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Right-Left Visual Field Performances of Congenitally Deaf and Normal Hearing Subjects

Merle Applebaum-Rosenberg

RIGHT-LEFT VISUAL FIELD PERFORMANCES - APPLEBAUM-ROSENBERG

THE UNIVERSITY OF NEW MEXICO
ALBUQUERQUE, NEW MEXICO 87106

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This thesis, directed and approved by the candidate's committee, has been accepted by the Graduate Committee of The University of New Mexico in partial fulfillment of the requirements for the degree of

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MERLE APPLEBAUM-ROSENBERG

Candidate

Communicative Disorders

Department

David T. Benedetti
Dean

Dec. 5, 1973
Date

Committee

William J. Rogan
Chairman

Robert J. Wertz

Richard B. Hood

David J. Draper

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BY

MERLE APPLEBAUM-ROSENBERG

B.S., INDIANA UNIVERSITY, 1971

THESIS

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ABSTRACT

The notion of cerebral dominance has been explored since the time of Broca. Two non-invasive techniques designed to assess hemispheric dominance have subsequently been developed. These two methods are commonly referred to as dichotic listening (simultaneous auditory stimulation) and rapid visual field stimulation (tachistoscopic viewing).

It has been found in dichotic listening studies that when verbal material is presented simultaneously to both ears, the stimuli are correctly identified most often in the right ear. Similar results have been found in tachistoscopic studies, with verbal material eliciting a right visual field advantage. Collectively, these findings have been used to support a left hemispheric dominance for processing verbal material, since the right ear and visual field are strongly connected to the left hemisphere.

It has been argued that the right visual field preference in tachistoscopic presentation may actually be reflecting a strong link between a visual stimulus and its auditory image in the brain. In order to explore this notion further, a tachistoscopic study was designed using subjects who lacked sufficient auditory input with which to develop auditory imagery for visual stimuli.

Twenty deaf and 20 normal hearing subjects were selected. Of these 40 subjects, 20 subjects (10 normal hearing and 10 deaf) were familiar with the manual alphabet. The visual stimuli selected for tachistoscopic presentation were 16 orthographic letters and the corresponding 16 manual alphabet letters. A total of four tasks was presented. All subjects completed one task in which orthographic stimuli were presented and an orthographic symbol was required as a response, and one task in which a manual stimulus was presented and a manual symbol was required as a response. In addition, the 20 subjects familiar with the manual alphabet completed one task requiring orthographic symbol to manual symbol matching and a final task requiring manual symbol to orthographic symbol matching.

The major findings of the present study were as follows:

1. A slight right visual field preference was noted on the average when linguistically meaningful stimuli were presented.

2. An equivocal visual field performance was noted on the average when the stimuli that were presented were assumed to be linguistically non-meaningful.

3. On overall right-left visual field performance, deaf subjects showed a reduced right-left difference when compared to the normal hearing subjects.

In conclusion, it is indicated by the results that although auditory imagery is not essential for the right visual field advantage to be exhibited, the absence of auditory influences may reduce the magnitude of this advantage.

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CHAPTER I

INTRODUCTION

Cerebral Dominance

The notion of localizing brain functions in specific cortical areas was first presented by Gall in the early nineteenth century (as cited in Schuell, Jenkins, and Jimenez-Pabon, 1964). He postulated language functions to be located in the anterior lobes of the brain, and believed that the size of the orbital area reflected one's oral recitation skills. Though his theory is less than empirically based, Gall's suggestion stimulated closer examination of brain function localization.

Subsequent to Gall, Bouillard localized speech in the frontal lobes anterior to the Rolandic Fissure (as cited in Schuell, *et al.*, 1964). Bouillard was the teacher of Broca who placed language in the third frontal convolution of the left hemisphere (Schuell, *et al.*, 1964). Broca's work was a result of observations of aphemic patients followed by post-mortem study of their intact brains. Wernicke (1874), using methods similar to Broca's, hypothesized that specific auditory language functions were localized in the left temporal lobe.

These early researchers and others sparked interest in the localization of cortical functions. Subsequent investigations generally supported the notion of asymmetrical functioning of the cerebral hemispheres, as well as the existence of a morphological asymmetry (Boyd, 1961; Wagner, 1964; Thurman, 1866, Braune, 1891; Geshwind and Levitsky, 1968; and LeMay and Culebras, 1972). However, these observations arose from speculation and inferences based upon studies involving patients with unilateral brain lesions.

A more precise procedure for determining the language dominant hemisphere of the intact brain was developed by Wada (1949). His technique was to inject sodium amytal into the right and left carotid arteries alternately and then compare the resulting effects upon the individual's speech. The drug resulted in a temporary contralateral hemiparesis accompanied by loss of language functions when injected into the dominant hemisphere. The non-dominant hemisphere injection resulted in a temporary contralateral hemiparesis without the concurrent language symptoms (Wada and Rassmussen, 1960).

Dichotic Listening

Coincidental with the development of the sodium amytal test, Broadbent (1954) was employing dichotic listening techniques (simultaneous presentation of

different auditory stimuli to each ear) in an attempt to study short term memory. When Broadbent reported a right ear preference for dichotically presented speech material, Kimura (1961b) recognized the potential of this technique in the study of cerebral dominance. Using dichotically presented paired digits, she found that stimuli presented to the right ear were perceived more accurately than similar stimuli presented to the left ear.

These findings in conjunction with those of Wada and Rassmussen (1964) led Kimura to conclude that the contralateral auditory pathways are more efficient than the ipsilateral auditory pathways (Kimura, 1961a). Anatomically, the contralateral pathway sends only a slightly greater number of fibers to the auditory cortex than does the ipsilateral pathway (Kimura, 1967). In his study with the cat's auditory system, however, Rosenzweig (1951) proposed that a point of overlap exists between the two pathways. It is at this point of overlap that the contralateral pathway has the capabilities of occluding the ipsilateral pathway impulses. This may account, in part, for the superiority of the right ear (in most subjects) on dichotic listening tasks. The right ear simply has better connections with the left hemisphere. These notions are further supported by anatomical evidence that decussation of most cochlear fibers occurs in the brain stem (Noback and Demarest, 1972).

Many investigators have followed Kimura's dichotic listening model (Bryden, 1963; Shankweiler and Studdert-Kennedy, 1966; Berlin, 1972; Satz, 1967; Curry, 1967; and others). Since Shanks (1973) has reviewed these studies in detail, the following summary has been excerpted from her manuscript:

> 1. There is a right ear superiority for speech signals, reflecting processing in the left hemisphere; with a left ear superiority for non-speech stimuli, reflecting processing in the right hemisphere.
>
> 2. Dichotic listening tasks reveal asymmetry as early as age five.
>
> 3. Listeners generally report all dichotic digits presented to one ear, usually the right ear, before reporting digits presented to the left ear.
>
> 4. Right ear superiority is retained when order of report is controlled, ruling out the effect of greater trace decay of stored stimuli; i.e., left ear stimuli.
>
> 5. The rate of presentation of dichotic stimuli effects the overall order of report, although a right ear advantage is retained.
>
> 6. A time lag of 30-90 msec enables the left ear to overcome the right ear superiority, but with lags of greater than 250 msec both stimuli are accurately perceived.
>
> 7. Although no direct relationship has been found between handedness and hemispheric dominance for speech on dichotic listening tasks, reversals are more frequent among left-handed subjects (pp. 3-5).

The results of the dichotic listening experiments all indicate that verbal stimuli processed in the left hemisphere are perceived more accurately than similar material processed through the right hemisphere. What basic factors are responsible for these results? Several investigators (Curry, 1967; Kimura, 1967; Kimura and Folb, 1968) have attempted to show that articulated speech, language perceived in the auditory modality, is the key to lateralization. This theory proves inadequate since linguistic impairment in the visual modality (dysgraphia and dyslexia) occurs as a result of left hemisphere damage with no accompanying impairment in speech production or comprehension.

In addition, Krashen (1972) demonstrated that dichotic presentation of Morse Code signals revealed a right ear effect for subjects familiar with Morse Code. No such effect was found with subjects unfamiliar with Morse Code. Since speech is not involved in the presentation of Morse Code a more inclusive process must be operating in the left hemisphere. For those who are familiar with Morse Code, it represents a communicating system or language. More directly stated, the left hemisphere is specialized to deal with all aspects of communication related to language.

Tachistoscopic Research

Further emphasizing the notion of left hemisphere language specialization as opposed to speech specialization alone, investigations involving visual verbal stimuli have been conducted. The visual system, like the auditory system, involves both ipsilateral and contralateral pathways to the brain. Again, as in the auditory system, the crossed or contralateral pathways to the brain are more efficient (Efron, 1963; and Kimura, 1966).

Investigations of asymmetrical functioning of the brain for visual stimuli, have been typically carried out using tachistoscopic presentation of visual verbal stimuli. In tachistoscopic presentation a visual stimulus is rapidly displayed to one or both of the visual fields. Presentation to only one visual field (successive or monoptic presentation) is achieved by displaying the stimulus to only one visual field at a time. In this manner, only one hemisphere receives the stimulus for processing. Presentation to both visual fields simultaneously (dichoptic presentation) is achieved by displaying different visual stimuli to both visual fields simultaneously. This method creates competition between the stimuli for processing and recognizing the information.

Since the literature dealing with visual verbal processing is quite extensive, only the major findings will be summarized here.

1. Successively presented visual stimuli of a verbally-identifiable nature (i.e., words, familiar forms, letters) are perceived more accurately in the right visual field (left hemisphere) than in the left visual field (right hemisphere) (Mishkin and Forgays, 1952; Forgays, 1953; Orbach, 1953; Heron, 1957; Bryden, 1960; Wyke and Ettlinger, 1961; Goodglass and Barton, 1963; Kimura, 1966; Bryden and Rainey, 1963; Bryden, 1964; Bryden, 1965; Overton and Wiener, 1966; and Orbach, 1967).

2. Successively presented visual material of a non-verbally identifiable nature (i.e., nonsense forms, unfamiliar objects) are more accurately perceived in the left visual field (right hemisphere) than in the right visual field (left hemisphere) (Kimura, 1963; Kimura, 1966; Rubino, 1970; and Adams, 1971).

3. A left visual field superiority has been observed with simultaneously presented stimuli of both verbally-related and non-verbally-related natures (Bryden, 1960; Bryden and Rainey, 1963; Heron, 1957; Dorff, Mirsky and Mishkin, 1965).

4. Temporal lobe damage results in the impairment of visual perception. The nature of the impairment

is dependent upon the locus of the damage: right side damage leads to more pronounced impairment of non-verbally-related stimulus perception while left side damage leads to more pronounced impairment of symbolic or verbally-related stimulus perception (Dorff, et al., 1965; Kimura, 1963; Dudle, Doehring and Coderre, 1968; and Rubino, 1970).

In addition to these findings, Mishkin and Forgays (1952) and Orbach (1952) have found that Hebrew words, which are read in a right-to-left direction, are more readily perceived in the left visual field (right hemisphere). This evidence contradicts other findings in which all verbally-related material is best perceived in the right visual field (left hemisphere). The above mentioned authors explain this phenomenon in terms of reading training. Since Hebrew is read in a right-to-left direction, a more efficient neural organization is developed in the visual field which receives the forthcoming information, the left in this case (Orbach, 1952). In a later study, Orbach (1967) found that although no significant recognition differential was obtained using Hebrew words as stimuli, right handers recognized more Hebrew words in the right visual field (left hemisphere), and left handers recognized more in the left visual field (right hemisphere). Orbach goes on to account for these results with the strong influence

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in hemispheric [illegible] (Kimura, [illegible];
[illegible], 1967; [illegible], [illegible] and [illegible], 1969;
and Hellige, 1976).

In addition to these findings, Mishkin and
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[illegible] were [illegible] in the right visual field
[illegible]. [illegible]
[illegible] field [illegible]. [illegible]
[illegible]

of directional scanning, selective attention, structural features, and cerebral dominance upon the left-to-right recognition differential.

Forgays (1953) also explained the right visual field superiority for English in terms of reading features. He felt that selective retinal training created a situation in which material presented to the right of fixation automatically receives more attention than material to the left of fixation (Forgays, 1953). In this study Forgays dismisses the theory of cerebral dominance as having strong influence upon the results of the investigation. However, more recent studies (Kimura, 1963; Kimura, 1966; Rubino, 1970; and Adams, 1971) present evidence which removes selective retinal attention as the major precipitator of a right-field effect and support the theory of cerebral dominance as the major factor.

The phenomenon of "order of report" and the "fading trace theory" are attributing factors to the conflicting information obtained from simultaneous presentation of visual material (Bryden, 1960; Bryden and Rainey, 1964; and Bryden, 1965). As previously stated, a left-field superiority is found with simultaneous presentation of visual material of both a verbal and non-verbal nature. Bryden (1960) found that subjects tended to report stimuli from left to right. In

fact, fewer stimuli were reported when the sequence of report was from right to left. Bryden (1960) further explains the effect is due to a "polarization" of the trace systems in a left-to-right direction. Such a situation facilitates perception of material to the left of fixation since there is more time between presentation and report for the trace of the stimulus on the right to fade (Bryden, 1963). This theory explains the left visual field superiority sufficiently while continuing to support the stronger influence of the theory of cerebral dominance upon the right visual field superiority obtained with successively presented verbal stimuli (Bryden, 1965).

The Non-Normal Brain

Studies which investigate the perceptual behavior of damaged brains further support the theory of cerebral dominance (Kimura, 1963; Dorff, et al., 1965; Dudley, et al., 1968; and Rubino, 1970). These investigators revealed that damage to the left temporal lobe resulted in severe impairment in perception of verbally-oriented visual stimuli, reflecting processing in the left hemisphere. In addition, damage to the right temporal lobe resulted in impairment in the perception of non-verbally-oriented stimuli, reflecting processing of this material in the right hemisphere

(Rubino, 1970). An overall depression of scores was found for subjects with left hemisphere damage. This was attributed to the symbolic nature of the task (Dudley, et al., 1968).

Though not directly damaged, a deaf individual's brain has imposed upon it non-normal limitations. Studies have been performed that indicate manual language (language of an exclusively visual nature) in congenitally deaf patients is impaired by left hemisphere damage. Two such studies were carried out by Reed (1971) and Sarno, Swisher, and Sarno (1969). Reed set out to demonstrate that except for auditory dysfunction, a deaf individual's neurological processes are not substantially different from the neurological processes of a hearing individual. He used four historic cases of aphasia among the deaf population for discussion purposes. Each of the four cases incurred damage to the left cerebral hemisphere. This damage resulted in loss or impairment of manual language and other language functions such as reading and writing. Reed concludes from these cases that the same areas in the brain of the deaf, function in a similar manner as do brains of normal hearing individuals with the obvious exception of the limited extent to which the auditory areas function in the deaf brain.

Sarno, et al., (1969) arrive at similar conclusions. Their study involved only one subject, a 69 year old congenitally deaf man. He had suffered what [illegible] et al. [illegible]

[illegible]

[illegible] and other language functions such as reading and writing. [illegible]

[illegible]

Satz, et al. [illegible]

was diagnosed as a cerebral infarction of the left frontal-parietal region. His physical symptoms included paresis of the right arm and leg. The subject's language impairment was demonstrated as reduced functioning in the expressive and receptive modalities in which he formerly had been proficient. These modalities included lip reading, general sign language, finger spelling, a combined method employing a mixture of the previous skills, reading, writing, and some speech or mouthing of words. Despite some recovery within the first six months after onset, the diagnosis remained severe aphasia.

Sarno, et al., (1969) felt that their subject performed better on a functional or conversational level than in the structured testing situation. This behavior is compatible with similar behavior of hearing aphasics. Additionally, the subject's letter finding difficulties in finger spelling were considered analogous to phoneme losses in hearing aphasics. The results of this study led Sarno and his co-investigators to suggest that "the congenitally deaf encode and decode language by the same fundamental processes as those with normal hearing" (Sarno, et al., 1969, p. 414).

was observed [illegible] of the [illegible]
from [illegible]
patterns of the right arm and leg. [illegible]
Treatment was [illegible] by [illegible]
the [illegible] and [illegible]
formerly had been [illegible]
(c) reading, [illegible] sign language, [illegible]
a combined [illegible] a [illegible] of [illegible]
skills, reading, [illegible] and [illegible]
of words. Results [illegible] recovery [illegible]
months after onset. The diagnosis [illegible]

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fundamental processes as those [illegible]
Sarno, et al., 1969, p. [illegible]

Rationale

Previously discussed dichotic listening studies have yielded strong evidence of left hemisphere dominance for language functions. On the basis of past tachistoscopic investigations it is possible to predict with a degree of certainty, that under monoptic (successive) presentation, normal hearing individuals will show a right visual field preference for verbal materials and a left visual field preference for non-verbal materials. It might be argued that a critical element in developing hemispheric dominance for visually presented verbal material is auditory stimulation to the temporal lobe. If this were the case, previous tachistoscopic studies may merely be reflecting the association between a visual stimulus and its auditory image in the brain.

One method of eliminating the effects of auditory-visual interaction when exploring cerebral dominance for visual verbal material is to use subjects who have had insufficient auditory input with which to develop auditory images of visual stimuli, namely, an auditory image of orthographic symbols. On limited information, Sarno, et al., (1969) and Reed (1971) have hypothesized that verbal material is handled in the deaf individual's brain in a manner similar to that of a normal hearing individual's brain. Since hemispheric

dominance in the deaf individual can be assessed via the visual modality without auditory influences, the present study was designed to investigate the visual performances of deaf individuals using visual-linguistic material.

Statement of the Problem

The major purpose of this study was to investigate the right-left visual field performances of congenitally deaf subjects using tachistoscopically presented orthographic and manual alphabet letters. In addition, the relationship between right-left visual field preference and degree to which a stimulus is acted upon as a verbal stimulus was explored by comparing the performances of two groups of deaf subjects with those exhibited by two groups of normal hearing subjects.

The following hypotheses, stated in the null form, were tested:

1. There is no significant difference between scores obtained for the right and left visual fields for either normal or deaf subjects for orthographic stimuli (Task 1).
2. There is no significant difference between scores obtained for the right

and left visual fields for normal or deaf subjects for manual stimuli (Task 2) when either group is familiar with the manual alphabet.

3. There is no significant difference between right and left visual field performances of normal or deaf subjects for manual stimuli (Task 2) when neither group is familiar with the manual alphabet.
4. There is no significant difference between right and left visual field performance of the normal or deaf subjects who know manual alphabet when orthographic stimuli are presented and a manual symbol is required as a response.
5. There is no significant difference between right and left visual field performances of the normal or deaf subjects who know the manual alphabet when manual stimuli are presented and an orthographic symbol is required as a response.

CHAPTER II

PROCEDURES

Subjects

Four groups of 10 subjects each were selected for this study. The following is a summarized description of these subject groups. For a more complete description of the subjects refer to Appendix A.

Group 1 was comprised of five males and five females ranging in age from 12 to 61 years with a mean age of 27.8 years. All subjects in this group were normal hearing individuals with no previous exposure to the manual alphabet.

Group 2 consisted of five males and five females ranging in age from 22 to 35 years with a mean age of 27.8 years. All subjects in this group were normal hearing individuals who were familiar with and used the manual alphabet.

Group 3 consisted of five males and five females ranging in age from 14 to 62 years with a mean age of 34.1 years. All subjects in this group were congenitally deaf individuals* who were familiar with and used the manual alphabet.

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* Congenital deafness is defined as a binaural pure tone average for the speech range of 90dB or greater from earliest records.

Group 4 was comprised of five males and five females ranging in age from 8 to 11 years with a mean age of 9.1 years. All subjects in this group were congenitally deaf individuals who had no previous exposure to the manual alphabet.

On the basis of available medical records, no subjects were included in this study who exhibited any disorder which may have directly affected performance on the experimental tasks. Each subject's ability to recognize the symbols of the manual alphabet was assessed by having the subject identify each of the stimulus symbols prior to experimental presentation.

Methods

Sixteen letters of the manual alphabet were selected for presentation in this study. The orthographic equivalents were also used. All vowels and vowel-like letters and all letters that require movement in the manual alphabet were eliminated. The remaining letters were B, C, D, F, G, H, K, L, M, N, P, R, S, T, V, and X. Orthographic letters are considered to be the smallest unit of visual linguistic material for the reading individual (Bryden, 1960). Therefore, for purposes of this study, manual alphabet letters were assumed to be the smallest unit of visual linguistic material for the individual familiar with manual communication.

Finally, [illegible] of subjects [illegible] were [illegible] tested [illegible] the [illegible] age of [illegible] years [illegible] comparability [illegible] was [illegible] made at the [illegible].

On the basis of available medical records, no subjects were included in this study who exhibited any disorder which may have adversely affected performance on the experimental tasks. Each subject's ability to recognize the letters of the manual alphabet was assessed by having him correctly identify each of the selected letters prior to experimental presentation.

Method

Fifteen letters of the manual alphabet were selected for presentation in this study. Their orthographic equivalents were also used. All static and moving-hand letters and all letters that require movement in the manual alphabet were eliminated. The remaining letters were [illegible], and [illegible]. Orthographic symbols are considered to be the smallest unit of visual language [illegible] for the reading individual ([illegible]). Therefore, for purposes of this study, manual alphabet letters were assumed to be the smallest unit of visual language [illegible] for the individual proficient with manual communication.

The stimuli were placed on white cards either one inch to the right or one inch to the left of fixation so that the stimulus was presented either to the right or to the left visual field of the subject. The orthographic letters used were Letraset 42-24-CLN. The manual letters were reprinted from a card displaying the entire manual alphabet which is distributed by the Santa Fe School for the Deaf. The overall size of the orthographic letters was 3/16 inch and the manual letters were approximately 1/2 inch in diameter (See Appendix B). Each stimulus was presented an equal number of times to both the right and the left visual fields.

For purposes of tachistoscopic presentation of the stimuli, a special viewing box was constructed (See Figure 1). The interior of the box was diagonally bisected by a two-way mirror. When compartment A was illuminated, the subject saw a reflection of the fixation dot directly ahead. When compartment B was illuminated (compartment A darkened), the mirror became transparent enabling the subject to see the presented stimulus through the viewing site. The two light sources (slide projectors) were successively triggered by a Gerbrands Electronic Timer Model 3004t coupled with a Gerbrands 2-Channel Projection Tachistoscope Model G 1171.

The sequence of events was as follows: Preceded by instructions to fixate on the dot, compartment A was

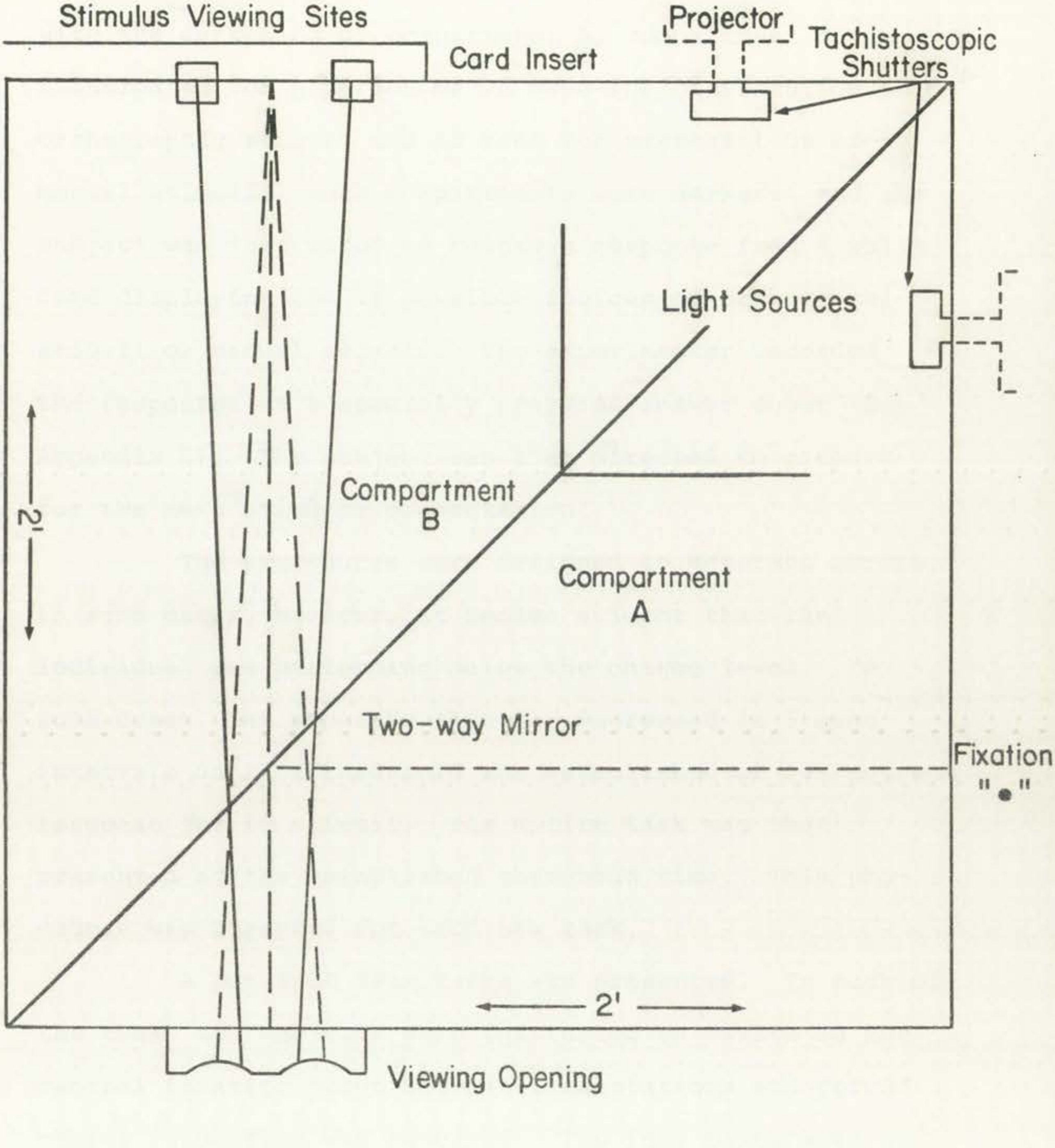


Figure 1. Schematic representation of viewing box for selective visual field stimulation.

Task 2: The subject was exposed to a manual alphabet letter and was required to choose the appropriate letter from the response card of manual letters.

Task 3: The subject was exposed to an orthographic letter and was required to choose the appropriate response from the response card of manual letters.

Task 4: The subject was exposed to a manual letter and was required to choose the appropriate letter from the response card of orthographic letters.

The procedure for the four groups was as follows: All groups completed Tasks 1 and 2. In addition, the two groups which were familiar with the manual alphabet completed Tasks 3 and 4.

Data Reduction and Analysis

Response sheets for each subject for each task were analyzed for total number of correct responses for right and left visual fields. Means and standard deviations of correct responses were subsequently computed for all groups and conditions. Appropriate group mean comparisons were obtained with the Student t-statistic.

Task 2: The subject was exposed to a single English letter and was required to choose the appropriate letter from the response panel of English letters.

Task 3: The subject was exposed to a single Russian letter and was required to choose the identical response from the response panel of Russian letters.

Task 4: The subject was exposed to a single letter and was required to choose the appropriate letter from the response panel of [illegible] letters.

The procedure for the four groups was as follows: All groups completed Tasks 1 and 2. In addition, the two groups which we introduced to the Russian alphabet completed Tasks 3 and 4.

Data Reduction and Analysis

Response sheets for each subject for each task were analyzed for total number of correct responses for right and left visual fields. Means and standard deviations of correct responses were subsequently computed for all groups and conditions. Appropriate group mean comparisons were obtained using the Student's t-statistic.

CHAPTER III

RESULTS AND DISCUSSION

Results

Right vs. left for orthographic stimuli.

As is indicated in Table 1, the mean number of correct responses was significantly greater for the right visual field when normal hearing subjects were exposed to orthographic stimuli. The right-left visual field difference for deaf subjects is implicative of a right visual field advantage since the t-value is approaching statistical significance. However, the formal null hypothesis must be retained as being plausible.

Table 1. Mean tachistoscopic recognition scores for normal and deaf subjects for Task 1.

	Task 1 (Orthographic)				
	N	Right	Left	Diff.	t
Normals	20	10.2	6.1	4.1	2.91*
Deaf	20	10.0	8.6	1.4	1.13

* p=.01

Right vs. left for manual stimuli for normal and deaf subjects familiar with the manual alphabet.

A significant right-left difference was not achieved when manual alphabet stimuli were presented to normal hearing and deaf subjects who were familiar with the manual alphabet. Table 2 summarizes the mean results which tend to indicate that subjects show a greater ambivalence on this task.

Table 2. Mean tachistoscopic recognition scores for Group 2 (normal) and Group 3 (deaf) on Task 2.

	Task 2 (Manual)				
	N	Right	Left	Diff.	t
Normals Group 2	10	9.5	9.6	0.1	.06
Deaf Group 3	10	8.3	8.1	0.2	.11

Right vs. left for manual stimuli for normal and deaf subjects unfamiliar with the manual alphabet.

The mean results of Task 2 for subjects unfamiliar with the manual alphabet are summarized in Table 3. Again, significance was not achieved. However, it should be noted that the difference scores reveal a slight but consistent left visual field preference.

Table 3. Mean tachistoscopic recognition scores for Group 1 (normal) and Group 4 (deaf) on Task 2.

Task 2 (Manual)					
	N	Right	Left	Diff.	t
Normals					
Group 1	10	7.5	8.0	-0.5	.39
Deaf					
Group 4	10	8.0	9.0	-1.0	1.01

Right vs. left for normal and deaf subjects for orthographic stimuli when a manual symbol is required as a response.

Table 4 summarizes the mean results of normal hearing subjects (Group 2) and deaf subjects (Group 3) on Task 3 (orthographic to manual matching). While the right-left differences do not achieve statistical significance, once again the consistent tendency towards a right visual field preference is apparent.

Table 4. Mean tachistoscopic recognition scores for Group 2 (normal) and Group 3 (deaf) on Task 3.

Task 3 (Orthographic to Manual)					
	N	Right	Left	Diff.	t
Normals					
Group 2	10	11.3	9.4	1.9	.74
Deaf					
Group 3	10	11.2	9.2	2.0	.46

Right vs. left for normal and deaf subjects for manual stimuli when an orthographic symbol is required as a response.

In examining Table 5 it may be observed that the normal hearing subjects' (Group 2) performance on the manual to orthographic matching task is equivocal, i.e., no visual field preference was revealed in this case. The deaf subjects (Group 3) showed a slight right visual field preference, although the right-left differences were again non-significant.

Table 5. Mean tachistoscopic recognition scores for Group 2 (normal) and Group 3 (deaf) on Task 4.

Task 4 (Manual to Orthographic)					
	N	Right	Left	Diff.	t
Normals Group 2	10	10.5	10.5	0.0	0.00
Deaf Group 3	10	9.0	7.2	1.8	.64

As can be seen from Tables 1-5, despite the fact that the visual field performance differences did not achieve significance, these differences tend to favor the right visual field when the stimuli can be assumed to be meaningful for a given group. A similar tendency is noted for the left visual field when the stimuli can be assumed to be linguistically non-meaningful for a group, i.e., Task 2 for Group 1 and Group 4. These results are in

accord with previous investigations (Kimura, 1966 and Bryden, 1965) in which a right visual field preference was found for orthographic stimuli. Kimura (1966) also found that nonsense forms, i.e., linguistically non-meaningful stimuli, yielded no significant visual field preference and that only enumeration of forms yielded a strong left visual field preference.

Since considerable variability in accuracy was noted within subject groups, the percentage-of-error method of analysis was employed a posteriori. In essence, the percentage-of-error score is actually the percentage of errors contributed by the left visual field to the total number of errors. This score has been reported to be least biased by variability in degree of task difficulty (Harshman and Krashen, 1972). Any score above 50% is considered to reflect an increasing advantage for the right visual field (left hemisphere).

In examining Table 6, it will be noted that all mean percentage-of-error (P-O-E) scores above 50% resulted from tasks when the stimuli could be assumed to be linguistically meaningful. The two mean P-O-E scores below 50% are found for tasks when the stimuli could be assumed to be linguistically non-meaningful for the groups involved. It is interesting to note that for linguistically meaningful stimuli, the normal hearing groups achieved higher mean P-O-E scores than did the deaf groups. In other

words, the overall performances of the two visual fields are more equivocal for deaf subjects than for normal hearing subjects.

Table 6. Mean P-O-E scores for Tasks 1-4.

	Task 1	Task 2	Task 3	Task 4
Normals				
Group 1	66%	48%		
Group 2	65%	54%	63%	58%
Deaf				
Group 3	58%	52%	52%	55%
Group 4	59%	47%		

Discussion

The present study deals with the relationship between right-left visual field performances in tachistoscopic recognition of manual letter and orthographic letter stimuli by normal hearing and deaf subjects. A significant right visual field preference was found with normal hearing subjects when presented with orthographic stimuli. No other significant relationships were found, but a consistent right visual field tendency was evidenced by group mean performances when linguistically meaningful stimuli were presented. A similarly consistent non-right visual field tendency was found for normal hearing and deaf subjects when presented with linguistically non-meaningful material.

The present study's findings support the contentions voiced by Kimura, Olson and others (i.e., that a subject's perception of words or orthographic stimuli will be correctly identified more often in the right visual field). On the basis of this consistency it would appear, then, that the procedures employed in the present investigation were adequate for indicating visual field preferences when they existed.

Kimura (1966) found that French pupils of a verbal nature were identified more often to the left hemisphere yielding a right visual field preference. The present results, as stated above, are in accord with Kimura's findings. However, it should be noted that Group 2 (normals who were familiar with the manual alphabet) did not achieve a significant preference on Task 3 (orthographic recognition), although the difference was approaching significance. Such a finding has not been previously reported. This discrepancy is difficult to explain on the basis of anything other than sampling artifact, since there is no theoretical justification for the knowledge of manual fingers (or hand alphabet) to be influential in affecting recognition of orthographic symbols by normal hearing subjects. Despite the discrepancy, however, when the two normal groups were combined, the resulting total difference was highly significant (p=.01).

The deaf subjects showed a t-value which was only approaching statistical significance on the orthographic task in question (Task 1). The difference is suggestive of a right visual field preference despite the failure to achieve significance. This finding suggests that the right visual field preference is still exhibited, although to a lesser degree, even when auditory imagery is not a factor in the recognition of a visual stimulus. Nevertheless, the greater ambivalence seen within the deaf subjects is considered to be the result of the absence of auditory influences. A similar argument for explaining reading difficulties exhibited by deaf individuals has been proposed by Conrad (1972). When the manual alphabet was used as stimuli, presumably stimuli that possessed linguistic meaning, ambivalent visual field performances were noted for both normal hearing and deaf subjects. Again, the slight difference which was noted was consistently in the direction of a right visual field preference. The results here tend to indicate that the manual alphabet may be best handled in the left hemisphere but that the experimental presentation of these stimuli may have all but eliminated the right visual field effect. It will be noted here that subjects did comment on the unnaturalness of the manual stimuli presentations. The investigator attributes these comments to the fact that the manual alphabet is normally "read" as a real, three-dimensional hand, shaping each

letter. The experimental stimuli were black and white drawings of each manual letter taken from a standard production of each letter. It was noted by the subjects that these standard productions are not necessarily the way the letters are produced in practical, everyday situations. In other words, the stimuli used in this study may not really be representative of the manual alphabet used daily by the subjects. Therefore, this task may have represented more of a form matching task, which Kimura (1966) found to be equivocal, than a linguistic task. The manner in which these particular stimuli might be presented deserves further investigation.

When the manual stimuli were presented to subjects unfamiliar with manual communication, again no significant difference was found between the visual fields. The manual alphabet was presumed to be a nonsense task for those subjects not familiar with this alphabet. Kimura (1966), Bryden and Rainey (1963) and Heron (1957) all found that recognition of nonsense forms were equivocal for the two visual fields. The present study supports these findings concluding that the manual alphabet stimuli were indeed nonsense forms for those subjects unfamiliar with the manual alphabet.

It was noted that on the orthographic to manual matching task (Task 3), the t-values were not statistically significant for either the normal hearing group or the

deaf group. In fact, the t-values were substantially lower for both groups than those achieved on the previous orthographic task (Task 1). This tends to indicate that the addition of more variables, i.e., short-term memory and conversion of one symbol into another symbol, aided in reducing the right-left difference noted in the simple orthographic to orthographic matching task. This finding does not agree with previous findings in dichotic listening research which indicate that with increased task difficulty, the magnitude of the right-left difference is increased.

In reviewing the behavior of the two subject groups familiar with the manual alphabet (Group 2 and Group 3), it was observed that neither group reached a significant t-value on Task 1. Another factor which may be influencing the low t-values is the varying degree of task difficulty within subject groups. This factor becomes most evident in reviewing Table 6 in which it is observed that the P-O-E scores for Group 2 on Tasks 1 and 3 are quite similar as compared to the large difference found between t-values in the same instances. In other words, Group 2 is performing similarly on these two tasks and that performance is well above the 50% score required to indicate a right visual field preference.

The deaf subjects (Group 3) did not perform in quite as similar a manner as did the normal subjects. Nonetheless, both P-O-E scores for Task 1 and Task 3 are

above the 50% score necessary to indicate a right visual field preference (Table 6). Again, the deaf group is performing more equivocally than the hearing group. As was discussed earlier, this tendency may reflect a weaker link between orthographic symbols and left hemisphere processing than is found in normal hearing individuals.

Turning to Task 4 (manual to orthographic matching), it was observed that neither the normal nor the deaf subjects achieved a statistically significant difference between right and left visual field performances. There is a very slight right visual field preference for the deaf subjects but literally no difference for the normal subjects. Again, degree of task difficulty is considered to be a factor in suppressing the right-left difference. The P-O-E scores in this case show a right visual field advantage for both subject groups (Table 6). It is interesting to note that the corresponding P-O-E scores on Task 2 (manual to manual matching) are slightly lower than on Task 4. It appears that requiring a conversion from a manual symbol to an orthographic symbol influences the right visual field performance in a way that was not observed when a conversion from an orthographic symbol to a manual symbol was required.

Overall, the present study supports the notion that stimuli of a linguistic nature are recognized most often in the right visual field. Also, nonsense forms

tend to be recognized slightly more often in the left visual field.

The investigator also feels that the P-O-E score may yield more information than the conventional t-values. The P-O-E score was found to neutralize the influences of variable task difficulty within subject groups. Although presently no method has been introduced to determine the statistical significance of the P-O-E score beyond 50%, this score is considered to be the most meaningful score in evaluating the present results.

In addition, this investigation reveals that although auditory imagery is not essential to production of the right visual field effect, in the absence of auditory influences, the right visual field effect may be reduced in magnitude. Therefore, it might be hypothesized that auditory influences are relevant to the right visual field effect, but these influences are not totally responsible for this effect. It may be postulated that the left cerebral hemisphere is better adapted to mediate linguistically meaningful material regardless of the absence of auditory influences on the left temporal lobe.

task to be recognized is simply more potent in the left visual field.

The investigator also feels that the T-test scores may yield more information than the conventional t-values. The T-test score was found to neutralize the influences of variable task difficulty within subject groups. Although presently no method has been introduced to determine the statistical significance of the T-test score beyond 50, this score is considered to be the most meaningful score in evaluating the present results.

In addition, this investigation reveals that although auditory imagery is not essential to production of the right visual field effect, in the absence of auditory imagery, the right visual field effect may be reduced in magnitude. Therefore, it might be hypothesized that auditory influences are relevant to the right visual field effect, but these influences are not totally responsible for this effect. It may be postulated that the left cerebral hemisphere is better adapted to mediate linguistically meaningful material regardless of the absence of auditory influences on the left temporal lobe.

Comment

The present study has several shortcomings. Perhaps the most obvious is the small number of subjects in each subject group. A much larger sampling is required to yield any definitive comments upon a population's behavior.

Also noted is the wide variation in age and general educational level of the deaf subjects. This problem was the result of a very limited subject pool. Difficulty was also encountered in the lack of subject interest in participating and failure to keep appointments. For these reasons, it is possible that the sampling fails to reflect a true representation of the deaf population. Naturally, with a larger sample, this possibility would be reduced.

Turning to the use of the manual alphabet as stimuli, it will be noted that these stimuli have not been employed in prior investigations. For this reason, many assumptions were made concerning the nature of the manual alphabet. Among these assumptions was the linguistic nature of the manual letters corresponding to that of orthographic letters. In addition, little is known about the confusion in discriminating between similar manual letters and to what extent this may have affected the recognition scores. Finally, as was discussed earlier,

[illegible]

The present study had several shortcomings. Perhaps the most obvious is the small number of subjects in each subject group. A much larger sampling is required to yield any definitive comments upon a population's [illegible].

Also noted is the wide variations in age and general educational level of the deaf subjects. This problem was the result of a very limited subject pool. Difficulty was also encountered in the lack of subject interest in participating and failure to keep appointments. For these reasons, it is possible that the sampling [illegible] to reflect a true representation of the deaf population. Naturally, with a larger sample, this possibility would [illegible] reduced.

Turning to the use of the manual alphabet as stimuli, it will be noted that these stimuli have not been explored in prior investigations. For this reason, many assumptions were made concerning the nature of the manual alphabet. Among these assumptions was the [illegible] the nature of the manual letters corresponding to their orthographic letters. In addition, little is known about the confusions in discriminating between similar manual letters and to what extent this may have affected the recognition scores. Finally, in the present [illegible] the manner in which the manual stimuli were presented removes them from the realm of daily context. Unlike orthographic letters which are seen daily as black figures on a white background, manual letters are seen daily as real hands forming the letters in space. The effect of this aspect is as yet unexplored, but should be kept in mind.

In considering further research along this line, the present investigator offers several suggestions. One, of course, is that a much larger sample of both hearing and deaf subjects be used. This would tend to better reflect the true behavior of these groups. Also concerning subjects, an attempt should be made to better group the subjects in terms of age and educational level. In fact, more complete information is needed on the effects of age on the tachistoscopic task. Naturally, it would be most beneficial to note these effects on normal subjects before probing any non-normal population.

More information is also needed concerning perception and processing of the manual alphabet. A confusion matrix might help reduce the effect of consistent errors based on similarities of features. The actual manner of presentation of manual stimuli should be explored further with a more natural presentation as the goal. It is possible that this type of material is not appropriate for tachistoscopic presentation.

If more knowledge is sought concerning the mediation of nonsense forms, true nonsense stimuli should be used. In the present study, manual letters were presumed to be acting as nonsense symbols for those subjects unfamiliar with the manual alphabet. This assumption may be invalid. Only by employing true nonsense forms can this mediation be examined.

Finally, before attempting to investigate the behavior of any non-normal population, the investigator should apprise himself fully of the availability of these subjects. Availability here refers to both the number of subjects as well as their willingness to participate in scientific research.

CHAPTER IV

SUMMARY

The notion of cerebral dominance has been explored since the time of Broca. Two non-invasive techniques designed to assess hemispheric dominance have subsequently been developed. These two methods are commonly referred to as dichotic listening (simultaneous auditory stimulation) and rapid visual field stimulation (tachistoscopic viewing).

It has been found in dichotic listening studies that when verbal material is presented simultaneously to both ears, the stimuli are correctly identified most often in the right ear. Similar results have been found in tachistoscopic studies, with verbal material eliciting a right visual field advantage. Collectively, these findings have been used to support a left hemispheric dominance for processing verbal material, since the right ear and visual field are strongly connected to the left hemisphere.

It has been argued that the right visual field preference in tachistoscopic presentation may actually be reflecting a strong link between a visual stimulus and its auditory image in the brain. In order to explore this notion further, a tachistoscopic study was designed

using subjects who lacked sufficient auditory input with which to develop auditory imagery for visual stimuli.

Twenty deaf and 20 normal hearing subjects were selected. Of these 40 subjects, 20 subjects (10 normal hearing and 10 deaf) were familiar with the manual alphabet. The visual stimuli selected for tachistoscopic presentation were 16 orthographic letters and the corresponding 16 manual alphabet letters. A total of four tasks was presented. All subjects completed one task in which orthographic stimuli were presented and an orthographic symbol was required as a response, and one task in which a manual stimulus was presented and a manual symbol was required as a response. In addition, the 20 subjects familiar with the manual alphabet completed one task requiring orthographic symbol to manual symbol matching and a final task requiring manual symbol to orthographic symbol matching.

The major findings of the present study were as follows:

1. A slight right visual field preference was noted on the average when linguistically meaningful stimuli were presented.

2. An equivocal visual field performance was noted on the average when the stimuli that were presented were assumed to be linguistically non-meaningful.

3. On overall right-left visual field performance, deaf subjects showed a reduced right-left difference when compared to the normal hearing subjects.

In conclusion, it is indicated by the results that although auditory imagery is not essential for the right visual field advantage to be exhibited, the absence of auditory influences may reduce the magnitude of this advantage.

APPENDICES

APPENDIX A

Description Summary of All Subject Groups

	Sex	Age	Hand	Task 1 R+	Task 1 L+	Task 2 R+	Task 2 L+	Task 3 R+	Task 3 L+	Task 4 R+	Task 4 L+
Group 1											
1	F	34	R	12	10	9	10				
2	F	24	R	8	2	9	9				
3	F	27	R	7	1	6	3				
4	F	14	R	13	12	2	3				
5	F	46	R	14	7	6	5				
6	M	12	R	7	0	8	10				
7	M	13	R	15	13	8	11				
8	M	23	R	3	2	8	10				
9	M	27	R	8	4	12	10				
10	M	61	R	14	3	7	9				
Group 2											
1	F	22	R	6	4	8	13	4	4	15	14
2	F	28	R	16	16	10	11	16	15	8	8
3	F	23	R	13	0	16	15	13	1	16	12
4	F	26	R	6	9	6	4	4	15	6	8
5	F	34	R	8	1	8	9	7	2	9	8
6	M	35	R	9	6	12	8	9	2	11	10
7	M	25	R	8	7	6	6	16	15	11	9
8	M	22	R	16	14	12	11	16	15	11	9

APPENDIX A
(Cont'd)

	Sex	Age	Hand	Task 1		Task 2		Task 3		Task 4	
				R+	L+	R+	L+	R+	L+	R+	L+
Group 2 (Cont'd)											
9	M	23	R	14	9	11	10	13	15	8	11
10	M	30	R	7	1	6	9	15	10	10	6
Group 3											
1	F	38	L	10	2	4	10	10	2	5	2
2	F	26	R	3	2	2	0	4	1	4	1
3	F	22	R	16	11	10	12	14	13	9	12
4	F	40	R	11	14	8	9	10	15	8	8
5	F	23	R	13	12	9	8	14	11	12	8
6	M	14	R	13	12	15	9	13	11	15	8
7	M	42	R	14	11	10	10	16	14	11	10
8	M	62	R	10	1	6	4	11	5	6	7
9	M	42	R	5	13	6	8	5	14	6	11
10	M	33	R	16	16	13	11	15	16	14	12
Group 4											
1	F	8	R	14	12	7	10				
2	F	8	R	9	6	6	6				
3	F	10	R	16	16	7	9				
4	F	8	R	8	4	4	8				
5	F	9	R	5	9	7	7				

APPENDIX A
(Cont'd)

	Sex	Age	Hand	Task 1		Task 2		Task 3		Task 4	
				R+	L+	R+	L+	R+	L+	R+	L+
Group 4 (Cont'd)											
6	M	10	R	16	16	8	8				
7	M	11	R	15	13	13	11				
8	M	9	R	14	14	11	10				
9	M	9	R	14	8	9	12				
10	M	9	R	9	7	8	9				

APPENDIX A
(Cont'd)

Mean, Range and Standard Deviation Scores for All Subjects

	Task 1		Task 2		Task 3		Task 4	
	Right	Left	Right	Left	Right	Left	Right	Left
Group 1								
$\overline{X}$	10.1	5.4	7.5	8.0				
R	3-15	1-13	2-12	3-11				
S.D.	3.8	4.5	2.45	2.93				
Group 2								
$\overline{X}$	10.3	6.7	9.5	9.6	11.3	9.4	10.5	10.5
R	6-16	0-16	6-16	4-15	4-16	1-15	8-16	8-16
S.D.	3.82	5.17	3.13	3.03	4.64	6.05	2.94	2.61
Group 3								
$\overline{X}$	11.1	9.4	8.3	8.1	11.2	9.2	9.0	7.2
R	3-16	1-16	2-15	0-12	4-16	1-16	4-15	1-12
S.D.	4.10	5.25	3.76	3.38	3.86	5.17	3.66	4.16

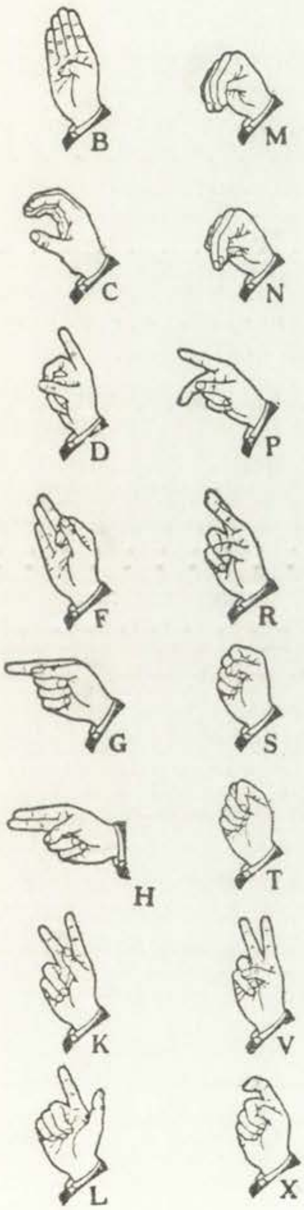
APPENDIX A
(Cont'd)

	Task 1		Task 2		Task 3		Task 4	
	Right	Left	Right	Left	Right	Left	Right	Left
Group 4								
$\overline{X}$	8.8	7.3	8.0	9.0				
R	0-15	0-14	4-13	6-12				
S.D.	5.38	4.71	2.40	1.73				

APPENDIX B

Manual and Orthographic Stimulus Materials

<u>Manual Stimuli</u>



<u>Orthographic Stimuli</u>

B	M
C	N
D	P
F	R
G	S
H	T
K	V
L	X

APPENDIX C

Sample Response Sheet

Subject # ____________

Task # ____________

	Left	Right	Answer		Left	Right	Answer
1.		L	____	17.	V		____
2.	S		____	18.		V	____
3.	R		____	19.		T	____
4.		S	____	20.	D		____
5.	M		____	21.		H	____
6.		P	____	22.	P		____
7.	N		____	23.		D	____
8.		F	____	24.	K		____
9.	C		____	25.	G		____
10.	F		____	26.		M	____
11.		K	____	27.		G	____
12.	X		____	28.	L		____
13.		N	____	29.		B	____
14.	T		____	30.		X	____
15.		C	____	31.	B		____
16.	H		____	32.		R	____

REFERENCES

Adams, J., Visual perception of direction and number in right and left visual fields. Cortex, 7, 227-235 (1971).

Berlin, C., Lowe-Bell, S., Jannetta, P., and Kline, D., Cerebral auditory deficits after temporal lobectomy. Arch. Otolaryng., 96, 4-10 (1972).

Branch, C., Milner, B., and Rasmussen, T., Intracarotid sodium amytal for the lateralization of cerebral speech dominance. J. Neurosurg., 21, 399-405 (1964).

Broadbent, D., The role of auditory localization in attention and memory span. J. Exper. Psych., 47, 191-196 (1954).

Bryden, M., The role of eye movements in perception. Unpublished master's thesis, McGill University (1958).

Bryden, M., Tachistoscopic recognition of non-alphabetical material. Canad. J. Psychol., 14, 78-85 (1960).

Bryden, M. and Rainey, C., Left-right differences in tachistoscopic recognition. J. Exper. Psych., 66, 568-571 (1963).

Bryden, M., Tachistoscopic recognition and cerebral dominance. Percept. Mot. Skills, 19, 686 (1964).

Bryden, M., Tachistoscopic recognition, handedness, and cerebral dominance. Neuropsychologia, 3, 1-8 (1965).

Bryden, M., An evaluation of some models of laterality effects in dichotic listening. ACTA Otolaryng., 63, 595-604 (1967).

Bryden, M., Laterality effects in dichotic listening: relations with handedness and reading ability in children. Neuropsychologia, 8, 443-450 (1970).

Conrad, R., Speech and Reading. In J. F. Kavanagh and I.G. Mattingly (Eds.), Language by Ear and by Eye. Cambridge, Mass: MIT Press, p. 205 (1972).

REFERENCES

B[illegible], A., Visual perception of direction and number in [illegible] visual fields. Cortex, 7, [illegible] (1971).

Berlin, C., Lowe-Bell, S., Jannetta, P., and Kline, D., Central auditory deficits after temporal lobectomy. Arch. Otolaryng., 96, 4-10 (1972).

Branch, C., Milner, B., and Rasmussen, T., Intracarotid sodium amytal for the lateralization of cerebral speech dominance. J. Neurosurg., 21, 399-405 (1964).

Broadbent, D., The role of auditory localization in attention and memory span. J. Exper. Psychol., 47, 191-196 (1954).

Bryden, M., The role of eye movements in perception. Unpublished master's thesis, McGill University (1958).

Bryden, M., Tachistoscopic recognition of non-alphabetical material. Canad. J. Psychol., 14, 78-86 (1960).

Bryden, M. and Rainey, C., Left-right differences in tachistoscopic recognition. J. Exper. Psych., 66, 568-571 (1963).

Bryden, M., Tachistoscopic recognition and cerebral dominance. Percept. Mot. Skills, 19, 686 (1964).

Bryden, M., Tachistoscopic recognition, handedness, and cerebral dominance. Neuropsychologia, 3, 1-8 (1965).

Bryden, M., An evaluation of some models of laterality effects in dichotic listening. Acta Otolaryng., 63, 595-604 (1967).

Bryden, M., Laterality effects in dichotic listening: relations with handedness and reading ability in children. Neuropsychologia, 8, 443-450 (1970).

Conrad, R., Speech and reading. In J. F. Kavanagh and I. G. Mattingly (Eds.), Language by Ear and by Eye. Cambridge, Mass.: MIT Press, p. 205 (1972).

Curry, F., Rutherford, D., Recognition and recall of dichotically presented verbal stimuli by right- and left-handed persons. Neuropsychologia, 5, 119-126 (1967).

Dirks, D., Perception of dichotic and monaural verbal material and cerebral dominance for speech. ACTA Otolaryng., 58, 73-80 (1964).

Dodwell, P., Some factors affecting the hearing of words presented dichotically. Canad. J. Psychol., 18, 72-91 (1964).

Dorff, J., Mirsky, A., and Mortimer, M., Effects of unilateral temporal lobe removals in man on tachistoscopic recognition in the left and right visual fields. Neuropsychologia, 3, 39-51 (1965).

Dudley, J., Doehring, D., and Coderre, L., Speed of visual perception in aphasic and non-aphasic patients with hemiplegia. Cortex, 4, 389-402 (1968).

Efron, R., The effect of handedness on the perception of simultaneity and temporal order. Brain, 86, 261-284 (1963).

Forgays, D., The development of differential word recognition. J. Exper. Psych., 45, 165-168 (1953).

Geffner, D., and Hochberg, I., Ear laterality performance of children from low and middle socioeconomic levels on a verbal dichotic listening task. Cortex, 7, 193-203 (1971).

Giannitrapani, D., Developing concepts of lateralization of cerebral functions. Cortex, 3, 353-370 (1967).

Goodglass, H. and Barton, M., Handedness and differential perception of verbal stimuli in left and right visual fields. Percept. Mot. Skills, 17, 851-854 (1963).

Hannah, J., Thompson, C., Cullen, J., Hughes, L., and Berlin, C., Size of the dichotic right ear effect as a function of alignment criteria. J. Acoustic Soc. Amer., 50, 130 (abstr.) (1971).

Harshman, R., and Krashen, S., An unbiased procedure for comparing degree of lateralization of dichotically presented stimuli. Working Papers in Phonetics, 23, 3-12 (1972).

Heron, W., Perception as a function of retinal locus and attention. Amer. J. Psych., 70, 38-48 (1957).

Hollingshead, A., and Redich, F., Social Class and Mental Illness: A Community Study. New York: Wiley and Sons (1958).

Inglis, J., Dichotic stimulation, temporal-lobe damage and the perception and storage of auditory stimuli--a note on Kimura's findings. Canad. J. Psychol., 16, 11-17 (1962).

Kimura, D., Some effects of temporal lobe damage on auditory perception. Canad. J. Psychol., 15, 156-165 (1961a).

Kimura, D., Cerebral dominance and the perception of verbal stimuli. Canad. J. Psychol., 15, 166-171 (1961b).

Kimura, D., Speech lateralization in young children as determined by an auditory test. J. Comp. Physiol. Psychol., 56, 899-902 (1963).

Kimura, D., Dual functional asymmetry of the brain in visual perception. Neuropsychologia, 4, 275-285 (1966).

Kimura, D., Functional asymmetry of the brain in dichotic listening. Cortex, 3, 163-178 (1967).

Knox, C., and Kimura, D., Cerebral processing of nonverbal sounds in boys and girls. Neuropsychologia, 8, 227-237 (1970).

LeMay, M., and Culebras, A., Human brain - morphologic differences in the hemispheres demonstrable by carotid arteriography. New Eng. J. Med., 287: 4, 168-170 (1972).

Milner, B., Branch, C., and Rasmussen, T., Observations on Cerebral Dominance. DeRevck, A. and O'Connor, M. (eds.), CIBA Foundation Symposium on Disorders of Language. (1964).

Needles, W., Concerning transfer of cerebral dominance in the function of speech. J. Nerv. and Ment. Dis., 95, 270-277 (1942).

Orbach, J., Retinal locus as a factor in the recognition of visually perceived words. Am. J. Psychol., 65, 555 (1952).

Orbach, J., Differential recognition of Hebrew and English words in right and left visual fields as a function of cerebral dominance and reading habits. Neuropsychologia, 5, 127-134 (1967).

Overton, W. and Wiener, M., Visual field position and word-recognition threshold. J. Exper. Psych., 71, 249-253 (1966).

Reed, J., Aphasia and language functioning of the deaf. Amer. Ann. Deaf, 116, 420-426 (1971).

Richlin, M., Weisinger, M., Weinstein, S., Giannini, M., and Morgenstern, M., Inter-hemispheric asymmetries of evoked cortical responses in retarded and normal children. Cortex, 7, 98-105 (1971).

Rosenzweig, M., Representations of the two ears at the auditory cortex. Amer. J. Physiol., 167, 147-158 (1951).

Rubino, C., Hemispheric lateralization of visual perception. Cortex, 6, 102-120 (1970).

Sarno, J., Swisher, L., and Sarno, M., Aphasia in a congenitally deaf man. Cortex, 5, 398-414 (1969).

Satz, P., Achenback, K., Pattishall, E., and Fennell, E., Order of report, ear asymmetry and handedness in dichotic listening. Cortex, 1, 377-396 (1965).

Schiller, P., and Wiener, M., Monoptic and dichoptic visual masking. J. Exper. Psych., 66, 386-393 (1963).

Schuell, H., Jenkins, J., and Jimenez-Pabon, E., Aphasia in Adults. New York: Hoeber (1964).

Shanks, J., A comparison of normals and aphasics on two dichotic listening tasks. Manuscript in progress, University of New Mexico (1973).

Shankweiler, D., and Studdert-Kennedy, M., Identification of consonants and vowels presented to left and right ears. Quart. J. Exper. Psych., 19, 59-63 (1967).

Smith, A., Speech and other functions after left (dominant) hemispherectomy. J. Neurol. Neurosurg., Psychiat., 29, 467-471 (1966).

Wada, J., and Rassmussen, T., Intracarotid injection of sodium amytal for the lateralization of cerebral speech dominance. J. Neurosurg., 17, 266-282 (1960).

Winer, B.J., Statistical principles in experimental design. McGraw-Hill Book Company, Inc. (1962).

Wyke, M. and Ettlinger, G., Efficiency of recognition in left and right visual fields. Arch. Neur., 5, 659-665 (1961).