests that the dominance of one hemisphere for speech is not as absolute as is often implied. "Absolute dominance of one hemisphere in respect to all mental functions is apparently far rarer than supposed and many persons show only partial or unequal dominance of the hemisphere in respect to different functions" (p. 89).

Bever (1971) states "that certain perceptual mechanisms in the dominant-ear-hemisphere system are selectively sensitive to more abstract aspects of syntactic organization than the internal structures of words" (p. 233). Bever (1971) supports this last statement with three findings:

1. There are more qualitative differences between the ears in simple perceptual and memory tasks and monaural stimulation.
2. There is a particular syntactic strategy of speech processing which is utilized most strongly in the dominant ear for adults.
3. Young children who have developed auditory asymmetry utilize this perceptual strategy much more than children of the same age who have not developed auditory asymmetry" (p. 234).
In this same article (Bever, 1971), a study was cited comparing ear differences for immediate processing of sentences and random words. Results demonstrated that more sentences were correctly responded to by subjects who heard them in the right ear than in the left ear, while no differences were found between ears for subjects who heard the random words. The examiner concluded

"that the dominant ear is more directly involved in the processing of the syntactic and semantic aspects of speech and that its involvement qualitatively affects perceptual judgments and immediate recall. While this phenomenon requires further study, it indicates that listening to speech affects the dominant ear differently from the nondominant ear, even with monaural stimulation" (pp. 239-240).

Many authors have researched various explicit aspects of language in relation to processing. Since it has been suggested that one hemisphere is not absolutely dominant for speech, the questions arise concerning whether each hemisphere is dominant for any specific aspects of language, and if so, then for which aspects of language. 

Broadbent (1974) divides speech perception into three stages:

1. stored representation of the recent past;
2. encoding which allocates the correct response to the particular stimulus by using information about the past context; and
3. response.

He states that the first and third stages are not considered to be specifically related to the left hemisphere, but the second stage (encoding) does demonstrate a left-hemisphere relationship. Liberman
(1974) describes linguistic information as having at least three different shapes:

1. an acoustic vehicle for transmission;
2. a phonetic representation for processing and storage in a short-term memory; and
3. a semantic representation of a non-linguistic intellect for the long-term memory.

This author supports Broadbent (1974) by concluding that highly encoded aspects of speech (those most in need of grammatical decoding) are almost always processed in the language hemisphere, while the unencoded aspects may or may not be processed in that same hemisphere. Liberman (1974) accounts for individual differences in "degree" of ear advantage, by proposing the possibility that some persons process all elements linguistically while others may use nonlinguistic processing whenever possible. Schouten (1980), however, cites research that concludes that the right-ear advantage for speech is a function of the temporal complexity of the stimulus and is inversely related to stimulus duration, with right-ear advantage being highest for stop consonants.

The above articles agree that there is a left hemisphere dominance for certain aspects of language, but fail to agree completely on which aspects those might be. The dominant ear may be more involved in processing syntactic and semantic aspects of speech (Bever, 1971), encoding (Broadbent, 1974; Liberman, 1974), or stop consonants (Schouten, 1980). The research continues to attempt to
gain further knowledge regarding specific left-hemisphere speech processing.

Krashen (1977) concurs that "all aspects of language are not limited to the left hemisphere, and the left hemisphere appears to do more than just control language functions" (p. 109). Not only might some language functions be less lateralized than originally suggested, but some people seem to be less lateralized than others. Some persons seem to have language more diffusely represented in the two hemispheres as did Bever's (1971) left-handed, bilateralized subjects, while others may utilize one side of the brain more than the other for all cognitive processing. Krashen (1977) gives as an example of the latter "children over five who exhibit deficits in linguistic development (dyslexics or poor readers), who do not show the adult level of cerebral dominance when tested by dichotic listening" (p. 119). Zangwill (1960) considers persons who are imperfectly lateralized to include left-handers, and persons with cerebral ambilaterality, the latter who may have "the proper development of reading and writing, of spatial judgment and directional control, relatively easily disturbed by accidents of circumstance" (p. 24). An investigation by Higgenbottam (1974), states a more extreme conclusion; that there is little support for any theory of "general hemispheric dominance, i.e., common to both the auditory and visual modalities" (p. 1049 B). The author concluded that handedness classifications are generally not associated with patterns of perceptual preference.
Milner (1964) contradicts Higgenbottom's (1974) findings in a study of 123 subjects who were left-handed, right-handed or ambidextrous. The subjects were subjected to the Wada technique of intracarotid injection of sodium amytal, to "incapacitate" one hemisphere while testing the other. The author found that the cerebral organization of language was less predictable in left-handed and ambidextrous persons than right-handers. Even in left-handers, speech was found to be represented more often in the left than the right hemisphere, but the proportion of left-hemispheric dominance was significantly lower than in right-handers. Rossi and Rosadini (1967), confirm Milner's (1964) findings in a similar study, but also cite the possibility of bilaterality and rare occurrences of an ipsilateral representation of speech in right-handers.

If so many studies are demonstrating variable hemispheric dominance for speech, then what is happening in the non-dominant hemisphere? According to Gazzaniga (1975), the right hemisphere does have tremendous cognitive powers, including the Imagery mechanism associated with language. Music was originally considered to be a left-hemisphere function, along with language; more recently, however, clinicians and researchers have considered the right hemisphere to be significant in the processing of music (Benton, 1972).

As in language, various aspects of musical processing are considered to be dominant for one hemisphere. Gates and Bradshaw (1977) consider that both hemispheres may be involved in musical processing with the left hemisphere dominant for the sequential and
analytical aspects of music, and the right hemisphere dominant when sound gestalt is emphasized. Case studies have shown that music capabilities may be preserved despite loss of language, and that language functions may be preserved with deficits in musical functioning (Gates & Bradshaw, 1977), indicating independent locational anatomic cites for processing of the two auditory stimuli. Usually, however, both abilities are impaired simultaneously, leading to the conclusion of a close interrelationship between the two processing areas. Many case histories are reported in which a brain-damaged patient maintains an ability to sing words despite an inability to say the same words out of musical context. Gates and Bradshaw (1977) conclude that the left hemisphere may be important for musical abilities which share properties with speech (e.g., temporal order, duration, simultaneity, rhythm, motor control, and categorical perception). Temporal ordering is of obvious importance in musical memory (Deutsch, 1970), and coding temporal information (both verbal and non-verbal) is considered to be highly precise in the left hemisphere. The left hemisphere, then, may play a very important role in processing various aspects of music, but while utilizing the right hemisphere to complete the total processing of music perception.

Jaynes (1966), examining dominance, cites research in which six-month old babies had electroencephalograms (EEG's) recorded when electrodes were placed over Wernicke's area of the left hemisphere and a corresponding area of the right hemisphere. When recordings of speech were played, the EEG's showed the greatest activity over the
left hemisphere, but when recordings of music were played, the greatest activity was over the right hemisphere. Such findings imply a hemispheric dominance for speech and a separate dominance for music. The same author (Jaynes, 1976) mentions that patients who have had the right anterior temporal lobe removed find it difficult to distinguish various melodies while patients with left temporal lobectomies are reported to have no similar difficulty, again defending the position for a right hemisphere dominance for music. A study by Molfese (1973) substantiates Jaynes' claims. In this study, auditory evoked responses were recorded from the temporoparietal language processing area of the left hemisphere, and the corresponding area of the right hemisphere. Auditory evoked response activity was found to be greatest in the left hemisphere when verbal stimuli was presented and greatest in the right hemisphere when musical stimuli was presented. These results support the theory that the brain is specialized to process language and music differentially.

Both of the above articles (Jaynes, 1976; Molfese, 1973) found that laterization was measurable from birth, and Molfese (1973) claims that laterization actually decreases with age. A later study (Davidoff, Done, & Scully, 1981), using children six, eight, and ten years of age, results in ear advantages (using dichotic presentation) for speech. Kinsbourne (1975) supports the view of the above authors, that children are hemispherically laterized at least down to the age of three years, and possibly younger. Other authors (Brown & Jaffe, 1975; Penfield, 1969; Robeck & Wilson, 1974) claim that laterization is a maturational process that is not completed
In early childhood. Robeck and Wilson (1974) state that speech and perception areas of the cortex do not appear to be well-lateralized until the age of six years. The authors substantiate this statement by claiming that prior to the age of six years, if the speech dominant hemisphere is damaged, the child then switches speech function to the other hemisphere and quickly re-learns speech; after the age of twelve years, this transfer is very unlikely. Brown and Jaffe (1975) consider the development of hemispheric dominance to be a continuous process which evolves throughout life and which accounts for age-dependent forms of aphasia (contrary to Molfese, 1973, who considers lateralization to decline with age). These authors (Brown & Jaffe, 1975) relate that dichotic listening studies evidence a significant increase of the right-ear advantage for verbal material between the ages of five and eight years. Penfield (1969) also cites transfer of laterality following brain-damage in young children as evidence for later development of hemispheric dominance. He also states that

"All learning is to be explained by the basic physiological fact that the movement of a train of nerve impulses down a path, through nerve-cell synapses and along nerve branches, facilitates the use of that pathway for subsequent passages. This facilitation effect is transient, as was pointed out by Sherrington, in the sensory and motor transmitting systems. In the cortical circuits responsible for conditioned reflexes, the facilitating effect easily becomes permanent. Thus, motor skills, speech mechanisms, and perception mechanisms are easily acquired and preserved through life" (pp. 142-143).
Physiological Aspects of Audition

The physiological basis for auditory processing, without consideration of age, can further be explained by considering the path of a spoken word to the cortical speech areas. Upon hearing the spoken word, sound waves travel through the outer and middle ear before activating the nerve fibers from the spiral ganglion of the organ of Corti and entering the cochlear nuclei in the upper part of the medulla. At this point, all fibers synapse, and second order neurons pass mainly to the opposite side of the brain stem through the trapezoid body to the superior olivary nucleus. Some second order fibers also pass ipsilaterally to the superior olivary nucleus where most of the fibers terminate.

The remaining fibers pass upward through the lateral lemniscus where many terminate in the nucleus, but other fibers bypass this nucleus to terminate in the inferior colliculus. Other fibers that do not terminate at the nucleus of the lateral lemniscus, cross through the commissure of Probst to the contralateral nucleus, while still others cross through the inferior collicular commissure from one inferior colliculus to another. From the inferior colliculus, the pathway passes through the peduncle of the inferior colliculus to the medial geniculate nucleus, where all of the fibers synapse. At this point, the auditory tract spreads by way of radiation to the auditory cortex, which is located mainly in the superior temporal gyrus (Guyton, 1976).

One factor that should be emphasized in relation to the auditory pathway is that transmission across the contralateral pathway occurs
at three different places in the brain stem (i.e., trapezoid body, commissure of Probst, and commissure connecting two inferior colliculi) and that these transmissions are all slightly greater than those that are ipsilateral (Guyton, 1976). The commisural fibers are what transfer impulses across hemispheres and they originate in the cortex or subcortical nucleus of one hemisphere and terminate in the cortex of the contralateral hemisphere. These fibers include:

1. the corpus callosum, which is the largest commissure and interconnects most of the neocortical areas of the hemisphere with those of others;
2. the anterior commissure, which consists of a smaller portion interconnecting olfactory structures and a larger portion interconnecting the neocortex of the anterior aspects of the temporal lobe;
3. the hippocampus commissure which interconnects the hippocampus;
4. the habenular commissure that interconnects paired habenular nuclei; and
5. the posterior commissure, which interconnects structures of the roof of the midbrain (Noback and Demarest, 1981).

Although the auditory pathway is said to have slightly more impulses traveling contralaterally than ipsilaterally, there is still a need to establish quantitative evidence that the response of the contralateral ear is significantly greater than the response of the ipsilateral ear at both hemispheres. Rosenzweig (1951) recorded the electrophysiological responses at the auditory cortex of five
anesthetized cats and results indicated that the response of each ear tended to be larger at the contralateral hemisphere, with the ipsilateral response being about three-quarters of the size of that in the contralateral hemisphere. Darwin (1974), however, theorizes that the longer the sound or the more similar are dichotic sounds, then the less is the ipsilateral occlusion. Moore (1983) supports the idea of greater contralateral stimulation when discussing behavioral bands consisting of two types of responses to behavioral stimulation. That author describes excitatory–excitatory neurones which are stimulated monaurally by either ear, or which respond moreso to binaural stimulation, and the excitatory–inhibitory neurones which have a weaker response to binaural than to monaural stimulation. Contralateral stimulations also produce consistently shorter latency periods when compared to ipsilateral stimulations (Butler, Keldel, & Spring, 1969; Majkowsky, Bochenek, Z., Bochenek, W., Knapik-Tijalkowska, & Kopec, 1971). Other studies emphasize that in behavioral stimulation, the most common interaction is summation, where the response to behavioral stimulation is greater in size than the response to stimulation of either ear alone (Butler, et al., 1969; Imig & Adrian, 1977).

When considering contralateral responses, the fact that there exists marked anatomical asymmetries between the upper surfaces of the human right and left temporal lobes is of importance. Geschwind and Levitsky (1968) found the planum temporal to be larger on the left hemisphere in 65% of the adult brains studied, and larger on the right hemisphere in only 11% of the adult brains studied. Signifi-
cant asymmetries of the planum temporal have been discovered in the brains of fetuses as early as 31 weeks of gestation, with the major cytoarchitectonic asymmetry being of the temporoparietal cortex, which is related to language function (Galaburda, LeMay, Kemper & Geschwind, 1978).

Localization of auditory responses in the cerebral cortex are of importance, even though cats and monkeys have been found to detect threshold levels of sound following the removal of the auditory cortex (thereby indicating that the nuclei in the brainstem and thalamus can independently perform many auditory functions) (Guyton, 1976). The auditory cortex is divided into the primary and associative areas, and is principally located on the supratemporal plane of the superior temporal gyrus; but also extends over the lateral border of the temporal lobe, much of the insular cortex, and into the lateral portion of the parietal operculum. Certain parts of the primary auditory cortex are known to respond to various frequencies, such that when excitation reaches the cortex, each sound-responsive neuron reacts to only a narrow range of frequencies. The auditory cortex, then, is considered important in the discrimination of tonal patterns (Guyton, 1976). The primary auditory zone is considered to be the transverse gyri of Heschl (Luria, 1966) which form part of the first temporal convolution on each hemisphere, and run deep into the lateral fissure of Sylvius (Penfield, 1959). Penfield (1959) states that removal of one transverse gyrus of Heschl affects hearing little because the auditory impulses pass from each ear to both hemispheres.
Adams and Victor (1977) describe three main language areas and their function, which are in the left hemisphere of most persons; these include Wernicke's area (comprehensive), the perisylvian region (semisoriculator motor process), and the entire cerebrum (complex elaborations of language). A more elaborate anatomical description is given by Werthelm (1977) which includes nerve-fibers connecting the primary and secondary auditory cortices with neighboring temporal and parietal cortices as well as with the frontal and occipital cortices. These are considered to be two-way connections, thereby allowing complex association and feedback circuits. Werthelm (1977) does not draw definite conclusions on focal localizations for auditory stimulation, as did Adams and Victor (1977), but does state that case histories suggest that music reception may be related to the anterior temporal region of the dominant hemisphere, since reception amusia corresponds to lesions in that area.

**Localization Research of Brain-Damaged Patients**

Anatomical location of specific processing functions has often been discovered or defined through the research of brain-damaged individuals. Knowledge of damage to a specific cerebral location, and absence of certain observable processes, leads to a correlation between anatomical localizations of these processes. Damage as extensive as a hemispherectomy gives insight into the gross functioning of the two hemispheres. A case study of this nature reviewed by Gott (1973), described the impairments of a 12 year old girl, two years following a dominant left hemispherectomy. Even
though the language center is considered to be located in the left hemisphere, this child's comprehension of verbal speech was the least impaired of language functions, implying that the right hemisphere can independently direct some functions of language. A study using subjects with either right or left lobectomies, and researching memory for words, found that subjects with left temporal lobectomies made significantly more errors than either of those with right temporal lobectomies or the control group. The author concluded that the learning difficulties were not due to any failure to encode verbal material, but instead were due to a breakdown in information processing such that words lost their identifying characteristics and led to an overgeneralization to similar words (Rausch, 1981).

Other researchers have looked at music skills of patients who have undergone temporal lobectomies. Milner (1967) found that right lobectomy patients maintained simple pitch discrimination, but were permanently impaired in their discrimination of tonal patterns (i.e., melody) and tone quality. In a study by Shankweiler (1966), patients were tested before and after having had unilateral temporal lobectomies, but the test material was presented dichotically (two similar but unequal auditory stimuli presented simultaneously one to the left, and one to the right ear). Stimuli consisted of dichotically presented digits. Subjects who had left lobectomies were found to have no change of score for melody recognition but a significant reduction in reporting digits, while persons with right lobectomies had opposite effects.
Much interesting research on hemispheric lateralization has been pursued through the examination of altered functioning of patients who have had sectioned commissures. The complete section of these fibers leaves two separate but functional half brains, while the section of the entire corpus callosum and the anterior commissure eliminates cross-communication for the neocortex.

"By far the most striking effect of this kind of surgery, speaking very generally, is the establishment of two entirely separate mental domains within the same cranium. Following surgical separation of the hemispheres, things experienced, learned, and remembered by one hemisphere remain quite unknown by the other. The learning experience of the one is inaccessible to, and outside the conscious awareness of, the other hemisphere, almost as much as in the case with two separate brains in separate skulls. As far as we can tell from the evidence to date, it would appear that in split-brain syndrome, we deal with two separate minds, i.e., two separate realms of conscious awareness, two separate sensing, perceiving, thinking, and remembering systems" (Sperry, 1967, pp. 716-717).

In the area of language, these post-operative patients have been unable to describe in speech or in writing, anything presented to the left hand or the left visual field, leading to the conclusion that engrams for speaking or writing may be confined to the dominant hemisphere (Sperry, 1967). In the absence of hemispheric connections, it is important to remember that all cerebral functions remain intact, excepting those that rely on cross-connections between the hemispheres (Sperry, 1974). Even the right hemisphere displays independent functions such as the construction of spatial relations, spatial orientation (Sperry, 1967), some non-verbal language, initiation of own non-verbal response, emotion, non-verbal learning ability, and non-verbal memory (Gazzaniga, 1977; Sperry & Gazzaniga,
The right hemisphere, however, has proven to be inferior to the left in overall command of the language. Gazzaniga (1970, 1974) reports that the right hemisphere can respond to concrete nouns, but responds more poorly to verbs, nouns derived from verbs, and grammar.

Examples of two experiments used to explore hemispheric functioning of language in split-brain patients are presented here. Gazzaniga (1970) reports that comprehension of spoken words in the right hemisphere was confirmed by requiring patients to push a response button, held in the left hand, when they saw one of five nouns projected in a serial order to the left visual field that matched a test word previously heard in a binaural presentation. Springer and Gazzaniga (1975) presented six CV syllables to their patients using a standard dichotic presentation, a dichotic presentation with selective attention instructions to attend to the non-dominant ear, and a monotonic presentation. Results indicated that the extent of the split of the commissures affected the responses, with interhemispheric transfer of speech seeming to be anterior to the splenium and posterior to the first one-third to one-half of the callosum.

Using split-brain patients to explore hemispheric localization of language functioning is limited due to the small number of subjects available and the variable extent of their commissurotomies. A more available group of subjects comes from persons who have localized brain lesions. Examining persons with unilateral lesions of the hemispheres has resulted in indications that dominant hemispheric damage causes subjects to lose verbal abilities (as measured by the
Wechsler-Bellevue Intelligence Scale) while non-dominant hemispheric damage causes a greater loss on performance subtests (Anderson, 1951; Fitzhugh, K., Fitzhugh, L., & Reitan, 1962). Similar studies by Costa and Vaughan (1962) and Assal (1974) used various speech and language tests, and found that overall performance was impaired when lesions of the left brain were identified. Using the Raven's Coloured Progressive Matrices; Denes, Semanga, Stoppa, and Gradingo (1978) found that subjects with right-brain damage have the greatest difficulty on Set A (which solutions require visuo-perceptible abilities) and subjects with left-brain damage have the greatest difficulty with Set B (which solutions require the formation of a coherent whole and analogical reasoning).

Using dichotic and monaural presentations of digits to unilaterally brain-damaged individuals, Kimura (1961a; 1961b) found that damage to the left temporal lobe impaired overall performance of digit recall but stimuli arriving to the ear contralateral to the dominant hemisphere were more efficiently recognized than stimuli arriving to the ipsilateral ear. Albert (1972) confirmed a disadvantage for the processing of verbal material in left-brain-damaged patients, while Milner (1962) using the Seashore Measures of Musical Talent, found that right temporal lobe damage impairs musical ability. Shapiro (1981) described the ability to recognize musical errors as being inferior in persons with right-brain damage and right anterior damage resulted in the specific inferiority of detecting pitch errors.
Aphasic patients are also used as subjects in experiments when exploring localization of auditory processing. A study using verbal dichotic listening tests with aphasic subjects found that when there was no damage to the left geniculo-temporal system, right-ear scores were above 75%. When there was damage to this same area, right-ear scores were below 50%. Such results imply a correlation between language functioning and the left geniculo-temporal system (Nlccum, Rubens, & Speaks, 1981).

The study of amusia has been of fascination to many authors and researchers. As early as 1926, Henschen stated that

"the musical faculty has forms analogous to those of language, and also analogous pathological forms. We have acoustic forms of amusia, that is inability to comprehend music as music, inability to sing, read and write music, and also to execute music, a form of music apraxia" (p. 177).

Despite Henschen's (1926) belief that musical function is located in the left hemisphere, he admits that some cases suggest that the destruction of the right temporal pole can produce amusia, and that the musical ability may be affected even when the left temporal pole remains intact. Actually, certain aphasic patients do lose some aspects of musical ability, while others do not; there is also loss of musical skills in some non-aphasic persons (Berman, 1981).

Speech therapists have successfully used melodic intonation therapy to rehabilitate speech in aphasic persons by "imbedding short phrases and sentences in a simple, nonlinguistically loaded melody pattern" (Albert, Sparks, & Helm, 1973, p. 130) "... which is composed so that the inflection pattern, rhythm, and stress are similar to the speech prosody of that sentence" (Sparks, Helm, &
Albert, 1974, p. 304). The authors' hypothesis for the successful outcome of this therapy is "that increased use of the right hemispheric dominance for the melodic aspects of speech increases the role of that hemisphere in interhemispheric control of language, possibly diminishing the language dominance of the damaged left hemisphere" (Sparks, et al., 1974, p. 315).

Dichotic Presentations

Neuropsychological studies using subjects with brain tumors "are often contaminated by secondary symptoms; and patients with symptomatic thrombotic infarcts usually have other vascular lesions, frequently in the other hemisphere" (Bogen, 1969, p. 140). Since studies using subjects with brain damage may be influenced by such uncontrollable variables, exploring means of researching lateralization in non-brain-damaged individuals would help to expand upon the knowledge regarding hemispheric processing. The use of dichotic presentations (as described earlier) has been used to meet this need and has produced an extensive amount of literature in the area of hemispheric dominance. Much of the literature substantiates previous claims that the left-hemisphere is primarily dominant for speech; such claims are made based on a right-ear advantage for speech (Demarest, J., & Demarest, L., 1980; Kraft, 1982). There are, however, some published research articles which do not support a right-ear advantage for language (Oxbury, S., Oxbury, J., & Gardiner, 1967), or any ear advantage, but these published claims are limited in quantity. Most of the dichotic research examines the recall of
words and whether more words were recalled from the left or right ear presentation (Belmore, 1981; Bryden, 1962, 1963). Broadbent and Gregory (1964) used recognition as a testing technique in their research, with each trial consisting of three pairs of digits arriving dichotically, followed by four groups of three digits presented binaurally. One triad of the binaural groups corresponded to the digits previously given to the right ear, and one corresponded to that previously given to the left ear; the subjects were to identify those two triads. The results indicated a tendency for more errors to be made on lists presented to the left ear. A similar study requested the subject to identify a target word among dichotically presented words and also results in a right ear advantage (Bradshaw, Farrelly, & Taylor, 1981).

The dichotic research has also explored the issue of age of subjects and whether chronological age affects any ear advantages that are found in most studies of adults. In studies using subjects who were from four to thirteen years of age and who were asked to recall either dichotically presented pairs of CV's or dichotically presented pairs of words, a significant number of children of all ages were found to demonstrate a right-ear advantage (Berlin, C., Hughes, Lowe-Bell, Berlin, H., 1973; Borowy & Zoebel, 1976; Geffner & Hochberg, 1971). In another study examining age in relation to responses to dichotic stimulation, Geffen (1976) chose subjects aged 4.8 to 11 years. The dichotic stimulus was a series of 120 word pairs and the subjects were asked to press a button in their right hand when the target word was heard in the right ear and one in their
left hand when the target word was heard in the left ear (thus entering a lateralized motoric condition into the response). Results again concluded a right-ear advantage for subjects regardless of age, with the author stating that the left hemisphere is specialized for the analysis of speech signals by five years of age.

Dichotic listening tasks have also been presented to learning disabled populations, including dyslexics (McKever & VanDeventer, 1975) and poor readers (Obrzut, 1975), who were found to be impaired in the efficiency of auditory and temporal processing, but still possessed a right-ear advantage for recall. Beaumont (1976) found "minimal brain damage" children to be less stable in their lateral preferences and less lateralized in motor performance but to have performed equally well on dichotic tasks when compared with a control group.

Fewer dichotic studies have been performed with mentally retarded subjects, but Jones and Spreen (1967) examined a generic group of mentally retarded children in a dichotic task using nouns, and found a right-ear advantage for the recall of words. Hartley (1981) used children who had been diagnosed as having Down's Syndrome as subjects in a study. The stimuli consisted of 38 dichotically presented word pairs made of single-syllable items and results indicated a significant left-ear advantage for recall in children with Down's Syndrome, while the more common right-ear advantage was maintained for the control group. The author implies that these results for reversed dominance in children with Down's Syndrome relates to the genetic syndrome itself and not to the mental retardation (which is
su bsta nti a te d by Jones and Spreen's 1980 study as previously mentioned).

Dichotic experimental stimuli are not always presented in speech forms. Dirks (1964) used spondee words (i.e., homogeneous words in intelligibility), filtered words, and digits when using right-handed adolescents as subjects, and found that filtered words were recalled more efficiently from the right ear. A study by Haydon (1975) varied the stimuli by presenting dichotic non-language sounds and dichotic verbal sounds; a right ear advantage resulted for the verbal sounds with no ear advantage results for the nonverbal sounds. Intonation contour patterns were used as dichotic stimuli in two other studies (Blumstein & Cooper, 1974; Mazzucchli, Parma, & Cattellani, 1981) and all experiments clearly demonstrated a left-ear superiority in the perception of tonal sequences, "suggesting quite clearly that the right hemisphere is more actively involved than the left in the processing of intonation contours" (Blumstein & Cooper, 1974, p. 155).

Rather than modifying speech into melodic contours, many examiners choose to compare verbal and musical dichotic stimuli in order to compare laterality of processing of the two modalities. King and Kimura (1972) found that the dichotic presentations of both hummed melodic patterns and vocal non-speech sounds resulted in a left-ear superiority. These results relate well with results of the previously mentioned studies regarding intonation contours, since all of these studies demonstrate a dependence of melody recognition in the right hemisphere regardless of how the pattern is produced.
Several reported studies comparing recall of dichotically presented words to recall of dichotically presented melodies demonstrate a significant right-ear advantage for words and a significant left-ear advantage for melodies (Franklin, 1978; Kimura, 1964; McCarthy, 1969; Zatorre, 1969). Results of a similar study by Reineke (1978) refutes the above findings in that the subjects showed a left-ear superiority for recognizing digits and no ear superiority for recognizing melodies while Jellison (1976) found a right-ear advantage for melodies. In a more complex study by Goodglass and Calderon (1977), the subjects were presented with dichotic digits, dichotic tonal patterns, a double dichotic tape combining the dichotic digits and dichotic tones, and a sung stimulus tape with digits repeated at pitch levels which corresponded to the tones. The right-ear advantage for digits and left-ear advantage for tones under all conditions supported the view that independent parallel processing takes place in the two hemispheres for their preferred (verbal/tonal) components of a complex stimulus, and therefore failed to support the view that only one hemisphere at a time can be functionally dominant. The authors state that "our results support a fixed neural pathway model which allows concurrent and opposite functional lateralization of stimulus components which depend for their processing on opposite hemispheres" (p. 404). Other studies, examining dominance for melodies or tones only, have found no significant differences for ear preferences (Gordon, 1973; Peretz & Morals, 1980; Shanon, 1981), but rhythmic recall has been found to be correctly recalled more
frequently when presented to the right ear as opposed to the left (Natale, 1977; Robinson & Solomon, 1974).

Some authors recommend caution when analyzing and interpreting data from studies using dichotic stimulation. In a study devised to provide data on the stability of paired-digit dichotic listening tests (Pizzamiglio, DePascalis, & Vignati, 1974), a test-retest correlation was found to be significant at the 70% level, and authors recommended caution in using this technique in research or clinically, due to the 30% inconsistency. Studdert-Kennedy (1981) considers the questionable interpretability of dichotic studies when stating that "shifts in degree of right ear superiority, with variability in the acoustic structure of competing syllables, cannot be safely interpreted as shifts in the degree of left hemisphere engagement. This limitation exists because an ear advantage in dichotic listening is not a simple index of hemispheric specialization" (p. 960).

Monaural Presentations

An alternative to using dichotic stimuli to explore ear preference/hemispheric specialization is to present subjects with monaural stimuli. Although some researchers hypothesize the need to occlude the ipsilateral pathway with dichotic presentations in order to effect significant ear preferences; Bever's (1971) experiments, using monaurally presented sentences, found

"that the dominant ear is more directly involved in the processing of the syntactic and semantic aspects of speech and that its involvement qualitatively affects perceptual judgments and immediate recall. While this phenomenon
requires further study, it indicates that listening to speech affects the dominant ear differently from the non-dominant ear, even with monaural stimulation" (pp. 239-240).

In studies examining auditory reaction time, and using both non-verbal and verbal stimuli, researchers found a faster response to trials presented to the right ear (Haydon & Spellacy, 1973; Simon, 1967). Such results indicated that, under conditions of uncertainty as to which ear would be stimulated, subjects will respond faster to stimuli in the right ear than to stimuli in the left ear, under monaural conditions. This suggests an asymmetry in auditory attention favoring the left hemisphere, even in the perception of some non-speech sounds.

A monaural study by Burns and Manning (1981) using CVC monosyllabic word lists, required subjects to listen to a probe word which preceded a ten-word list, and then write down the word that originally followed the probe word in the list. Results indicated superior performance for word recall when the lists were presented to the right ear. Bakker (1969) measured recall of monaurally presented letters and found a right-ear advantage for five-letter series but not for four-letter series. Thus indicating that a right-ear dominance for verbal material can be proved subsequent to monaural stimulation if temporal order perception and retention are involved in the task. Belmore (1961), however, found no significant right-ear advantage for recall of monaurally presented word lists.

Using the more complex stimuli of monaurally presented complete sentences, Frankfurter and Honeck (1973), found a right-ear advantage for recall. A similar study using monaurally-presented sentences of
the same syntactic structure but varying in semantic Integration
concord with Frankfurter and Honeck (1973), as sentences presented
to the right ear were recalled faster and with fewer errors than
sentences presented to the left ear (Jarvella, Herman, & Plisoni,
1970). The authors concluded that "laterality factors related to
cerebral dominance for language functions influence short-term memory
for sentences heard monaurally" (p. 85).

Non-verbal processing has also been explored in monaural studies,
with Bakker (1967) comparing responses to both digit series and sound
patterns (i.e., morse code-like series). Using subjects who were
6-11 years of age, the author found that ear preference was subject
to age level, but that overall, no significant ear advantage was
established for recall of the verbal material. A significant left
ear advantage was discovered for recall of the sound patterns.

In a similar study by the same author (Bakker, 1968), learning
disabled children were used as subjects, and the findings equivocated
those of the earlier study (Bakker, 1967) in which there was no ear
advantage for verbal material, and a significant left-ear advantage
for sound patterns. Researching ear preference for verbal, speech,
and musical stimuli when presented monaurally, Stankov (1981)
utilized nineteen different test items. Results indicated that a
right-ear superiority existed on vocabulary, letter reordering, and
rapid spelling, all of which were considered to be measures of
crystallized intelligence. Matching melodies, considered to be
measures of fluid intelligence, was also superior for the right ear.
A left-ear superiority was found for Seashore's tonal memory test and
Wing's tests of chord analysis and tonal memory, all of which were considered to measure general auditory functioning. This study of monaural stimuli, then, again supports a right-ear advantage for language and a left-ear advantage for musical memory.

Some studies using monaural stimulation have researched only music perception, without any consideration or relation to verbal stimuli. Gaede, Parsons, and Bertera (1978) requested subjects to determine the number of notes in a monaurally presented chord and to determine if a tune had been melodically altered during a second performance. Results indicated a left-ear advantage for chord analysis, but a somewhat surprising right-ear advantage for memory sequence analysis. Bever and Chiarello (1974) used musically naive and musically sophisticated subjects for a monaural melody recognition task, and found the naive subjects to have a left-ear superiority for the task while the musically sophisticated had a right-ear superiority. The authors interpreted their findings as indicating that the musically sophisticated subjects could organize a melodic sequence in terms of the internal relations of its components, thereby making the task more analytic in nature, as opposed to being holistic in nature for the naive listeners. A study of ear asymmetry for discrimination of monaural tonal sequences led Doehring (1972) to find a left-ear superiority for intensity discrimination, but no superiority for frequency discrimination. The author concludes that

"the observed left-ear advantage for monaural nonverbal stimulation is in accordance with the hypothesis that contralateral pathways are more efficient, but indicates that the greater efficiency does not necessarily require
occlusion of ipsilateral auditory pathways by competing input or differences between ears in attending to competing sounds” (p. 109).

**Implications of Hemispheric Specialization**

Although there are exceptions, much of the literature which explores aspects of hemispheric dominance, supports a general processing advantage for the right ear/left hemisphere when stimuli is verbal in nature and an advantage for the left ear/right hemisphere when stimuli is nonverbal and/or musical in nature. How to practically utilize such information in educational or therapeutic endeavors is the natural sequence for research to now follow.

"If the right hemisphere does indeed process data in a manner different from the left, we may be shortchanging ourselves when we educate only left-sided talents in basic schooling. Perhaps, when people speculate about an inverse relationship between scholastic achievement and creativity, they are really talking about the effect of overtraining for verbal skills at the expense of non-verbal capacities. Many problems can be solved either by analysis or synthesis; but if people are taught to habitually examine only one approach, their ability to close the most effective and efficient manner is diminished" (Nebes, 1977, p. 105).

Bogen (1977) extends those Ideas to the area of learning disabilities when he states that some of these disorders may "result from a maldevelopment of one or the other mode of thought, or perhaps their failure to lateralize in the visual fashion" (p. 144). And Buchsbaum (1979), addressing the issue of impairment of the corpus colossum and resulting learning disorders, writes that "a better understanding of how the hemispheres communicate might help us not only to treat these conditions, but also to learn ways to convey information more efficiently to normally functioning brains" (p. 100). The further
researching of lateralization should not only continue to provide information regarding hemispheric processing, but also should expand our ability to better reach, counsel, and teach both normal and learning-impaired populations.
CHAPTER III

METHOD

Subjects

The 36 subjects who participated in the present study all had been previously diagnosed as having Down's Syndrome and are described in Table 1. They were clients of the Franklin County Board of Mental Retardation and Developmental Disabilities (Columbus, Ohio), the Licking County Board of Mental Retardation and Developmental Disabilities (Newark, Ohio), or the Seaside Regional Center (Waterford, Connecticut). Subjects were 18 females and 18 males who ranged from 12 years to 57 years in age. Twenty-one of the subjects were enrolled as students in county educational programs for the mentally retarded, one subject attended a special education classroom at a public high school, and fourteen subjects worked in sheltered workshops or at supervised work placements.
**TABLE 1**

DESCRIPTION OF SUBJECTS

<table>
<thead>
<tr>
<th>Age yr.-mo.</th>
<th>Sex</th>
<th>Agency/</th>
<th>Training Program</th>
</tr>
</thead>
<tbody>
<tr>
<td>34-7</td>
<td>F</td>
<td>LCBMR/DD</td>
<td>LICCO, Inc. (sheltered workshop)</td>
</tr>
<tr>
<td>20-4</td>
<td>M</td>
<td>FCBMR/DD</td>
<td>West Central Training Center</td>
</tr>
<tr>
<td>19-1</td>
<td>F</td>
<td>FCBMR/DD</td>
<td>Southeast Training Center</td>
</tr>
<tr>
<td>40-7</td>
<td>M</td>
<td>SRC</td>
<td>Preston Work Activity Center</td>
</tr>
<tr>
<td>14-11</td>
<td>F</td>
<td>FCBMR/DD</td>
<td>West Central Training Center</td>
</tr>
<tr>
<td>18-3</td>
<td>F</td>
<td>FCBMR/DD</td>
<td>Northeast Training Center</td>
</tr>
<tr>
<td>26-9</td>
<td>F</td>
<td>SRC</td>
<td>Saybrook Work Activity Center</td>
</tr>
<tr>
<td>38-11</td>
<td>F</td>
<td>SRC</td>
<td>On-the-job Training</td>
</tr>
<tr>
<td>15-11</td>
<td>F</td>
<td>FCBMR/DD</td>
<td>Southeast Training Center</td>
</tr>
<tr>
<td>13-10</td>
<td>F</td>
<td>FCBMR/DD</td>
<td>Southeast Training Center</td>
</tr>
<tr>
<td>14-11</td>
<td>M</td>
<td>FCBMR/DD</td>
<td>Southeast Training Center</td>
</tr>
<tr>
<td>19-10</td>
<td>F</td>
<td>FCBMR/DD</td>
<td>West Central Training Center</td>
</tr>
<tr>
<td>26-4</td>
<td>F</td>
<td>SRC</td>
<td>Mystic Work Activity Center</td>
</tr>
<tr>
<td>30-6</td>
<td>M</td>
<td>SRC</td>
<td>Seaside Sheltered Workshop</td>
</tr>
<tr>
<td>20-5</td>
<td>M</td>
<td>FCBMR/DD</td>
<td>West Central Training Center</td>
</tr>
<tr>
<td>19-0</td>
<td>F</td>
<td>FCBMR/DD</td>
<td>Northeast Training Center</td>
</tr>
<tr>
<td>19-9</td>
<td>M</td>
<td>FCBMR/DD</td>
<td>West Central Training Center</td>
</tr>
<tr>
<td>19-11</td>
<td>M</td>
<td>FCBMR/DD</td>
<td>West Central Training Center</td>
</tr>
<tr>
<td>18-8</td>
<td>M</td>
<td>FCBMR/DD</td>
<td>Northeast Training Center</td>
</tr>
<tr>
<td>20-2</td>
<td>M</td>
<td>FCBMR/DD</td>
<td>Southeast Training Center</td>
</tr>
<tr>
<td>37-4</td>
<td>M</td>
<td>SRC</td>
<td>Preston Work Activity Center</td>
</tr>
<tr>
<td>17-5</td>
<td>M</td>
<td>FCBMR/DD</td>
<td>Southeast Training Center</td>
</tr>
<tr>
<td>12-1</td>
<td>F</td>
<td>LCBMR/DD</td>
<td>Starlight Training Center</td>
</tr>
<tr>
<td>25-4</td>
<td>F</td>
<td>SRC</td>
<td>Mystic Work Activity Center</td>
</tr>
<tr>
<td>14-6</td>
<td>M</td>
<td>FCBMR/DD</td>
<td>West Central Training Center</td>
</tr>
<tr>
<td>57-10</td>
<td>M</td>
<td>SRC</td>
<td>Preston Work Activity Center</td>
</tr>
<tr>
<td>22-3</td>
<td>F</td>
<td>LCBMR/DD</td>
<td>LICCO, Inc. (sheltered workshop)</td>
</tr>
<tr>
<td>15-8</td>
<td>M</td>
<td>FCBMR/DD</td>
<td>West Central Training Center</td>
</tr>
<tr>
<td>14-5</td>
<td>M</td>
<td>FCBMR/DD</td>
<td>West Central Training Center</td>
</tr>
<tr>
<td>31-3</td>
<td>M</td>
<td>SRC</td>
<td>On-the-job Training</td>
</tr>
<tr>
<td>17-8</td>
<td>F</td>
<td>SRC</td>
<td>Norwich Public High School</td>
</tr>
<tr>
<td>21-10</td>
<td>F</td>
<td>LCBMR/DD</td>
<td>LICCO, Inc. (sheltered workshop)</td>
</tr>
<tr>
<td>19-7</td>
<td>F</td>
<td>LCBMR/DD</td>
<td>Starlight Training Center</td>
</tr>
<tr>
<td>31-3</td>
<td>M</td>
<td>LCBMR/DD</td>
<td>LICCO, Inc. (sheltered workshop)</td>
</tr>
<tr>
<td>16-8</td>
<td>F</td>
<td>FCBMR/DD</td>
<td>West Central Training Center</td>
</tr>
<tr>
<td>23-5</td>
<td>M</td>
<td>LCBMR/DD</td>
<td>LICCO, Inc. (sheltered workshop)</td>
</tr>
</tbody>
</table>

a FCBMR/DD = Franklin County Board of Mental Retardation/Developmental Disabilities; LCBMR/DD = Licking County Board of Mental Retardation/Developmental Disabilities; SRC = Seaside Regional Center
Letters of explanation regarding the study were sent to the legal guardians of those potential subjects who were underage or who had been adjudicated incompetent and assigned guardians by the courts. This letter (presented in Appendix A) describes the procedure and intent of the present research project and requests that the guardians sign an accompanying consent form (Appendix B) if they agree to allow their child to participate in the study. Potential subjects who were their own guardians were given a brief and simplified verbal explanation of the procedure (Appendix A) and were allowed to ask questions before being asked to sign the consent form.

Upon receipt of the signed consent forms by the examiner, the potential subjects were screened for right-handedness and for adequate hearing in each ear. First, the individual was presented with a blank piece of paper and pencil which was placed directly in front of him/her on a table. The examiner requested that they draw a picture of a person and observed which hand the individual used. Next, a ball, 13 inches in circumference, was placed directly in front of the person who was asked to throw it to the examiner with one hand. After throwing the ball, the person was requested to sign his/her name to the picture which had been drawn previously.

If the individual used the right hand to perform all of the above tasks (drawing, throwing and writing), then he/she was considered to be right-handed and a hearing screening was performed. Using a portable audiometer, the person was asked to raise one hand when a pure tone was heard over the headphones. The tones were presented at frequencies of 1000, 2000, and 500 hertz. The 1000 hertz frequency
was presented to the right ear first, followed by the 2000 hertz frequency, and finally the 500 hertz frequency. The frequencies were then presented to the left ear in the same order. Each frequency was presented at six decibel levels (50, 45, 40, 35, 30, and 25) in descending order. All frequencies must have been heard in both ears down to and including the 30 decibel level for the person to qualify as a subject in the research project. All screening took place either in the training environment or group homes, in an isolated area, with some minor external distractions occurring.

If the person used the right hand in all of the above tasks (drawing, throwing, and writing), and passed the hearing screening for both ears, then he/she was considered to be an appropriate subject for this research procedure and was included in the actual study. Of the 97 persons who were high enough functioning to be screened for this study, 67 (69%) were right-handed. From those 67 persons, 38 persons (57%) were considered to have adequate hearing, and 36 were able to complete the experimental procedure.

**Apparatus**

The auditory tape that was used for the experimental procedure was recorded at the Derby Hall Recording Studio on The Ohio State University campus. The examiner provided the voice which was recorded onto a 1/4-Inch reel-to-reel tape.

The tape was played back to the subjects on a portable reel-to-reel Wollensack 3M tape recorder (model number 6250) at a consistent decibel level which was within normal speech limits. The
subjects listened to the test presentations over Realistic Nova 20 stereo headphones while the examiner simultaneously listened using a Besser super-mini stereo headphone (model HP-8). A y-cord connected the headphones to the recorder.

A portable Malco audiometer was used to screen potential subjects for adequate hearing.

The hardware pieces used in the experimental procedures included a 1/2-inch decorative tack (upholstery tack), a 2 1/2-inch bolt, a one-inch screw, a 1/2-inch nut, and a 3/4-inch "S" hook. All items were silver in color and were selected due to their single syllable names.

Procedure

Experiment 1

In Experiment 1, each subject was required to repeat three-word phrases in the exact order in which they were heard. The phrases were derived from the one-syllable words for five hardware pieces (nut, bolt, tack, screw, hook); the words were randomly ordered so that no three-word phrases were identical, and no single word was used twice in any one three-word phrase. Of the 18 phrases (Appendix C), nine were spoken and nine were sung. The sung phrases were composed from a pentatonic scale based on middle C with the notes being randomly assigned to the sung words (Appendix C). A pentatonic scale was used to avoid any familiarity by some subjects with traditional Western tonalities.
The phrases were recorded on a tape at a rate of one word per second with three seconds of silence intervening between the time the recorder was turned on and the initiation of the first word of each phrase. The spoken and sung phrases were recorded as three varying auditory presentations which included a two-channel presentation, right-channel presentation, and left-channel presentation. The final tape resulted in 18 phrases which were divided into six auditory conditions of three phrases each. The conditions were as follows: three verbal phrases presented to both ears (V), three verbal phrases presented to the right ear only (VRE), three verbal phrases presented to the left ear only (VLE), three sung phrases presented to both ears (S), three sung phrases presented to the right ear only (SRE), and three sung phrases presented to the left ear only (SLE).

The phrases were randomly ordered into three sets of 18 and subjects were divided randomly into groups of 12 and each group was assigned to listen to one of the three sets, so as to counterbalance for any possible order effects.

In Experiment 1, each of the subjects was individually trained to the task by requesting that they repeat each of the five words singly, then repeat six two-word phrases, and finally to repeat six three-word phrases. The phrases used during training (Appendix D) were not identical in order to any used during the actual testing. The subject and examiner then put on their respective headphones, with the examiner using headphones in order to monitor the tape. The subject repeated each of the three-word phrases heard on the trial tape (Appendix D), which consisted of six three-word phrases, each of
which was presented in one of the auditory conditions to be used in the actual testing (V, VRE, VLE, S, SRE, SLE). The trial tape also did not replicate any phrases from the actual test tape. The training continued until the subject could consistently repeat at least two of the three words in each phrase.

After the training session, the subject was presented with the test tape. The examiner used the cue word, "listen", before turning on the tape recorder. Following the presentation of each one of the 18 three-word phrases, the tape recorder was turned off, and the subject was allowed an unlimited amount of time to repeat the phrase. The subject's response was then recorded on an answer sheet (Appendix E) by the examiner.

Two separate scoring methods were used in Experiment 1. The first scoring procedure measured verbal recall for word sequences, and gave credit only for those responses which were an exact repetition of the stimuli. The responses had to include the same words, in the same order as heard in the trial. No credit was given if the subject inserted a word foreign to the stimuli, nor if any of the three words were misplaced in the sequence. One point was awarded for each completely correct response to a trial, and no points were awarded for incorrect responses to a trial. Therefore, given three trials per condition, the minimum number of points per condition were zero (i.e., no correct responses for any of the three trials), and the maximum number of points possible per condition were three (i.e., correct responses for all three trials).
The second scoring procedure measured verbal recall for words only, with no consideration given to the sequencing of the words. One point was credited for each word correctly recalled from the three-word stimuli. Therefore, given three trials per condition, the minimum number of points per condition were zero (i.e., no correct words recalled for the three trials), and the maximum number of points possible per condition were nine (i.e., all three correct words recalled for each of the three trials).

Experiment 2

Experiment 2 utilized the same subjects, training phrases, and tapes, as were used in Experiment 1. Following the completion of Experiment 1, the subject was trained to identify the actual hardware pieces which were named in Experiment 1 (nut, bolt, tack, screw, hook). The examiner named each hardware piece, required the subject to hold the piece and place it on the table in front of him/her. The subject was asked to hold the item in order to facilitate learning through a tactile mode. When all five pieces were placed in front of the subject, the examiner requested him/her to point to each item as it was randomly named. The subject was required to correctly identify all five pieces, three consecutive times, before the training continued.

Next, the examiner demonstrated the required task. She stated a three-word phrase, sorted the three named objects (which were randomly placed in front of the subject) in the order presented, into three cups which were placed behind the hardware pieces. The
examiner then restated the phrase used during the demonstration, accompanying each word with a gestural prompt which identified the correct location for each item. The subject then sorted the objects and corrections were made, if necessary. Five more trials were used, with accompanying prompts, before allowing the subject to attempt the task with the trial tape. During the use of the trial tape, prompts were faded, and the subject had to consistently sort two of the three items correctly before proceeding to the test tape.

The test tape was presented in the same manner as in Experiment 1. The examiner placed the three items needed for the specific phrase in front of the subject, gave the cue word "listen", and then started the recorder. The recorder was stopped after the three-word phrase had been heard. The subject was allowed an unlimited amount of time to sort the objects, and then the subject's response was recorded on the answer sheet by the examiner.

Experiment 2 utilized a similar scoring procedure as the initial procedure used in Experiment 1. This procedure measured a performance response to word sequences, and gave credit only for those responses which resulted in the hardware pieces being placed in the exact sequential order heard during the trial. No credit was given if any of the objects were placed in any ordinal position other than that heard during the trial. One point was awarded for each completely correct response to a trial, and no points were awarded for incorrect responses to a trial. Therefore, given three trials per condition, the minimum number of points per condition were zero (i.e., no completely correct responses for any of the three trials),
and the maximum number of points possible per condition were three (i.e., correct responses for all three trials).

**Testing Procedure**

Both Experiment 1 and Experiment 2 were performed during a single session with each subject. The sessions were 30-45 minutes in length, depending upon the learning rate of each subject, and took place either at the training cites or in the group homes. There were some minor external distractions which occurred during the testing, but the procedure was generally performed in an isolated area in order to eliminate interruptions.

The above procedures were selected to approximate applied educational or vocational training tasks. Experiment 1 was based on auditory sequential memory and recall activities, while Experiment 2 was selected as a task similar to those sorting tasks used in pre-vocational and sheltered workshop settings.
Experiment 1

The research objectives for Experiment 1 were as follows:

1. To evaluate the auditory memory of persons with Down's Syndrome by requiring them to repeat three-word phrases heard verbally and melodically.

2. To evaluate the auditory memory of persons with Down's Syndrome by requiring them to repeat three-word phrases heard binaurally, or in the right ear only, or the left ear only.

The subjects heard three trials for each of the six presentation conditions including separate presentations of both the verbal and sung modes which were presented to both ears (binaural), the left ear only, and the right ear only. The scores for all 18 trials were tallied for the 36 subjects and a total score was calculated for each of the six conditions (Appendix F). Since the data revealed no significant sex differences, the scores for the 18 males and 18 females were combined in the statistical analyses.

Table 2 presents the means and standard deviations for the six conditions as scored for correct sequential recall of the three-word phrases. The mean scores range from a low of 0.8 (verbal mode of
presentation to left ear only) to a high of 1.14 (sung mode of presentation to right ear only). The means that were derived for mode only (verbal means = 0.92; sung means = 0.99), and ear only (binaural means = 0.94; left ear means = 0.86; right ear means = 1.05) fall in the same range as the means for interactional conditions (mode X ear).

Table 2

Mean Scores and Standard Deviations of Verbal Sequential Responses

<table>
<thead>
<tr>
<th></th>
<th>Verbal Binaural</th>
<th>Verbal Left Ear</th>
<th>Verbal Right Ear</th>
<th>Sung Binaural</th>
<th>Sung Left Ear</th>
<th>Sung Right Ear</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>X</strong></td>
<td>0.97</td>
<td>0.80</td>
<td>0.97</td>
<td>0.92</td>
<td>0.92</td>
<td>1.14</td>
</tr>
<tr>
<td><strong>S.D.</strong></td>
<td>1.11</td>
<td>1.17</td>
<td>1.11</td>
<td>1.02</td>
<td>1.11</td>
<td>1.22</td>
</tr>
</tbody>
</table>

Any differences between conditions were estimated by an analysis of variance (Table 3) for a two-factor, repeated measures design. The analysis reveals no evidence of any significant differences between conditions (p > .05).
### Table 3

**Analysis of Variance for Verbal Sequential Responses**

<table>
<thead>
<tr>
<th>Source</th>
<th>SS</th>
<th>df</th>
<th>MS</th>
<th>F</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>267.54</td>
<td>215</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Subjects</td>
<td>209.54</td>
<td>35</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Mode</td>
<td>0.296</td>
<td>1</td>
<td>0.296</td>
<td>0.83</td>
<td>n.s.</td>
</tr>
<tr>
<td>Ear</td>
<td>1.37</td>
<td>2</td>
<td>0.685</td>
<td>1.93</td>
<td>n.s.</td>
</tr>
<tr>
<td>Mode X Ear</td>
<td>0.48</td>
<td>2</td>
<td>0.241</td>
<td>0.68</td>
<td>n.s.</td>
</tr>
<tr>
<td>Error Mode</td>
<td>8.37</td>
<td>35</td>
<td>0.239</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Error Ear</td>
<td>22.63</td>
<td>70</td>
<td>0.323</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Error Mode X Ear</td>
<td>24.852</td>
<td>70</td>
<td>0.355</td>
<td>--</td>
<td>--</td>
</tr>
</tbody>
</table>

Table 4 presents the means and standard deviations for the six conditions as scored for total word recall (regardless of ordinal position) of the three-word phrases. The mean scores range from a low of 6.67 (sung mode of presentation to both ears) to a high of 6.92 (verbal mode of presentation to right ear only and sung mode of presentation to right ear only). The means that were derived for mode only (verbal means = 6.84; sung means = 6.82) and ear only (binaural means = 6.76; left ear means = 6.82; right ear means = 6.92) are in the same range as the means for interactional conditions (mode X ear).
Table 4

Mean Scores and Standard Deviations of Verbal Recall Responses

<table>
<thead>
<tr>
<th>Source</th>
<th>SS</th>
<th>df</th>
<th>MS</th>
<th>F</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>474</td>
<td>215</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Subjects</td>
<td>295.67</td>
<td>35</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Mode</td>
<td>0.018</td>
<td>1</td>
<td>0.018</td>
<td>0.02</td>
<td>n.s.</td>
</tr>
<tr>
<td>Ear</td>
<td>0.861</td>
<td>2</td>
<td>0.43</td>
<td>0.40</td>
<td>n.s.</td>
</tr>
<tr>
<td>Mode X Ear</td>
<td>1.009</td>
<td>2</td>
<td>0.505</td>
<td>0.47</td>
<td>n.s.</td>
</tr>
<tr>
<td>Error Mode</td>
<td>36.315</td>
<td>35</td>
<td>1.038</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Error Ear</td>
<td>64.472</td>
<td>70</td>
<td>0.921</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Error Mode X Ear</td>
<td>75.657</td>
<td>70</td>
<td>1.081</td>
<td>--</td>
<td>--</td>
</tr>
</tbody>
</table>
Experiment 2

The research objectives for Experiment 2 were as follows:

1. To evaluate the auditory memory of persons with Down's Syndrome by requiring them to sort three objects in the order heard when the names of the objects are presented verbally and melodically.

2. To evaluate the auditory memory of persons with Down's Syndrome by requiring them to sort three objects in the order heard when the names of the objects are presented binaurally, or in the right ear only, or the left ear only.

Subjects heard three trials for each of the six presentation conditions which included separate presentations in both the verbal and sung modes, to both ears (binaural), the left ear only, and the right ear only. The scores for all 18 trials were tallied for the 36 subjects and a total score was calculated for each of the six conditions (Appendix G). Since this experimental data also revealed no significant sex differences, the scores for the 18 males and 18 females were combined in the statistical analyses.

Table 6 presents the means and standard deviations for the six conditions as scored for correct ordinal placement of the three hardware pieces (as compared to the ordinal positions of the names of the hardware pieces heard in the trial presentation). The mean scores range from a low of 1.19 (verbal binaural presentation) to a high of 1.64 (verbal mode of presentation to left ear only). The means that were derived for mode only (verbal means = 1.37; sung means = 1.5), and ear only (binaural means = 1.33; left ear means =
1.55; right ear means = 1.42) fall in the same range as the means for interactional conditions (mode X ear).

Table 6
Mean Scores and Standard Deviations of Sorting Responses

<table>
<thead>
<tr>
<th></th>
<th>Verbal Binaural</th>
<th>Verbal Left Ear</th>
<th>Verbal Right Ear</th>
<th>Sung Binaural</th>
<th>Sung Left Ear</th>
<th>Sung Right Ear</th>
</tr>
</thead>
<tbody>
<tr>
<td>X</td>
<td>1.19</td>
<td>1.64</td>
<td>1.28</td>
<td>1.47</td>
<td>1.47</td>
<td>1.56</td>
</tr>
<tr>
<td>S.D.</td>
<td>1.42</td>
<td>1.17</td>
<td>1.11</td>
<td>1.08</td>
<td>1.16</td>
<td>1.21</td>
</tr>
</tbody>
</table>

Any differences between conditions were estimated by an analysis of variance (Table 7) for a two-factor, repeated measures design. The analysis reveals no evidence of any significant differences between conditions (p > .05).
Table 7
Analysis of Variance of Sorting Responses

<table>
<thead>
<tr>
<th>Source</th>
<th>SS</th>
<th>df</th>
<th>MS</th>
<th>F</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>291.09</td>
<td>215</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Subjects</td>
<td>199.42</td>
<td>35</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Mode</td>
<td>0.91</td>
<td>1</td>
<td>0.91</td>
<td>1.91</td>
<td>n.s.</td>
</tr>
<tr>
<td>Ear</td>
<td>1.81</td>
<td>2</td>
<td>0.91</td>
<td>1.91</td>
<td>n.s.</td>
</tr>
<tr>
<td>Mode X Ear</td>
<td>2.37</td>
<td>2</td>
<td>1.18</td>
<td>2.49</td>
<td>n.s.</td>
</tr>
<tr>
<td>Error Mode</td>
<td>13.42</td>
<td>35</td>
<td>0.38</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Error Ear</td>
<td>39.85</td>
<td>70</td>
<td>0.57</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Error Mode X Ear</td>
<td>33.296</td>
<td>70</td>
<td>0.476</td>
<td>--</td>
<td>--</td>
</tr>
</tbody>
</table>
The purpose of this study was to measure the ability of persons with Down's Syndrome to recall three-word phrases, either verbally or as a sorting task, when those phrases were presented in various auditory input modes (spoken binaurally, spoken - left ear only, spoken - right ear only, sung binaurally, sung - left ear only, sung - right ear only). The results clearly do not support any significant differences in the scores of the three-word phrase recall tasks, when comparing responses to verbal phrases presented in various auditory input modes.

Experiment 1, which measured verbal responses to the auditory phrases, was scored to determine both sequential memory and free recall of the three-word phrases. Neither scoring method resulted in any significant differences in scores between phrases utilizing various auditory input modes. Experiment 2, which measured performance responses (i.e., sorting task) to the auditory phrases, also did not result in any significant differences in scores between phrases utilizing various auditory input modes.

These results indicate that persons with Down's Syndrome do not demonstrate the hemispheric dominance that is widely acclaimed in non-retarded populations. All forms of auditory input, whether
limited to the right or left ear or presented binaurally, result in an equal memory performance for three sequentially-presented words. Adding a melodic content to the stimuli also does not result in any increase or decrease in ability to remember a three-word phrase in a Down's Syndrome population. Cognitively, the person with Down's Syndrome is apparently using a processing system contrary to other populations, which lacks a significant transcortical communication system for verbal or melodic input.

Previous reports of auditory memory of persons with Down's Syndrome is generally limited to studies investigating psycholinguistic deficits in mentally retarded populations (Bllovsky & Share, 1965; Rohr & Burr, 1978; Snart et al., 1982), or poorly controlled studies examining the effects of music on auditory memory (Doepke, 1967; Isern, 1959, 1961; Myers, 1979; Weigl, 1969). The current study does not concur with the previously mentioned (albeit, poorly controlled) music research which all state that music enhances auditory memory. Using a melodic mode of presentation did not improve memory or recall in the present study. A musical factor not involved in this study, which was included in the aforementioned literature, was that of rhythm. Weigl (1969) concludes that phrases are better remembered by a person when in a song, as the rhythm "carries them over the hurdles" (p. 56). As the present study maintained a consistent, almost arhythmic, presentation (varying only melodic content), future studies should begin to examine whether various aspects of music might enhance or detract from auditory memory (e.g., melody, rhythm, pitch, timbre). It may be that melody
alone does not affect auditory memory, but various other aspects, or combined aspects of music may indeed contribute to changes in levels of auditory memory.

Jones and Spreen (1967) used a dichotic listening task to examine ear preferences in subjects who were mentally retarded. These authors did find a significant right-ear advantage for the recall of nouns, thereby concluding that ear advantages for subjects who were retarded equated those same ear advantages as are described for non-retarded subjects. Hartley (1981), however, found reversed ear preferences when using persons with Down's Syndrome as subjects in a dichotic listening study. The subjects with Down's Syndrome demonstrated a left-ear advantage for word recall. The present study does not concur with either Jones and Spreen (1967) or Hartley (1981), in that there were no significant ear advantages for verbal recall of words. Of course, the present author used monaural presentations rather than dichotic presentations, but Bever (1971) states "that listening to speech affects the dominant ear differently from the non-dominant ear, even with monaural stimulation" (p. 240).

The current study does concur with previous articles that refute a clear-cut ear advantage for speech. Although less reported in the literature than articles which substantiate an ear advantage, those articles which do not report ear advantages are well-documented. Luria (1966) states that

"the dominance of one hemisphere in relation to speech functions proved not to be so absolute as was supposed, and research showed that the degree of dominance varied considerably from subject to subject and from function to function" (p. 87).
Many workers have returned to the concept that both hemispheres participate jointly in the performance of complex mental functions (including speech)” (p. 89).

Hilgenbottam (1974) concurs with Luria’s conclusions following an investigation of lateral and perceptual preference measures. The study resulted in "little support for a theory of general hemispheric dominance" (p. 1049-B).

Penfield (1959) brings physiological support to Luria and Hilgenbottam when he concludes that the removal of one transverse gyrus of Heschl affects hearing little, because auditory impulses pass from each ear to both hemispheres. One specific study which utilized a verbal dichotic listening task with normal subjects resulted in no significant differences between performances of right or left ears. Oxbury, et al., (1967) found no significant differences when using three digits as the dichotic stimuli.

Other studies, examining melodic recall in a dichotic task, have also found no significant ear differences (Gordon, 1973; Peretz & Morais, 1980). A more analytical musical study was reported by Shanon (1981), in which the subjects were required to:

1. Indicate whether pairs of tones constituted physical matches;
2. Indicate whether chords defined an octave; and
3. Indicate whether any two tones in a sequence of three defined an octave.

Again, no significant ear advantages were found for any of the three tasks.
Some monaural studies which examine hemispheric dominance through ear advantage scores, have also demonstrated no significant results (Bakker, 1967; Belmore, 1981). An article by Bakker (1968), reports that learning disabled children had no ear preference for monaurally presented words.

Studies demonstrating no ear asymmetries are less pronounced in the literature than those which support the asymmetries, however, they are reported frequently enough to raise major questions in regards to the issue of hemispheric dominance for speech. The present study, demonstrating no ear asymmetries, contributes to the hemispheric dominance literature and the questions surrounding it. One major flaw in this body of literature is the tremendous variance in the populations and stimuli utilized. The subjects defined in the literature range in age from preschoolers through adulthood, with the emphasis placed on school-aged children and college-aged adults. If age is a factor in the development or presence of hemispheric dominance, as many authors suggest (Brown & Jaffe, 1975; Daviddoff, et al., 1973; Jaynes, 1976; Kinsbourne, 1975; Molfese, 1973; Penfield, 1969; Robeck & Wilson, 1974), then comparison of studies, irregardless of age of subjects, is futile. The cognitive level of the subjects may also affect results. Several articles reported using subjects with learning disabilities or mental retardation. Unfortunately, these studies are infrequent, but should be reviewed with the understanding that neurological development of the subjects may have been abnormal, therefore contributing results which may be inconsistent with those found in normal populations.
Presentation of experimental stimuli may be the major cause of dissension between studies of hemispheric dominance for audition. Bever (1971) concludes that the dominant ear is more involved in processing syntax and semantic aspects of speech, while Broadbent (1974) and Liberman (1974) consider encoding to be the speech aspect processed by the dominant ear. Schouten (1980) disregards all three authors to conclude that stop consonants are most likely to produce a right-ear advantage. Bakker (1969) combined theories from all of the above authors by using monaurally presented letters (i.e., shortened stimuli), while finding ear differences for five-letter series but not for four-letter series (i.e., lengthened task). Given the findings discussed in the above articles, the verbal stimuli utilized in the present study should either have been lengthened to sentences, or shortened to stop consonants, in order to have produced ear asymmetries.

As future studies further explore auditory memory in persons who are mentally retarded, researchers should consider the importance of extensive training time for the experimental task. The present study controlled for subjects' comprehension of the experimental task, but did not attempt to train the subjects to commit the task to long-term memory. Tyler (1965) postulates a short-term memory deficit in persons with mental retardation. Those persons are considered to have difficulty keeping instructions in mind for a long enough time to learn efficiently. If such a theory is true, unless instructions are entered into long-term memory, then experimental tasks may be merely responded to in a random manner. The more distanced the task
is from the original instructions, the more likely the retarded subject may be to respond inappropriately. Allport (1955) supports this viewpoint when he states that

"without an extended learning period generalization of perception cannot be accomplished. Objects, also, whose names have been learned may fail to be recognized, i.e., named, when their previous surroundings have been changed" (p. 168).

This problem was evidenced in the current study when several subjects who were responding to the test stimuli in a consistent manner, suddenly changed their behavioral responses midway through the trial presentations. When briefly reminded of the instructions, most subjects were able to return to their original and consistent response patterns. A longer training period, or training sessions which occur over several days, may help to insure a long-term understanding of the task.

Identifying subjects for the present study who had been diagnosed as having Down's Syndrome, were aged 12 or over, right-handed, had normal hearing in both ears, and could conceptualize the experimental task, proved somewhat difficult. However, utilizing subjects of more homogeneous backgrounds and histories (e.g., chronological age, educational experiences, residential placements), might contribute to different results than were found in this study (although the present data does not clearly support this view). Milgram (1973) states

"that lingustic competence in . . . moderately to severely retarded individuals was more strongly controlled by maturational (for example, CA) than intellectual factors (for example, IQ)" (p. 165-166).
Seeking out persons whose Down's Syndrome was a result of the same etiology (e.g., Trisomy G, mosaicism, translocation) might help to demonstrate the contribution of etiology of mental retardation to various cognitive abilities.

From the scores resulting from recall of three-word phrases in the present study, there are clear indications that the Down's Syndrome person does not effectively utilize memory strategies. As Spitz (1973) states,

"retardates do not use as efficient strategies to reduce the memory load; they do not efficiently (or as frequently) convert bits into chunks" (p. 137).

Some subjects were observed by the examiner to silently repeat the experimental words as they were heard over the headphones, but then be unable to verbally repeat the phrase upon its completion (apparently because they had not converted "bits into chunks"). Other subjects consistently recalled the first or last word of the phrase at the expense of forgetting the remaining two words (having remembered "bits" but not "chunks"). The most effective memory strategy observed by the examiner was displayed during Experiment 2 when several subjects, upon hearing the first word of the phrase, placed their hand on the hardware piece which was named first, thereby reducing their memory load to only the two remaining words in the sequence. Tapping the effective memory strategies that the retarded person elicits, and training others to utilize similar strategies, could be useful in educational and training cites.

Another training procedure that is already in place in many facilities for the mentally retarded is the use of nonverbal stimuli
to teach a task. In the current study, subjects performed better when a visual and tactile stimuli was added to the task (as in Experiment 2). Milgram (1973) reports that

"children who are presented with information in a verbal medium (that is, the spoken or written word) frequently have greater difficulty in understanding or decoding the verbal input than they would have in understanding a nonverbal input . . ." (p. 167).

This may be especially true for persons who have Down's Syndrome since their psycholinguistic weaknesses are generally found to be in the areas of auditory abilities (Bilovsky & Share, 1965; Rohr & Burr, 1978). Adding visual cues apparently facilitates the processing of even a simple three-word memory task.

The study presented in this dissertation, then, supports a theory of non-hemispheric dominance/ear asymmetry and non-facilitation of melody in persons with Down's Syndrome for recall of three-word auditory phrases. The results contribute to questions raised in the literature such as:

1. are there subjects who consistently demonstrate a clear dominance for audition;
2. are there stimuli which result in a consistent response of dominance from the subjects; and
3. is there an auditory mode (e.g., melodic, rhythmic, verbal) which actually facilitates verbal recall?

Until these questions can be addressed with more consistent research yielding more consistent results, the practical application of knowledge regarding hemispheric dominance and alternative modes of audition, can only be approached in a speculative context.
APPENDIXES
APPENDIX A

VERBAL AND WRITTEN EXPLANATIONS TO
PARTICIPANTS OR GuardianS OF PARTICIPANTS
Dear _______________________

I am a doctoral student at The Ohio State University in developmental psychology. Your child, ____________________, is eligible to participate in my research project which is entitled, "The effects of melody and speech in binaural and monaural presentations to persons with Down's Syndrome". The study has been approved by Dr. Krause of FCBMR/DD.

Prior to the study, all children will be screened for normal hearing. The study will include having your child trained to repeat the names of five hardware pieces (nut, bolt, screw, hook, tack) and sort those pieces in the order which they hear them. The order of the sequence will change and your child will hear these sequences over headphones. Sometimes the sequences will be spoken and other times they will be in the form of a simple song. Some of the sequences will be heard from both headphones and others will be heard from only the left headphone or from only the right headphone. The study should not extend beyond 45 minutes with each child.

The intent of this study is to determine if memory for words can be improved by changing the way in which persons hear those words.

If you have any questions regarding the study please contact me at:

The Nisonger Center
1580 Cannon Drive
The Ohio State University
Columbus, Ohio 43210
Phone: 422-6522

If you agree to allow your child to participate in this study, please read and sign the enclosed consent form and return it to me in the enclosed envelope as soon as possible.

Thank you for your time and cooperation.

Sincerely,

Phoebe Parker, M.A.
Researcher
Verbal Explanation of Procedure
to Potential Subjects

I am going to ask you to listen over the headphones (which subject has in from of him) to three words and then you repeat those words back to me just the way you heard them. You'll do that a lot of times. Then I'm going to show you a nut, bolt, tack, screw, and hook. You'll hear those words over the headphones but this time, instead of repeating the words, you'll sort those things into cups in the order you hear them.

If you want to do this then I need you to sign this paper that says you will do what I just told you about. You can quit whenever you want.
APPENDIX B

CONSENT FORM
THE OHIO STATE UNIVERSITY

CONSENT FOR PARTICIPATION IN
SOCIAL AND BEHAVIORAL RESEARCH

I consent to participating in (or my child’s participation in) research entitled:

The effects of melody and speech in binaural and monaural presentations to persons with Down’s Syndrome.

Phoebe Parker ______ or his/her authorized representative has (Principal Investigator)

explained the purpose of the study, the procedures to be followed, and the expected duration of my (my child’s) participation. Possible benefits of the study have been described as have alternative procedures, if such procedures are applicable and available.

I acknowledge that I have had the opportunity to obtain additional information regarding the study and that any questions I have raised have been answered to my full satisfaction. Further, I understand that I am (my child is) free to withdraw consent at any time and to discontinue participation in the study without prejudice to me (my child). The information obtained from me (my child) will remain confidential unless I specifically agree otherwise by placing my initials here ____________________.

Finally, I acknowledge that I have read and fully understand the consent form. I sign it freely and voluntarily. A copy has been given to me.

Date: ____________________ Signed: ____________________

(Participant)

Signed: ____________________ Signed: ____________________

(Principal Investigator
or his/her Authorized Representative)

(Person Authorized to Consent for Participant - If Required)

Witness: ____________________

HS-027 (Rev. 12-81) -- To be used only in connection with social and behavioral research.
APPENDIX C

EXPERIMENTAL PHRASES
Verbal Phrases - Binaural
1. screw - bolt - tack
2. tack - bolt - screw
3. hook - screw - nut

Verbal Phrases - Left Ear
1. tack - nut - bolt
2. tack - nut - screw
3. hook - tack - screw

Verbal Phrases - Right Ear
1. screw - hook - bolt
2. nut - hook - tack
3. bolt - tack - screw

Sung Phrases - Binaural
1. bolt - hook - screw
   F - C - G (melodic notation)
2. nut - screw - tack
   F - G - A
3. bolt - screw - hook
   A - G - F

Sung Phrases - Left Ear
1. bolt - tack - hook
   G - D - A
2. nut - hook - screw
   C - C - F
3. nut - bolt - tack
   F - A - A

Sung Phrases - Right Ear
1. nut - bolt - hook
   D - G - D
2. hook - nut - bolt
   A - C - F
3. hook - nut - screw
   D - G - F
APPENDIX D

TRIAL PHRASES
One-Word Phrases
1. screw
2. bolt
3. hook
4. nut
5. tack

Two-Word Phrases
1. screw - nut
2. bolt - nut
3. hook - bolt
4. nut - tack
5. bolt - tack
6. tack - screw

Three-Word Phrases
1. screw - nut - hook
2. bolt - nut - tack
3. hook - bolt - screw
4. nut - tack - hook
5. hook - bolt - tack
6. tack - screw - bolt

Verbal Trial Phrase - Binaural
screw - nut - hook

Verbal Trial Phrase - Right Ear
bolt - nut - tack

Verbal Trial Phrase - Left Ear
hook - bolt - screw

Sung Trial Phrase - Binaural
nut - tack - hook
C - D - F (melodic notation)

Sung Trial Phrase - Right Ear
hook - bolt - tack
C - F - C

Sung Trial Phrase - Left Ear
tack - screw - bolt
F - F - C
# ANSWER SHEET A

**Group A**

**Name _______________________________**

<table>
<thead>
<tr>
<th></th>
<th>1. tack nut bolt</th>
<th>10. bolt tack screw</th>
</tr>
</thead>
<tbody>
<tr>
<td>v-</td>
<td>___ ___ ___</td>
<td>v- ___ ___ ___</td>
</tr>
<tr>
<td>p-</td>
<td>___ ___</td>
<td>p- ___ ___</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>2. tack bolt screw</th>
<th>11. bolt hook screw</th>
</tr>
</thead>
<tbody>
<tr>
<td>v-</td>
<td>___ ___ ___</td>
<td>v- ___ ___ ___</td>
</tr>
<tr>
<td>p-</td>
<td>___ ___ ___</td>
<td>p- ___ ___ ___</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>3. screw hook bolt</th>
<th>12. nut hook tack</th>
</tr>
</thead>
<tbody>
<tr>
<td>v-</td>
<td>___ ___ ___</td>
<td>v- ___ ___</td>
</tr>
<tr>
<td>p-</td>
<td>___ ___ ___</td>
<td>p- ___ ___</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>4. hook screw nut</th>
<th>13. nut hook screw</th>
</tr>
</thead>
<tbody>
<tr>
<td>v-</td>
<td>___ ___ ___</td>
<td>v- ___ ___ ___</td>
</tr>
<tr>
<td>p-</td>
<td>___ ___ ___</td>
<td>p- ___ ___ ___</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>5. hook nut bolt</th>
<th>14. hook tack screw</th>
</tr>
</thead>
<tbody>
<tr>
<td>v-</td>
<td>___ ___ ___</td>
<td>v- ___ ___ ___</td>
</tr>
<tr>
<td>p-</td>
<td>___ ___ ___</td>
<td>p- ___ ___ ___</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>6. bolt screw hook</th>
<th>15. hook nut screw</th>
</tr>
</thead>
<tbody>
<tr>
<td>v-</td>
<td>___ ___ ___</td>
<td>v- ___ ___ ___</td>
</tr>
<tr>
<td>p-</td>
<td>___ ___ ___</td>
<td>p- ___ ___ ___</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>7. bolt tack hook</th>
<th>16. nut screw tack</th>
</tr>
</thead>
<tbody>
<tr>
<td>v-</td>
<td>___ ___ ___</td>
<td>v- ___ ___ ___</td>
</tr>
<tr>
<td>p-</td>
<td>___ ___ ___</td>
<td>p- ___ ___ ___</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>8. screw bolt tack</th>
<th>17. nut bolt tack</th>
</tr>
</thead>
<tbody>
<tr>
<td>v-</td>
<td>___ ___ ___</td>
<td>v- ___ ___ ___</td>
</tr>
<tr>
<td>p-</td>
<td>___ ___ ___</td>
<td>p- ___ ___ ___</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>9. tack nut screw</th>
<th>18. nut bolt hook</th>
</tr>
</thead>
<tbody>
<tr>
<td>v-</td>
<td>___ ___ ___</td>
<td>v- ___ ___ ___</td>
</tr>
<tr>
<td>p-</td>
<td>___ ___ ___</td>
<td>p- ___ ___ ___</td>
</tr>
</tbody>
</table>
**Group B**

<p>| | | | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1. <strong>bolt screw hook</strong></td>
<td><strong>10. bolt tack screw</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>v-</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>p-</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. <strong>nut bolt tack</strong></td>
<td><strong>11. hook tack screw</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>v-</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>p-</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. <strong>nut hook screw</strong></td>
<td><strong>12. nut screw tack</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>v-</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>p-</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. <strong>nut hook tack</strong></td>
<td><strong>13. bolt hook screw</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>v-</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>p-</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. <strong>tack nut screw</strong></td>
<td><strong>14. screw bolt tack</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>v-</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>p-</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. <strong>bolt tack hook</strong></td>
<td><strong>15. tack bolt screw</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>v-</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>p-</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7. <strong>screw hook bolt</strong></td>
<td><strong>16. tack nut bolt</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>v-</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>p-</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8. <strong>hook screw nut</strong></td>
<td><strong>17. hook nut screw</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>v-</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>p-</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9. <strong>hook nut bolt</strong></td>
<td><strong>18. nut bolt hook</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>v-</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>p-</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
GROUP C

Name ________________________________

1. hook tack screw
   v-______
   p-______

2. bolt tack screw
   v-______
   p-______

3. hook screw nut
   v-______
   p-______

4. hook nut bolt
   v-______
   p-______

5. screw hook bolt
   v-______
   p-______

6. nut hook tack
   v-______
   p-______

7. nut screw tack
   v-______
   p-______

8. tack bolt screw
   v-______
   p-______

9. tack nut bolt
   v-______
   p-______

10. bolt screw hook
    v-______
    p-______

11. bolt tack hook
    v-______
    p-______

12. nut hook screw
    v-______
    p-______

13. nut bolt hook
    v-______
    p-______

14. hook nut screw
    v-______
    p-______

15. tack nut screw
    v-______
    p-______

16. bolt hook screw
    v-______
    p-______

17. screw bolt tack
    v-______
    p-______

18. nut bolt tack
    v-______
    p-______
## WORD RECALL - DISREGARDING ORDINAL POSITION

<table>
<thead>
<tr>
<th>Ss</th>
<th>V</th>
<th>VLE</th>
<th>VRE</th>
<th>S</th>
<th>SLE</th>
<th>SRE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>8</td>
<td>7</td>
<td>6</td>
<td>6</td>
<td>7</td>
<td>6</td>
</tr>
<tr>
<td>2</td>
<td>8</td>
<td>5</td>
<td>7</td>
<td>4</td>
<td>6</td>
<td>5</td>
</tr>
<tr>
<td>3</td>
<td>9</td>
<td>9</td>
<td>8</td>
<td>9</td>
<td>7</td>
<td>9</td>
</tr>
<tr>
<td>4</td>
<td>6</td>
<td>6</td>
<td>6</td>
<td>5</td>
<td>7</td>
<td>5</td>
</tr>
<tr>
<td>5</td>
<td>7</td>
<td>9</td>
<td>7</td>
<td>8</td>
<td>6</td>
<td>8</td>
</tr>
<tr>
<td>6</td>
<td>6</td>
<td>6</td>
<td>8</td>
<td>9</td>
<td>8</td>
<td>7</td>
</tr>
<tr>
<td>7</td>
<td>4</td>
<td>7</td>
<td>6</td>
<td>5</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>8</td>
<td>9</td>
<td>9</td>
<td>9</td>
<td>8</td>
<td>9</td>
<td>9</td>
</tr>
<tr>
<td>9</td>
<td>6</td>
<td>4</td>
<td>6</td>
<td>6</td>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td>10</td>
<td>8</td>
<td>6</td>
<td>5</td>
<td>8</td>
<td>7</td>
<td>7</td>
</tr>
<tr>
<td>11</td>
<td>8</td>
<td>7</td>
<td>7</td>
<td>8</td>
<td>7</td>
<td>8</td>
</tr>
<tr>
<td>12</td>
<td>8</td>
<td>5</td>
<td>6</td>
<td>8</td>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td>13</td>
<td>6</td>
<td>5</td>
<td>7</td>
<td>5</td>
<td>7</td>
<td>7</td>
</tr>
<tr>
<td>14</td>
<td>8</td>
<td>8</td>
<td>8</td>
<td>8</td>
<td>7</td>
<td>9</td>
</tr>
<tr>
<td>15</td>
<td>8</td>
<td>5</td>
<td>8</td>
<td>6</td>
<td>6</td>
<td>3</td>
</tr>
<tr>
<td>16</td>
<td>4</td>
<td>6</td>
<td>8</td>
<td>6</td>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td>17</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>18</td>
<td>6</td>
<td>6</td>
<td>5</td>
<td>5</td>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td>19</td>
<td>8</td>
<td>7</td>
<td>6</td>
<td>6</td>
<td>7</td>
<td>4</td>
</tr>
<tr>
<td>20</td>
<td>8</td>
<td>9</td>
<td>9</td>
<td>8</td>
<td>9</td>
<td>9</td>
</tr>
<tr>
<td>21</td>
<td>9</td>
<td>9</td>
<td>8</td>
<td>9</td>
<td>8</td>
<td>9</td>
</tr>
<tr>
<td>22</td>
<td>6</td>
<td>4</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>23</td>
<td>4</td>
<td>6</td>
<td>5</td>
<td>6</td>
<td>5</td>
<td>4</td>
</tr>
<tr>
<td>24</td>
<td>6</td>
<td>6</td>
<td>6</td>
<td>7</td>
<td>6</td>
<td>7</td>
</tr>
<tr>
<td>25</td>
<td>5</td>
<td>7</td>
<td>6</td>
<td>7</td>
<td>7</td>
<td>6</td>
</tr>
<tr>
<td>26</td>
<td>5</td>
<td>8</td>
<td>7</td>
<td>8</td>
<td>6</td>
<td>8</td>
</tr>
<tr>
<td>27</td>
<td>6</td>
<td>7</td>
<td>9</td>
<td>8</td>
<td>9</td>
<td>9</td>
</tr>
<tr>
<td>28</td>
<td>8</td>
<td>9</td>
<td>9</td>
<td>7</td>
<td>8</td>
<td>9</td>
</tr>
<tr>
<td>29</td>
<td>7</td>
<td>4</td>
<td>4</td>
<td>6</td>
<td>7</td>
<td>6</td>
</tr>
<tr>
<td>30</td>
<td>5</td>
<td>7</td>
<td>7</td>
<td>7</td>
<td>8</td>
<td>9</td>
</tr>
<tr>
<td>31</td>
<td>7</td>
<td>6</td>
<td>6</td>
<td>5</td>
<td>7</td>
<td>7</td>
</tr>
<tr>
<td>32</td>
<td>6</td>
<td>6</td>
<td>6</td>
<td>4</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>33</td>
<td>9</td>
<td>9</td>
<td>8</td>
<td>9</td>
<td>9</td>
<td>9</td>
</tr>
<tr>
<td>34</td>
<td>8</td>
<td>6</td>
<td>6</td>
<td>6</td>
<td>7</td>
<td>6</td>
</tr>
<tr>
<td>35</td>
<td>8</td>
<td>7</td>
<td>8</td>
<td>5</td>
<td>7</td>
<td>8</td>
</tr>
<tr>
<td>36</td>
<td>4</td>
<td>7</td>
<td>7</td>
<td>5</td>
<td>6</td>
<td>5</td>
</tr>
</tbody>
</table>

Total: 247 243 249 240 248 249
APPENDIX G

RAW DATA FOR EXPERIMENT 2
## Sorting Response as Measure of Sequential Recall

<table>
<thead>
<tr>
<th>Ss</th>
<th>V</th>
<th>VLE</th>
<th>VRE</th>
<th>S</th>
<th>SLE</th>
<th>SRE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>2</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>4</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>5</td>
<td>2</td>
<td>0</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>6</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>7</td>
<td>0</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>8</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>9</td>
<td>1</td>
<td>3</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>10</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>11</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>12</td>
<td>3</td>
<td>3</td>
<td>2</td>
<td>2</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>13</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>14</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>15</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>16</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>17</td>
<td>3</td>
<td>3</td>
<td>2</td>
<td>3</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>18</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>19</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>20</td>
<td>3</td>
<td>3</td>
<td>2</td>
<td>3</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>21</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>22</td>
<td>0</td>
<td>2</td>
<td>1</td>
<td>3</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>23</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>24</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>25</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>26</td>
<td>2</td>
<td>3</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>27</td>
<td>3</td>
<td>2</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>28</td>
<td>2</td>
<td>3</td>
<td>1</td>
<td>0</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>29</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>30</td>
<td>2</td>
<td>3</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>31</td>
<td>1</td>
<td>1</td>
<td>3</td>
<td>2</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>32</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>33</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>34</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>0</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>35</td>
<td>3</td>
<td>2</td>
<td>2</td>
<td>3</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>36</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

Total 43 59 46 53 53 56
REFERENCES


Henschen, S.E. (1926). On the function of the right hemisphere of the brain in relation to the left in speech, music, and calculation. *Brain*, 42, 110-123.


