DICHOTIC LISTENING VERSUS DICHHAPTIC BRAILLE READING

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A Dissertation submitted in partial fulfillment for the Degree of Master of Science (Speech and Hearing) to the University of Mysore, 1978.

TO

My Parents and Smt. Premalatha Rathna

CERTIFICATE:

This is to certify that the Dissertation entitled “Dichotic Listening versus Dichhaptic Braille Reading “is the bonafide work in partial fulfillment for M.Sc. Speech and Hearing, carrying 100 marks, of the student with Register Number 10.

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DECLARATION:

The dissertation entitled “dichotic Listening versus Dichhaptic Braille Reading” is the result of my own study undertaken under the guidance of Mr. N.P. Nataraja, Lecturer in speech pathology, All India Institute of Speech and Hearing, Mysore. This has not been submitted earlier to any other university for any other Diploma or Degree course.

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CHAPTER I: INTRODUCTION

CHAPTER I

INTRODUCTION:

Each hemisphere in the human brain appears dominant of specialized for specific cognitive functions. The distinctiveness of the hemisphere lies in the information processed. For most individuals, the left hemisphere, may be described as processing in a sequential, analytic, linguistic mode and the right hemisphere in a parallel, holistic, spatial, non-linguistic mode.

Any particular behavioral or cognitive function is mediated predominantly by one hemisphere but minimally by the other.

The hemispheric perceptual asymmetry for different materials has been demonstrated through different tasks using Dichotic Listening (Kimura, 1961), Visual Half Field (VHF) Asymmetry (Mckeever and Huling, 1971) and Dichhaptic Stimulation (Witelson, 1974).

There are several studies using Dichotic Listening and Visual Half Field Asymmetries but there are only few studies using Dichhaptic Stimulation.

Most studies using Braille have indicated left hand superiority in reading Braille (Critchley, 1953; Harris, Wagner and Wilkinson, 1976; Hermelin and O’Conner, 1971; Rudel, Denckla and Spalten, 1974; Lowenfeld, Abel and Hatlin, 1969).

But studies have pointed out that clicks, noises and music which are usually in the right hemisphere, are processed in the left when they become linguistic (Papcun, et al., 1974; Sussman, MacNeilage and Lumbley, 1975; Natale, 1977; Bever & Chairello, 1974; Gates and Bradshaw, 1977(a), 1977 (b); VanLancker & Fromkin, 1972; Robinson & Solomon, 1974; Cook, 1973).

Therefore, it is expected that Braille, though it is a somesthetic mode, should be processed in the left hemisphere because it becomes linguistic. But the studies have been equivocal leading us to two alternative hypotheses: (a) that in the blind, Braille stays in the left hemisphere even when spatial or (b) localization of all linguistic activity is shifted to the right hemisphere.

No report is available comparing dichotic listening and dichhaptic stimulation, which could throw more light on this. Hence, the present study.

Braille requires spatial processing of the arrangement of dots and becomes meaningful massage for the Braille Reader.

The present study tries to evaluate the relationship between the perceptual asymmetry of the brain and spatial perception of meaningful stimuli using Braille, in contrast to the relationship with meaningful auditory messages.

Dichhaptic stimulation of the Braille and Dichotic Listening techniques will be used for the purpose of the study. The intention of check if there are differences in hemispheric localization of Braille and of auditory stimuli; speech. The following statement will be examined experimentally.

> “There will be right hand advantage (RHA) for Braille in the Dichhaptic stimulation with a Right ear advantage (REA) in the Dichotic Listening Task.”

Meaningful linguistic auditory messages arouse a right ear advantage (REA) when presented dichotically. It is hypothesized that for the same reason, a right hand advantage (RHA) may be expected in a Blind – Braille Reader, because Braille becomes a meaningful linguistic message for him.

Congenitally blind subjects who have been trained in reading and writing Braille (Bharati Braille, that is, Kannada Braille) will be selected for the study.

Lists of Kannada words (familiar) will be presented dichhaptically (to both the hands simultaneously, each hand reading a different list of words) and dichotically. The differences between the performances of the two hands and those between the two ears will be compared.

The implication of the study will be dependent upon the type of hand and ear advantage revealed by the study. The following are the possible results and their implications:

	Results	Implication
1.	REA + RHA	Linguistic processing is in the left hemisphere.
2.	REA + LHA	Processing depends upon the mode not on the type of material.
3.	LEA + LHA	The total linguistic processing is shifted to the right hemisphere either dependent on the handedness or on the dominant use of the spatial mode.

Results	Implication
4. Inconsistency in both hand and ear performance.	Other factors intervene in Establishment of hemispheric perceptual Asymmetry.
5. REA and inconsistency in the dichhaptic performance.	

Thus, whatever the results may be very useful information regarding hemispheric perceptual asymmetry is to be expected. Based on these results further studies can be initiated. This may lead to a better understanding of hemispheric perceptual asymmetry among the blind and the normals.

Limitations of the Study:

1. Study is planned for only ten subjects for want of time and because of limited age range between 16 and 20 years.

2. The stimulus will be words written in Braille and taped.

3. Study is planned to the available instruments.

4. Only congenitally blind (totally) subjects will be selected for the study. They should know reading and writing Braille with minimum education of eighth standard.

DEFINITIONS AND TERMINOLOGY:

Dichhaptic Braille Reading:

It is the somesthetic perception of two different words/messages in Braille presented simultaneously to both hands.

Dichotic Listening:

It is the auditory perception of two different words/messages presented simultaneously to both ears.

Right Hand Advantage (RHA):

It is the superiority of percentage of the right hand in performance over the left hand in a dichhaptic Braille Reading Task.

Right Hand Advantage (RHA):

It is superiority of percentage of the right hand in performance over the left hand in a dichhaptic Braille Reading Task.

Right Ear Advantage (REA):

It is the superiority of percentage of the right ear in the performance over the left ear in the dichotic listening task.

page contd…

Left Hand Advantage (LHA):

It is the superiority of percentage of the left hand in performance over the right hand in a Dichhaptic Braille Reading Task.

Left Ear Advantage (LEA):

It is the superiority of percentage of the left ear in performance over the right ear in a Dichotic Listening Task.

CHAPTER II: REVIEW OF LITERATURE

CEREBRAL DOMINANCE:

> “The cerebral hemispheres are paired organs. The anatomic appearance of the two hemispheres is more or less symmetrical. Functionally there is a considerable degree of symmetry, each hemisphere serving the opposite side of the body for many motor and sensory functions. In the human, however, several functions are distributed between the hemispheres in a distinctly asymmetrical fashion. The tendency for one of the cerebral hemispheres to predominate in certain functions has been termed dominance” (Benson and Geschwind, 1968).

Thus, the term “dominance”, expresses the idea of unequal capacities of the two hemispheres in a quantitative sense, for a given function.

> Rossi and Rosadini (1967) point out that “………the dominant hemisphere is that which governs, which controls, the other, the non-dominant one ….the dominant hemisphere, “does the work”, while the non-dominant one is silent or capable of only rudimental activity”.

Bay, Zangwill and others (in Disorders of Language: A CIBA Foundation Symposium, 1964, 216-217) indicate that it is not simply correct to speak of dominant versus non-dominant hemispheres. There is no good evidence that the major (dominant) hemisphere exercises any direct control over the subordinate (non-dominant) hemisphere (Pp 217).

Brain (1965) uses the term “hemisphere dominance” with reference to the anatomical basis of a certain function which is located mainly or exclusively in one cerebral hemisphere. He feels (Disorders of Language, Pp 217, 1964) that “dominant” might mean that it controls the other hemisphere or it might merely mean predominant.

Still, the usage of terms dominant and non-dominant with references to the hemispheres is ambiguous.

Bay, Zangwill and others (Pp 216 – 217) agree with each other that the problems of dominance is very complex and it might be better to speak of a percentage of dominance of either side of the brain.

Cerebral dominance has been studied for different functions using different approaches. The functions studied are: -

<u>Handedness:</u> (Corad, 1949; Subirina, 1952; Humphrey and Zangwill, 1952; Bauer and Wepman, 1955).

<u>Speech and Language:</u> (Jackson, 1986; Penfield and Robers, 1959; Brain 1965; Milner, 1965; Rossi and Rosadini, 1967).

<u>Listening:</u> Milner, 1965; Tsunoda, 1968.

<u>Vision:</u> (Jasper and Raney, 1931; Brain, 1965; Geschwind, 1967; Milner, 1967).

<u>Footedness:</u> (Morley, 1965).

<u>Mood and Emotions:</u> (Terzian, 1959; Rossi and Rosadini, 1967; Hecaen, 1965).

<u>NEUROPHYSIOLOGICAL STUDIES to assess cerebral dominance for Language:</u>

The study of cerebral dominance and its relations to language, has been a topic of investigation for over a century.

It was clinically observed in the nineteenth century that lesions in the left hemisphere caused disturbances of language, or aphasia, while lesions in the right hemisphere did not. A paper was read on this by Dax, as early as 1836.

The observation of left hemisphere dominance for language was made generally known by Broca (1861)through his article “Remarques Sur le Siege de la faculte’ du language articule’, Suives d’une observation d’ aphemie” (Remarks on the seat of the faculty of articulate language followed by an observation of aphemia, in Von Bonin, 1962).

The traditional view, well attested since Broca’s time, it that the left hemisphere is dominant for language in most normal right handers. Recent figures suggest that about 90 percent to 95 percent of all right handed people can be expected to be left – dominant for language. The case for dominance in left handed individuals is unclear, and the relationship between handed-ness and lateralization for language remains unexplained.

Intercarotid amytal studies, which inactivate one hemisphere at a time to test for language function, in each suggest that 50 percent to 70 percent of left handers are left dominant for language (Efron, 1963a; Milner, Branch and Rasmussen, 1964).

Goodglass and Quadfasel (1954) report that fifty percent of left handed individuals in aphasiological literature had aphasia as a result of damage to the left hemisphere. These studies have been confirmed in studies on aphasia due to brain wounds (Russel and Espir, 1061).

There have been reports stating that language is not lateralized to the left or right hemisphere is some people, particularly the left handers, but that it is bilaterally represented.

Conrad (1949) concluded from a study of 808 brain damaged subjects, of whom 47 were reportedly left handed, that left handedness had all the signs of less hemispheric specialization. The evidences was that in left handed people, hemispheric injury produced milder and more transitory aphasia than in right handed people.

Similarly, Zangwill (1964 b) suggests that in left – handers, lateralization may develop more slowly and less completely than in right handers. He also points to the different clinical picture in aphasia, and adds that left handers, like children, have less receptive defect in aphasia. In those leading toward left handeness:

> "the degree of cerebral specialization appears to vary widely as between both individuals and functions and to offer greater possibilities of restitution after injury to either hemisphere".

He uses the terms "cerebral ambilaterality" and "indeterminate cerebral dominance" to describe observations in left handed individuals.

Zangwill (1960) suggests that:

> "Cerebral dominance is in all probability itself a graded characteristic, varying in scope and completeness from individuals to individual. Its precise relation to handedness and its vicissitudes still remains to be ascertained".

Enfield and Roberts (1959) state from their extensive work in mapping language functions in the brain that a definitive possibility of bilateral representation of speech exists (Pp 98), especially in left handers.

Luria's review indicates that left sided lateralization for language is not always complete. He (1970) cites Jackson, Bastian, Goldstein, Nissl Von Meyendorff, Zangwill and Subirina who said that the right hemisphere may take part in the organization of speech. Luria observes, clinicians such as, Charcot, Monakow, and Preobranzensij report speech disturbances in right handers after injury to the right hemisphere. Sometimes damage to speech zones in the left hemispheres of right handers not leading to aphasic disturbances. In Luria’s words:

> “there is a whole series of intermediate states ranging from total and absolute dominance to the left hemisphere to partial or total transfer of the dominant role to the right hemisphere. Thus both the paradoxical appearance of aphasia following the injury the subdominant hemisphere in right handers and absence of, or rapid recovery from, aphasia following injury of the speech Zones of the dominant left hemisphere may be explained on the basis of variation among individuals in the degree of left hemisphere dominance which is reflected in variations in the relation of the right hemisphere to speech functions” (1970, Pp 56 – 57).

Lateralization of language functions in the human brain remains a mystery. It is unclear whether the ‘reasons’ are neuroanatomical, developmental or combination of these.

Lateralization of function has been suggested to be unique to language in human beings.

it is now known, however, that:

1) in man other functions (for example, spatial relationships) also involve hemispheric specialization; and
2) functions are lateralized in other species.

For many decades the two cerebral hemispheres were considered to be exactly alike physiologically. it is now believed that there are differences in the hemispheres, although their gross appearances is of mirrored images. The alpha rhythm is reported to be lower over the dominant hemisphere (Lindslely, 1940; Espir and Rose, 1970), the morphological structure is reportedly different in the left. Von Bonin (1962) has reviewed anatomical differences in the two hemispheres. There is a little more cortex on the left (dominant) side; the left sylvian fissure is somewhat longer, the insula is longer and higher. Von Bonin remarked that these differences were small and did not account for the astonishing differences in function.

Geschwind and Levitsky 91968) studied one hundred adult human brains, and found that in 65 percent of the brains examined, the planum temporale was longer on the left. On an average it was 1/3 longer on the left than on the right.

Lemay and Culebras (1972) observed the similar findings as was observed by Geschwind and Levitsky (1968) using carotid anteriograms and coronal sections of the bran. Geschwins and Levitsky consider it reasonable to assume relationship between morphological differences in the classical speech areas and hemispheric specialization for speech.

These anatomical differences for specialization of language are still controversial, because of the complexity of relationship between the brain structures and brain function.

Berlin, Lowe – Bell, Cullen, Thompson and Loovis 91973) account these morphological differences as evidences for a hypothesis of left hemisphere perception of speech. Berlin proposing a “Preliminary working hypothesis”, places the specialization for perceptions of languages at the level of acoustics processing, arguing that the structures in that part of the brain uniquely process just those sounds that can be made in the vocal tract. In his hypothesis he states that:

> "The proximity of tongue and larynx areas in the left hemispheres to both Broca's area and the primary and secondary areas of the temporal lobe, might improve the efficiency of interaction of the right ear with any movements of the vocal tract. The asymmetry of the human brain in the left temporal lobe areas may facilitate this heightened efficiency by extending the primary auditory areas more medially and under the rolandic strip".

However, the structural proximity in the brain need not necessarily imply cooperation in function.

Jung (1962) commenting on the problem of exploring dominance says that:

> "The minute differences between the human cerebral hemispheres and their various morphological asymmetries cannot account for the astounding differences in hemisphere function. At this time morphology offers no explanation whatever for the facts of cerebral dominance".

commenting further on the issue he offers that:

> “. . . .We can only assumed that there must be functional differences in the learning capacity of the two hemispheres, differences which lack, so far, an obvious basis in structure”.

The difference in arguments from structure to function comes from the observations of apes ‘brains. The cortical substrate in the language areas is present in the ape’s brain as in the human brain. The cytoarchitectural speech areas in apes are well developed and similar to those in man, but they are apparently used for other purposes.

Nissl von Meyendorff (1930) found the same special calls as appear in man’s speech areas in analogous to cortical zones in the apes. Similar finings were suggested by Kriendler and Fradis (1968).

Motor sources of speech (for phonation and articulation) are bilaterally represented in the primary and supplementary areas in the cortex. There are four cortical areas which, when stimulated by an electric current at surgery, cause the patient to emit a vowel – like phonation; the precentral Rolandic gyrus of both hemispheres and the supplementary motor area of both hemispheres (Penfield and Roberts, 1959). Thus, vocalization can be initiated by electrode stimulation of either hemisphere.

Singing and music perception are considered to be the capacities of the right hemisphere (Henschen, 1926; Luria, 1966). These abilities may be bilaterally represented (Bogen, 1969 a). Subjects with left hemispherectomy have confirmed the early belief that the right hemisphere is capable of motor control for singing words (Smith, 1966).

Smith (1966) studied two patients who had left hemispherctomy. Both the patients were able to recall and sing songs, implying the significant role of the right hemisphere in “Musical memory” and in the “neuromotor process of singing”, each of which involves many of the same processes of vocalization and articulation used in spoken language.

Bogen and Gordon (1971) studied six patients to determine hemispheric dominance using the Wada technique. They concluded that the:

> “the right hemisphere is more important for singing than speech”.

and that the right is specialized for:

> "tonal abilities".

Thus, both phonation and articulation of speech gestures seem to be bilaterally represented.

Goldstein (1948) viewed that:

> "Eventhough there can be no doubt that, for the right handed person, the left hemisphere is of paramount significance for language, it must be noted that for the formation of sounds the corresponding area of the other hemisphere may play an important part, different in individual cases . . . . with regard to the bilateral speech movements . . . . there is a close relationship between the two motor speech areas".

Penfield and Roberts (1959) point out as further evidence that the motor sources for strip of one hemisphere is destroyed, the other one takes over. They claim that "cortical control of the voice, including articulatory movements and vocalization" can be served by either hemisphere. Excision of the lower Rolandic motor cortex on either side only temporarily produces dysarthria or thickness of speech, which fully recovers to normal speech. Penfiled and Roberts state that:

> "It seems likely that such a patient is able to speak (after the removal of the lower portion of the Rolandic strip) by employment of the cortical motor mechanism of the either hemisphere".

The conclusions drawn by Penfield and Roberts (1959)are based on the electrical stimulation and surgery on brains of brain damaged subjects.

"Representation of most motor functions on the cortex is associated with movement on the opposite side of the body, or contralateral control of movement. The relationship between speech and lateralized function is more complex" (Van Lancker, 1975).

Anatomically there are bilateral connections between the right and left cranial motor nuclei involved in speech. "Eye lids, jaw and trunk" have the greatest degree of bilateral representation (Buchanan, 1951). For, the larynx, the neuroanatomical findings are confirmed by clinical observations which suggest that the control of laryngeal muscles is to a large extent bilateral. Pitch control (as in singing, emotional vocalizations) usually remains intact with left or right hemisphere damage or removal.

There are neurophysiological basis for bilaterality besides the presence of both ipsilateral and contralateral innervation. One such basis lies in “association and commissural neurons”, which being other areas in the cortex into relationship with the innervation of the cranial nerves of speech (Van Riper and Irwin, 1958).

Another explanation has been advanced by Penfiled (1954). It suggests the importance of subcortical mechanisms in speech processes, or the “centrencephalic center”, which is “bi-encephalic” in the sense of being a coordinating center for both hemispheres.

Penfield and Roberts (1959) take the position that although the motor sources of speech are bilaterally represented. “ideational” speech is organized in the left hemisphere. Gazzaniga (1970) reports similar findings from his studies on split – brain subjects. He suggests that the primary motor control of speech musculature is present in each half brain, but the “neural organization required for spoken language is usually lateralized”.

Berry and Eisenson 91956, 1962) observe that the mechanisms for speech, subserved by the “midline organs” such as jaw, lips, tongue and larynx, are bilaterally represented in the cortex. Therefore, for speech, only one side is “needed”. There may be a teleological explanation for this specialization to one hemisphere of a potentially bilateral mechanism.

Brain (1961) points out that the skilled integration necessary for speech “requires that the motor cortex of both hemispheres should be under the control of single coordinating area, ‘the motor speech center’”. Speech, in other words, because of its complexity, necessitates localization. Emotional sounds in man and animals

> “are simple involuntary performances, and such simple reactions can utilize symmetrical and bilateral pathways. In contrast ….the precise integration of the small muscles of the lips, tongue, palate and larynx besides the respiratory muscles, so that these contract synchronously on the two sides with such delicacy that a variety of sounds can be differentiated through a range of gradations.”

Brain (1961) and Luchsinger and Arnold (1965) agree that hemispheric localization is required for development of human language.

> “The telecological explanation does not accommodate all the relevant facts. In some individuals, dominance may be “mixed” and degrees of dominance may vary in different people. Furthermore, singing, and emotional expressions in man (for which other than left hemisphere control is possible) involve the same complex articulation in integration of many motor skills as those other utterances called human language. Curses and expletives may fall into the class of the “simple involuntary performances “which many aphasiologists have suggested can utilize bilateral pathways or the pathways from the non-dominant hemisphere, or are subcortically mediated.” (Van Lancker, 1975).

The two cerebral hemispheres are equipotential for motor control of speech. Specialization is not at the level of motor organization of speech gestures. Similarly, specialization for speech perception is not to be explained at the level peripheral processing (auditory function).

> According to Neff (1962), in the auditory system “One might expect to find some differences in the functions of the cortex of right and left cerebral hemispheres”.

The auditory pathways from the organ of corti to the auditory cortex have been investigated in detail. Each ear projects to both auditory receiving areas in the cortex (by ipsilateral and contralateral pathways). The asymmetry in projections from each ear to the auditory cortices has been observed in records of gross evoked responses to click stimulation recorded from the auditory areas of the right and left hemisphere (Thompson, 1967). Tunturi (1946) and Rosenzweig (1951, 1954) demonstrated that the amplitude of the evoked response is greater at cortical area contralateral to the ear stimulated by the click in animals. The contralateral pathways, that is, from left ear to right cortex, and from right ear to left cortex, are stronger than the ipsilateral pathways, as measured by electrical activity. Anatomical and clinical studies in humans support the observations in animals. According to Rosenzweig (1972),

> “the majority of nerve pathways starting in the cochlear nucleus cross to the opposite side of the brain”.

However, there is considerable interaction between left and right ascending auditory pathways. Clinically, the ear contralateral to a hemispheric lesion shows greater deficit than the ear on the side of the lesion (Milner, 1962).

Much work has been done on processing of components of the acoustic signal: Pitch, intensity and duration (Rosenblith, 1961; Whitfield, 1967; Gulick, 1971). It is known that:

> “tone frequency has a clear spatial representation at all levels from the basilar membrane to the cerebral cortex” (Thompson, 1967).

Butler, et al, (1957) demonstrated that cats discriminated pitch even after extensive lesions of the cortex including all auditory areas. Studies on cats (Katsuki, 1961, 1962; Thompson, 1960) suggest that pitch discriminations are subcortically processed; bilateral transactions of the auditory pathways below the level of the inferior colliculus does not impair pitch discriminations. Simple pitch discriminations can be made by subjects with unilateral brain damage on either side (Milner, 1970). Right temporal lobectomy subjects made more errors on pitch discrimination tasks than the left temporal lobectomy subjects, but the difference was not significant (Milner, 1962).

Curry (1968)reported a right hemispherectomy subject performing better than normal subjects on both monotic and dichotic pitch discriminations. Hagan (1971) reported three right hemispherectomy subjects performing normally on bilateral puretone tests and bilateral normal speech discrimination

Intensity discriminations can also be made by animals that lack the auditory cortex (Dewson, 1964). Animal studies suggest that

> “Corticothalamic participation does not appear to be required for intensity discriminations” (Milner, 1970).

Milner (1962)found that right temporal lobectomy subjects did slightly worse on intensity discriminations then left temporal lobectomy subjects. It is reported that discrimination of different durations and timbres is impaired in cats (Neff, 1961) with lesions in the auditory cortex, and in humans with right temporal lobe damage (Milner, 1962).

Frequency, intensity, timbre and duration are all components of the speech signal. Frequency and intensity are subcortically and bilaterally processed in the brain, while normal timbre and duration discriminations require intact cortex in animals and intact right auditory areas in man.

Independently, these components can be processed subcortically, bilaterally, or in humans, better in the right cerebral cortex. Yet, speech comprehension is a specialization of the left hemisphere. Neff (1962) concluded that the differences in function of two hemispheres in man

> “cannot be accounted readily in terms of the manner in which sense organs project to, and motor organs receive innervations from contralateral and ipsilateral hemispheres”.

There is evidence that speech is not the only lateralized function. The left hemisphere is thought to be superior for calculation (Sperry, 1964) and for temporal order processing (Effron, 1963 a, b) and the right hemisphere for personal geography, facial recognition, and other visuospatial processes (Jung, 1962). Lateralized specialization has been determined from clinical symptomatology of brain injury to each hemisphere and from studies on subjects in whom the corpus callosum connecting the two hemispheres has been sectioned (Gazzaniga, 1970; Sperry, 1964). Information about lateralized processing comes also from experimental testing of brain damaged subjects and normal subjects using special such as tachistoscope, which projects in image to the hemispheres independently; and dichotic listening, in which two different sounds are presented to both the ears simultaneously.

Another method involves recordings of electrical activity or evoked potentials over each hemisphere, as visual or acoustic stimuli are presented to the subject. Greater or lower activity associated with different stimuli indicate greater or lower functional involvement. Thus there is a large body of accumulating data describing details of specialized function, or preferred processing in the cerebral hemispheres. General differences between hemispheres in modes of processing have also been proposed. Bogen (1969) has attempted to determine features common to phenomena seen to be left hemisphere specialization, is comparisons to features common to right hemisphere functions, and to distill two “modes” to abstractly characterize any of the specific abilities of each hemisphere.

Bogen (1969) hypothesized that the left hemisphere operates in a “propositional” mode, while the right hemisphere has its own unique mode of functioning, an “appositional” mode. Bogen has not reduced these to simple descriptions and the basis for his hypothesis comes from the beliefs on the “duality of the minds”.

These differences correlate with facts and folklore about right and left hands, and the right and left sided of the body. Notions about two minds, and two modes of consciousness are discussed by Ornstein (1972) where facts from nerophysiological studies are interwoven with philosophy, mythology and speculation. Ornstein presents his tentative dichotomy based on the “two modes of consciousness”.

> “The bases for the specialization of language function are not primarily to be found in the physical system basic to speech. The peripheral processes of articulation and hearing are represented in both hemispheres, and there is evidence of subcortical involvement in important subparts of speech processing. The important subparts of speech processing. The specialization must be viewed as not physical, but functional. Specialization in one hemisphere involves features of structure and organization superimposed on the physical processes. It can be inferred that there are properties of speech and language that can be correlated with left hemisphere specialization of function” (Van Lancker, 1975)

Van Lancker (1975) furthering states that:

> “The hypothesis that specialization for language is functionally determined leads to interesting

> possible for linguistic research . . .. Such studies may be compared with facts about "modes" of cerebral processing associated with right and left hemispheres. This approach, in the context of cerebral functioning, generates specific hypotheses about the properties of language".

MODES OF HEMISPHERIC FUNCTIONING:

Models of hemispheric functioning have been proposed by Semmes (1968), Levy 91963, 1964), Dimond and Beaumont (Beaumont (1974) and Hardyck (1977) for spatial and linguistic abilities.

Semmes' Model:

Semmes' (1968) paper on hemispheric specialization is an attempt to systematize a number of observed clinical and research finings on sensory and motor capacities and their hemispheric representations. Her specific views are as follows:-

> "Focal representation of elementary functions in the left hemisphere favours integration of similar units and consequently specialization for behaviours which demand fine sensorimotor control, such as manual skills, and speech. Conversely, diffuse representation of elementary functions in the right hemisphere may lead to integration of dissimilar units and hence, specialization for behaviors requiring multimodal coordination, such as the various spatial abilities".

The Semmes' model is based on the results of studies of brain function in some thesis on subjects with penetrating brain injuries. The results of these studies indicated that responses were different for the right and the left hand over several lesion locations.

The model is limited to a general specification of types of processes that occur within hemispheres and doesnot offer any guidelines as to the functions of the commissures and basis for asymmetries. The model is based primarily on the high degree of cerebral lateralization characteristic of right handed individuals who had negative family history of left handedness. She comments that her model does not offer satisfactory explanations of either the bilateral speech organization found in many left handed or of those cases of left handedness where speech is completely lateralized in the left hemisphere. Her model accounts for the relatively rare mirror image individual who is left handed, and has speech localized in the right hemisphere.

Levy's Model:

Levy (1973, 1974) proposed the model based on her studies of commissurotomy subjects and the studies of Sperry (1968 a,b; 1973, 1974). Gazzaniga, Bogen and Sperry (1967), Levy (1969), Levy, Nebes and Sperry (1971), Nebes (1971) and Sperry, Gazzaniga and Bogen (1969).

She considers that a right handed individuals is the optimally functioning individual and has a high degree of lateralization of functions. The left hemisphere in these individuals is specialized for speech, language and calculation . . .types of analytical processing in which a high degree of precision and specification is required. The right hemisphere processes spatial relationships, interprets music, recognizes patterns, and, in general, processes those aspects of perception which are most efficiently treated globally. The organization of the hemispheres can be represented in the following manner:-

Left Hemisphere	Right Hemisphere
Speech	Spatial
Language	Abilities
Writing	Nonverbal
Calculation	ideation

Right Handed

She states that the left handed individual has a high probability of having language functions located in both the right and left hemispheres. This bilateralization of language according to her, limits and capacity of the right hemisphere is process spatial information. Hemispheric organization of these left handed individuals can be represented as follows:-

Left Hemisphere	Right Hemisphere	
Speech	Speech	Spatial
Language	Language	Abilities
Writing	Writing	Nonverbal
Calculation	Calculation	ideation

Left Handed

Evidence for these models of organization comes from studies of Levy (1969), Miller (1971), Nebes (1971), and Nebes and Briggs (1974) showing that left handed individuals do less well on nonverbal intelligence tasks and tests of certain types of spatial ability that are thought to measure right hemisphere functions. The samples of subjects used in these studies are very small drawn from highly selected populations, and not selected on familial handedness.

Attempts using the model have not revealed similar findings (Fagan – Dubin, 1974; Hardyck, 1976; Peterinovich & Goldman, 1975; Kutas, Mc Carthy and Donchin, 1975; Newcombe and Ratcliff, 1973).

Commenting about the model proposed by Levy, Hardyck (1977) states:

“ …… The left handed in the Levy model are treated as an undifferentiated group. However, studies of handedness and hemispheric functioning (….……)strongly indicate that bilateralization of function in left-handedness may cover a wide range of localization, from a complete left side lateralization of speech and right side lateralization of spatial ability through bilateral localization of both speech and visual functions to complete lateralization of speech in the right hemisphere and spatial ability in the left hemisphere … a mirror image of the usual right – handed localization pattern."

The Levy's model offers statements as to what occurs in each hemisphere, but they have very little to offer as to how the commissures work. In the model, each hemisphere seems largely responsible for its specialized functions than the interhemispheric transfer which has been given very little importance.

Hardyck (1977) comments and concludes that:

> "Functions appear to be organized in a competitive rather than a cooperative mode, as suggested by the model for the left – handed, where spatial abilities are displayed by the more dominant speech functions."

Diamond and Beaumonts' Model:

The model proposed is based on the extensive experimental works of Beaumont (1974), Beaumont and Dimond (1973, 1975), Dimond (1970 a,b,c; 1971; 1972) and

Dimond and Beaumont (1971 a,b; 1972 a,b,c,d,e and 1974 a,b).

Dimond and Beaumont argue that the brain works as a unit, with specialized abilities located within hemispheres, but with the capacity of sharing functions and distributing work loads between the hemispheres.

According to them, the right hemisphere is seen as specialized for analysis and processing spatial information and the left hemisphere as having language and serial, analytic processing ability.

They postulate that the hemispheres of the brain function as two computers, similar in many ways, but each with specialized abilities. Both the hemispheres are both capable of processing stimuli separately where, appropriate, or of sharing a work load where necessary.

According to Dimond and Beaumont, abilities such as colour naming, incidental learning, paired – associate learning, and matching may be interhemispheric tasks and not the private province of one hemisphere as in Levy’s model. The commissural transfer of information serves to share work load and ease demands placed on a particular hemisphere.

They argue that the effect of handedness is related to one of the three possibilities,

> “an increased laterality effect, a decreased laterality effect, or no effect at all” (Beaumont, 1974).

In their studies they found that the mode of response … verbal or manual …. was produced no significant effects related to handedness.

The “non-right-handed “subjects showed longer hemispheric differences as “higher level” cognitive tasks such as speed of substraction, a stroop – type inference task, normality of word association, and paired – associate learning. They showing less hemispheric differences for “lower level” cognitive tasks such as fatigue effects on digits identification, speed of translation of letters, from English to Greek, addition and colour naming.

> “It is proposed therefore, that the level of complexity and the order of integration demanded by the task, interacting perhaps to some degree with modality of response, mediates the differential effects of handedness, mediates the differential effects of handedness. Tasks requiring more processing are associated with grater

> interhemispheric differences in the more sinistral, the additional effect of the response mode being to reduce interhemispheric differences in the non-right hander.
>
> ……….the brain of the left-hander might be less lateralized than that of the right hander …………… Many of our experimental results –the majority –certainly support such a view of the differential cerebral organization of the left and right hander. None suggested the contrary.
>
> ………the greater diffusion observed in the sinistral does not apply to verbal functions alone. The experiments supporting the concept most clearly do not all involve verbal material, nor do they exclusively involve vocal responses …………..The greater diffusion of the system of non-right-hander is therefore, considered to be a general characteristic" (Beaumont, 1947).

The characterization of the left handed, as possessing a more diffuse cerebral organization that requires more cerebral processing time on higher level cognitive tasks seems at first, similar to the Levy's model, at least in the sense of suggesting a possible handicap for the left handed. Dimond and Beaumont go on to state

> "In simple terms, the diffuse system, that of the left-hander, carries and advantage for complex, integrative operations, but a disadvantage for rapid simple communication" (1974).

A graphic representation of the cortical organization is given in the following diagram for both the right –and left handed (Dimond and Beaumont, 1974 a):-

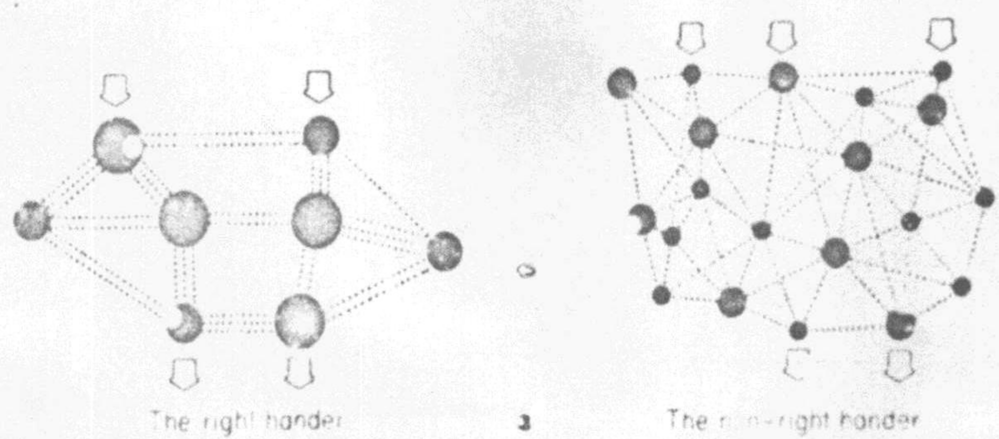


Figure 5.1 The cortical organization of the right- and left-handed. [From Dimond and Beaumont, 1974a.]

In the Dimond the Beaumont model of handedness and cerebral functioning, the left handed differ from the right handed, not in hemispheric specialization but in degree of cerebral organization.

The limitations of the Dimond and Beaumonts' Model are:

1. The classification is too arbitrary to be useful.
2. The model implies that diffusion of organization in the left handed requires more processing time for complex cognitive tasks, as compared to time required by the right handed. This seems to contradict the argument that the diffuse system of the left handed has an advantage for complex integrative operations.

Cohen (1972) found left handed subjects faster overall in a letter – classification task. Provins and Jeeves (1975) found the left handed to have faster overall reaction times to tones, regardless of ears.

Finally, the model does not develop the relationship between the postulated greater differences of functioning and the hemispheric differences reported for the tasks classified as measuring higher – level cognitive functioning.

Hardyck's Model: A model of individual differences in Hemispheric Functioning:

This model has been proposed by Hardyck (1977). The model was introduced to overcome the difficulties amounted by the other three models, that is, difficulty in integrating the differences in hemispheric organization in the familial left handed.

The model postulates existence of two types of human cerebral organization, representing extremes of a continuum.

The first, most frequently occurring type. This organization is highly lateralized for special kinds of processing within each hemisphere, with little ability for such specialized processing inhering in the other. Skills such as language an corresponding long – term memory are located almost completely within the left hemisphere, which is specialized for such processing. Skills such as spatial ability and pattern recognition (with appropriate memory) are located primarily in the right hemisphere, also specialized for such processing.

Hardyck (1977)stats that:

> “The hemisphere specialized for a given type of activity can accept data, carry out what ever processing is necessary, and output an appropriate response. In such an organization, interhemispheric transfer is limited to functions which may be carried out as shared hemispheric activities. Complete lateralization is not assumed –- a hemisphere specialized for language will also have some spatial ability, and interhemispheric communications of these abilities is possible”.

A second type of organization in the model is less frequently occurring and bilateral with multiple specializations present in each hemisphere. Processing of language skills and of spatial abilities can be done in either hemisphere. Hardyck states that:

> “It is not argued that the two hemispheres are identical, but that much duplication of functions and specialized abilities including memory is present in each hemisphere. This organization is characterized by a high degree of interhemispheric transfer of information between the corresponding specialized areas. For example, verbal processing carried out in the one hemisphere can be sent to the

> Corresponding verbal processing center in the other hemisphere.”

These two types of extreme cerebral organizations are represented as the end points of a continuum of human cerebral organization.

Under conditions where problem solving ability of a given type is assessed on a hemispheric basis, the most extreme between – hemisphere differences will be found in those persons whose hemispheres are highly specialized for particular kinds of processing. The smallest between – hemispheres differences will be found in persons who are bilateralized, where hemispheric functions are duplicated, and specializations for multiple types of data processing.

It is hypothesized that under normal conditions of information processing, where visual and auditory input are unrestricted, equal flow of information processing to both hemispheres occurs, and responses to problems will be identical outcome, regardless of type of cerebral organization. Hence, the two types of cerebral organization can be differentiated only under experimental conditions where the input is restricted.

The model tries to correlate the familial handedness with cerebral organizations. It considers three types of handeness in a continuum.

1. The right handed individual with no family history of left handedness is presumed to be the representative of extreme lateralization in the model.

2. The left handed individual with a positive family history of left handedness, is presumed to display the characteristics of multiple specialization bilateral model, and

3. The right handed individual with a family history of left handedness is presumed to display the characteristics of bilateral organization characteristic of the second group, but to a lesser degree.

Hardyck (1977) defines familial left handedness as "….. the presence of left – hand preference in at least three members of a biologically related family spanning at least two generations."

Left handedness to him is defined as "…… encompassing range from moderately strong left – hand preference through ability to use either hand for a variety of tasks”.

According to Hardyck, an individual with a highly lateralized form of cerebral organization will solve a problems by processing it in the hemisphere specialized for that type of problem, until a satisfactory answer is reached. In an individual with bilateralized type of cerebral organization it is presumed that two hemispheres solve the problem in a parallel manner, sharing the data. The successful solutions for the problem in both the types of individuals will be identical.

In this model also, the cerebral organization for a right handed individual with no family history of left handedness, will be as in the Levy’s model; as follows:

<u>Left Hemisphere</u>	<u>Right Hemisphere</u>
Speech	Spatial
Language	Abilities
Writing	Nonverbal
Calculation	ideation

Right Handed

The corresponding model of cerebral organization for the left handed with a family history of left handedness is as follows:-

Left Hemisphere		Right Hemisphere	
Spatial Abilities Nonverbal ideation	Speech Language Writing Calculation	Speech Language Writing Calculation	Spatial Abilities Nonverbal ideation

Left Handed

The following assumptions are also presented in the Model:-

1. Organization of motor functions does not differ as a result of differences in lateralization. In a majority of the people, whether they are laterally specialized or bilateral, motor speech is controlled by the left hemisphere.

2. The efficiency of callosal transmission between the hemispheres does not different between the types of cerebral organization.

3. Even in the highly lateralized individual, lateralization is far from absolute and differences in cerebral asymmetry/cerebral specialization are a matter of degree.

However, thorough research seems to be necessary for validating these models of hemispheric functioning.

For the last quarter of a century, tests of perceptual asymmetry have been used extensively to determine cerebral dominance/hemispheric specialization for language.

TESTS OF PERCEPTUAL ASYMMETRY:

These tests of perceptual asymmetry are based on the perceptual differences of the two different stimuli presented simultaneously. The following are the tests of perceptual asymmetry:-

1. Dichotic Listening: auditory mode.
2. Visual Half Field (VHF) Asymmetries: visual mode
3. Dichhaptic performance tasks: somesthetic mode.
4. Dichnosnic Perception: Olfactory mode.

The methods either employ one or the other of the senses.

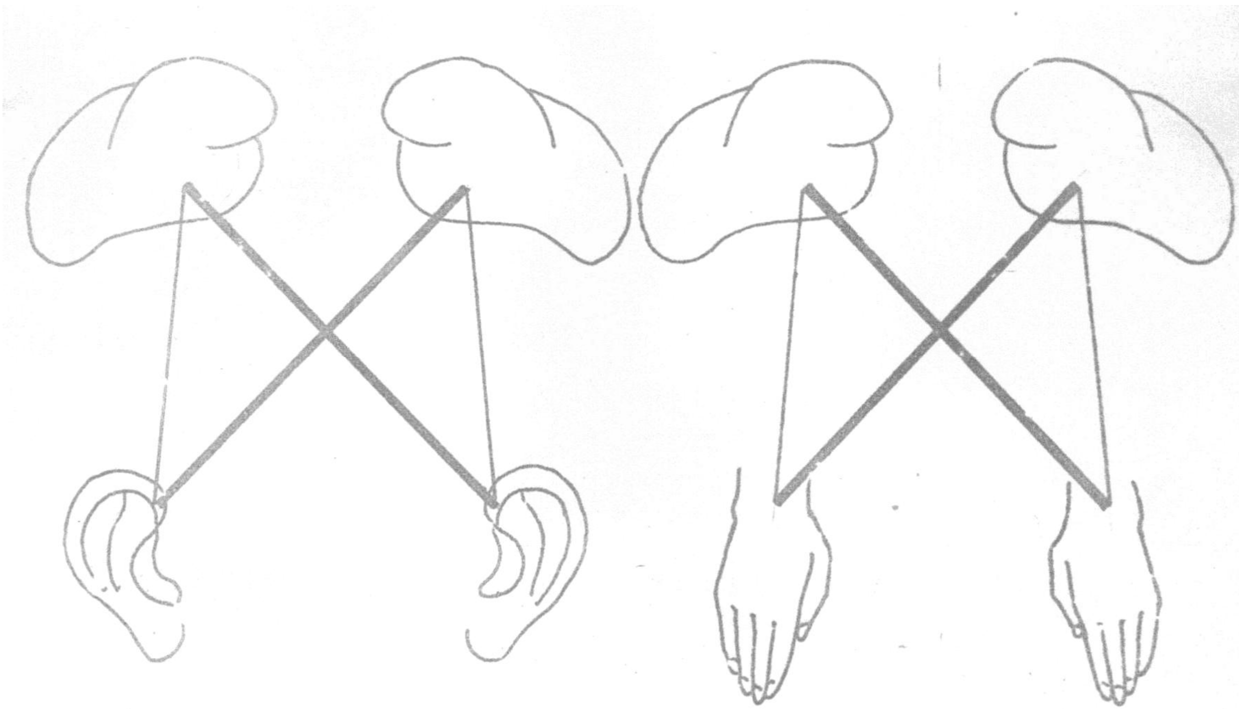
Several test paradigms and the procedures adopted in the tests of perceptual symmetry are common in nature. All these tests compared the perception of stimuli presented simultaneously in the left and right sensory fields.

The basic rationale of these tests is based upon the fact that stimulation may be lateralized so that it is initially transmitted predominantly (as in the auditory and somesthetic modalities) or solely (as in the visual modality) to the contralateral hemisphere.

Any asymmetry in accuracy or in reaction time in the perception of simultaneously presented stimuli may reflect the superiority of one hemisphere, usually contralateral to the side performing better.

Out of these tests, the tests of dichotic listening and test of dichhaptic stimulations will be discussed here.

In the auditory and tactual (somesthetic) modalities, there is ipsilateral as well as contralateral transmission of information (Vide Figure)



in the neural system. This competition is most effective in emphasizing perceptual asymmetries.

In the auditory modality, the dichotic stimulation /listening procedure (Broadbent; 1954; Kimura, 1961a, b and many others) is well known. The stimuli in dichotic listening vary from simple non-sense syllable to meaningful speech and from simple clicks and tone to musical chords and require linguistic, sequential, or holistic, parallel processing. The results of these tests either reflect right or left hemisphere superiority, or ambilaterality (Berlin and Mc Neil, 1976; Gordon, 1974; Kimura, 1967; Studdert –Kennedy and Shankweiler, 1970).

In the haptic modality (that is, active touch which involves tactile and proprioceptive stimulation), a technique of dichhaptic stimulation has been devised (Witelson, 1974, 1976).

In the dichhatic stimulation test, various forms of spatial stimuli are used. The tests reflect a right hemisphere specialization or superiority or in some cases a balance between left and right hemisphere processing (Witelson, 1974).

The situation of balance between the hemispheres may occur more frequently than that of the left hemisphere superiority (Witelson, 1977). The haptic perception, even for tasks involving linguistic processing, depends sufficiently on spatial processing by the right hemisphere than the participation of left hemisphere (Witelson, 1974; 1976).

Studies in Dichotic Listening:

The dichotic listening technique is a psychophysical measure that was developed by Broadbent (1954).

The technique is one of the popular of the contemporary attempts to determine whether and to what extent one hemisphere is better then the other in the processing of certain auditory material (Gruber and Segalowitz, 1977).

The technique involves presenting to the subject different stimuli to each ear simultaneously and asking the subjects to report or recognize the content of the signals. If reports from one ear are more easily forthcoming than the reports from the other then a conclusion is drawn that the hemisphere opposite the higher scoring ear is more efficient in processing the type of signal being presented.

Researchers have found that there is a consistent right ear advantage (REA), indicating a left hemisphere processing for verbal and linguistic materials (Kimura, 1961 a; b) and left ear advantage (LEA) indicating right hemisphere processing, for nonverbal environmental sounds (Knox and Kimura, 1970) and music (Kimura, 1973).

These results are generally accounted by two claims about the structure of the auditory system:-

1. that there exists a greater number of contralateral ear – to – hemisphere connections than ipsilateral connections (Rosenzweig, 1951; Hall and Goldstein, 1968); and

2. that ipsilateral input from one ear is blocked by contralateral input from the other ear (Cullen, Berlin, Hughes, Thompson and Samson, 1974).

Although, these two facts of dichotomous stimulation are well established, the interpretation of dichotic listening data is not so straight forward (Gruber and Segalowitz, 1977).

Systematic variation of the acoustic features (for example, time of onset, intensity of signals) dichotically presented show that the REA for speech is extremely fragile (Berlin and McNeil, 1976; Berlin and Cullen, 19770. The lack of agreement across experiments are not surprising due to variations in the acoustic features. Since the degrees of REA and LEA is dependent on acoustic variables, any measure of degree of laterality is automatically confounded with the particular test stimuli used (Berlin and Cullen, 1977).

The handedness does not really reflect the ear advantage. The right handed subjects may not reveal REA or a left handed subject may not reveal an LEA, on a dichotic verbal task.

Estimates of the percentage of the right handed population with language lateralized to the right hemisphere vary between zero percent and eight percent (Gruber and Segalowitz, 1977).

The REA or LEA for a given stimuli depends upon its meaningfulness to the subject to whom it is presented.

Papcun et al (1972)presented Morse code signals to Morse code operators and to subjects who did not know Morse code. Morse code operators showed right ear superiority indicating a left hemisphere processing for the perception of dichotically presented Morse code signals. The subjects who did not know Morse code indicated a left hemispheric processing when presented with a set of dot-dash patterns which was restricted to seven or few elements. But the same subjects showed a right hemispheric processing, when the length of the stimuli increased.

The results suggest that the language is lateralized to the left hemisphere, because of its ability to analyze the sequence and sequential subparts. They also indicate that the stimuli which are meaningful for one individual (Morse code operators) need not be always meaningful to the other (subjects who did not know the Morse codes).

A clear case for cognitive factors is presented by Van Lancker and Fromkin (1972, 1973), who found that tone words in Thai produce an REA with Thai speakers but not with English speakers. One group considered the stimuli as linguistic and the other did not.

Van Lancker and Fromkin (1972)reported that the pitch contours are perceived more readily by the right ear when pitch is linguistically used to distinguish one lexical item from another in the speakers of tone languages like, Thai. In 1973, Vanlancker and Fromkin, pointed out that, in the past, dichotic listening studies with linguistic stimuli had shown REA, implying a left hemisphere dominance for language processing, while other stimuli incorporating pitch distinctions had shown no ear preference or showed a left ear (right hemisphere) advantage. They a studies ear preferences in the tone language speakers using comparison of three sets of stimuli:

a) Pitch differences within language stimuli (tone words in the tone language, Thai);

b) language stimuli without pitch differences (CV words on mid tone); and

c) Pitch differences alone (hums).

Results from twenty two native Thai speakers demonstrated that tone words and consonant words are better heard at the right ear, while the hums showed no ear effect. Preliminary results on 14 English speaking subjects suggested a right ear effect for consonant words with no ear effects for tone words and hums. They concluded that pitch discrimination is lateralized to the left hemisphere when the pitch differences are linguistically processed.

Robinson and Soloman (1974) reported that non-speech rhythmic patterns are processed in the same hemisphere as the speech. They presented thirty dichotic pairs of rhythmic pure tone patterns, on a counter balanced, forced- choice recognition task to 24 subjects. The subjects indicated that they heard the patterns in the right ear significantly more often than in the left ear. Robinson and Solomon concluded that the left hemisphere is better able to process hierarchically, because both speech and rhythm require hierarchical organization.

Berlin, Lowe-Bell, Cullen, Thompson, and Loovis (1973) suggested that the RE As in the Speech -like tasks may be related to the use of any acoustic event which is perceptually linkable to rapid gliding motions of the vocal – tract.

Sussman (1971), in a tone tracking task using target tones in the right or left ears (with cursors in the opposite ear) using either the tongue or the right hand as controllers, found that the tongues was able to coordinate its movements better when the right ear processed the acoustic results of those tongue movements than when the left ear processed the acoustic results of the tongue movements. Though there was no dichotic stimulations of speech, the tongue functioned better in working with the right ear than with the left ear. Such asymmetry was not observed when the right hand was used. Berlin, Cullen, Lowe – Bell, Thompson and Loovis (1973) attributed this asymmetry to the proximity between the left hemisphere auditory areas and the control centres for the movements of the vocal tract. They concluded that this might have improved the efficiency of interaction of the right ear with any movement of the vocal tract.

Sussman (1971)summarizes by saying that:

> "…......the same hemisphere that is specialized for the extraction of linguistic feature can also be specialized, in a sensory motor fashion, to monitor and control the dynamic movements of the tongue……..".

Sussman, Mac Neilage and Lumbley (1974), have demonstrated a laterality effect that appears to results from the presence of a speech related auditory motor algorithm in the left hemispheres similar to that used in speech. The subjects had to “track” the frequency of a varying computer generated (target) tone introduced into one ear, with another (cursor) tone controlled by the transduced out put of either articulatory movements or hand movements, and presented to the other ear. Findings showed that tracking performance of right handed subjects were significantly better when the tone controlled by a speech articulator was presented to the right ear, but not if the tone was hand controlled.

Sussman, Mac Neilage and Lumbley (1975) in a pursuit auditory masking task, had their subjects to match a continuously varying pure tone presented to one ear with a second tone presented to the other and controlled by unidimensional movements of parts of their motor system. The tonal amplitude was varied in mandibular and manual tracking modes. Subjects indicated a small REA for both the tracking modes which was not significant. They concluded that

> “Frequency modulated stimuli may more efficiently differentiate speech from non-speech tracking because …….. speech experience”

They state that speech:

> “possesses a more developed lateralized auditory sensori-motor algorithm for frequency-motor relationships involving the mandible than for amplitude –motor relationships.”

Berlin, Porter, Lowe – Bell, Berlin, Thompson and Hughes (1973) have reported the suppression of the left ear in the presence of an unintelligible signal in the right ear sounding like a vocal tract transition in a dichotic listening task.

Berlin, Lowe – Bell, Cullen, Thompson and Loovis (1973) concluded that

> “………. any acoustic signal may become lateralized to the left hemisphere, if a difficult enough auditory task can be related to a complex vocal tract movement.”

The large RE As experienced by Morse code operators for dichotically presented Morse codes (Papcun, et al, 1972) has been attributed to a general superiority of the left temporal lobe in handling temporal sequences (Berlin and McNeil, 1976). Efron (1963) believed in an active role of temporal lobe in processing all temporal sequences.

However, there is a dichotomy between the two ears in the perception of verbal and nonverbal inputs which is not unequivocal. An LEA has been reported in subjects attending to the nonverbal properties like Pitch and Loudness variations of dichotic verbal input or in identifying the vowels embedded in a nonverbal context (Nachshon, 1970; Spellacy and Blumstein, 1970). That is, the nonverbal aspects of verbal input are attended to and mediated by the right hemisphere.

Then the question arises as to whether this nonverbal input can be so constructed as to be perceived better in the right ear, meaning the left hemisphere which has important sequential character (Lashley, 1961; Neff, 1964; Hirsh, 1967). It is possible to assume a mediation of left hemisphere for sequentially patterned nonverbal sounds. This assumption is evidenced by both clinical and experimental studies, showing lesions of the left hemisphere selectively impairing the perception of sequential –visual and audio-visual stimuli (Efron, 1963; Jerger, Weikers, Sharbrough, and Jerger, 1969; Goldman, Lodge, Hamma, Semmes and Mishkin, 1968; Carmon, 1971; Carmon and Nachshon, 1971).

Halperin, Nachshon and Carmon, (1973), presented dichotic nonverbal stimuli with either two, one, or zero.

frequency transitions between the stimuli with a sequential complexity either of frequency or of duration. The subjects were asked to identify the sets sounds differing in sequential complexity. The number of frequency or duration transitions in a set of three sounds was defined as sequential complexity. They reported an LEA in case of zero transitions similar to that reported by Gordon (1970) for between –ears discrimination of pitch. A gradual shift from the left ear to the right ear advantage was reported with increase in sequential complexity from one and then to two transitions. This finding is in agreement with the significantly greater REA perception of dichotically presented consonants which are more complexly encoded than vowels, than in perception of vowels (Studdert – Kennedy, Lieberman, Harris and Cooper, 1970).

Locke and kellar (1971) undertook assessment of categorical perception in a nonlinguistic mode to evaluate “uniqueness” of the speech analyzing mechanisms and its relation to the left hemisphere which is presumed to be “inhate”. Identification and discrimination function was assessed in fifteen musicians and eighteen non-musicians employing synthetically generated triads as stimuli. Categorization was more prominent in the subject classified as musicians, and discrimination more closely paralleled the prediction from the categorization curves than was true for non-musicians. They concluded that the categorical perception is not unique for language nor limited to the left hemisphere.

Blumstein and Cooper (1974) concluded in their study that the right hemisphere is actively involved in processing intonation contours. They added that the normal language processing involves the active participation of both the cerebral hemispheres.

Early observations of right hemisphere superiority for elements of music (Milner, 1962; Kimura, 19640 and left hemisphere for language in dichotic listening studies (Kimura, 1961 a, b) provided initial credibility to the verbal – nonverbal distinction between the hemispheres. However, these studies have not indicated an exclusive right hemisphere mediation of music. Previous evidence for left hemisphere involvement in music perception (Hanschen, 1926; Nielsen, 1946; Wertheim and Botez, 1961) seems to have been ignored.

Cook (1973) studied the perception of musical stimuli presented under the influence of dichotic stimulation with subjects from second semester freshman music classes. He concluded that in the right handed subjects musical sounds appear to be processed more efficiently in the right hemisphere of the brain than the left.

Bever and Chairello (1974) reported and REA for music in musicians and an LEA for music in nonmusicians. They concluded that this difference is because of the analytical and holistic characteristics of the music that has been perceived by these groups.

Bartholomeus (1974)in an effort to find out the effect that task requirements on ear superiority for sung speech, presented two different sequences of letters sung to two different melodies by two different singers, three times to each of the twelve subjects. The task requirements were to recognize the letters sequence, melody, and singer recognition. The subjects reported no ear difference for sung voices, significant REA for recognition of letter sequences and an LEA for melody recognition, He concluded that laterality effects in audition are not solely determined by stimulus characteristics, but are also dependent on task requirements.

Johnson (1977), dichotically stimulated the ears of thirty two musicians and thirty two nonmusicians. Subjects with musical backgrounds reported and REA and subjects who were nonmusicians reported an LEA for violin melodies. He found that the musicians mainly use the left hemisphere, to process the musical stimuli and the nonmusicians, the right hemisphere.

Gates and Bradshaw (1977 b) conducted six experiments to detect pitch, rhythm, and harmonic changes in music perception. Ten males and ten females, who were the subjects of this study did not show any difference in reaction times, between the ears. The right ear was more accurate in perceiving the whole tones sequence. The right ear was more accurate in recognizing rhythm changes though the left ear was faster in this aspect. The right ears of the males were more sensitive to the excerpts from unfamiliar melodies, where as for the females the left ears were more sensitive.

Gates and Bradshaw (1977 b) reported that in a normal music situation, perception depends upon the synthesis of the features and rhythms, and thus, both processes are involved, not in terms of the specialization of one hemisphere “dominant” for music, but as an interaction of both hemispheres, each operating according to its own specialization, in the complex process of music perception.

The studies using music as dichotic stimuli have shown equivocal results. The differences among them may be due to the variations in the subjects, and variations in the task required to be performed. However, studies with musicians as subjects have shown a left hemispheric specialization for music perception (Barthalomeus, 1974; Gates and Bradshaw, 1974 b; Natale, 1977; Johnson, 1977; Bever and Chairello, 1974), and a right hemispheric processing of music has been reported for nonmusicians (Bever and Chairello, 1974; Kimura, 1964, 1967; king and Kimura, 1972). These studies show that the music becomes meaningful to a musician and hence, is processed in the left hemisphere and a right hemisphere processing is observed in nonmusician for whom music is not meaningful.

Kimura (1961 a) and Milner (1962) reported that patients with left temporal lobe lesions have poorer verbal recall and patients with lesions of the right have poorer musical recall.

Bakker (1970) has demonstrated that there is a superior right ear performance in a monaural listening task when the recall task (memory) is made long and complex with more time intervals. Several studies show tasks involving memory functions seem to have certain effects on the ear advantages.

Dichotic studies have found that memory can alter both the size and direction of the REA (Moray, 1959); Deutsch and Deutsch, 1963; Triesman, 1964; Deutsch, Deutsch and Lindsay, 1967; Triesman and Gaffen, 1968; Wilson, Dirks and Cartelette, 1968; Triesman, 1969; Triesman and Riley, 1969; Day, Bartellette and Cuttings, 1973; Yeni – Komshian, Gordon and Sherman, 1973; Porter, Mc Cormick and Guillory, 1974; Gallagher, Tobey, Cullen and Rampp, 1976; Berlin and Mc Neil, 1976).

Oscal – Berman, et. al., (1974) believe that storage (memory) mechanism is more sensitive to laterality differences than the perceiving and reporting mechanism. They observed in their study, that the storage ears performed more efficiently than the reporting ears, on nonlinguistic sounds, like pitch contours.

Yeni – Komshian, Gordon and Sherman (1973) examined the effects of memory load on the REA. Increase in the memory load on the dichotic listening task revealed a pronounced REA, whereas the reduction in memory load showed an increased in LEA.

Porter, Mc Cormick and Guillory (1974) observed that the practice manipulations and memory having eliminated the serial position effect on the right ear, increasing its performance leaving the left ears scores unaffected.

The involvement of memory in the dichotic listening task, seems to increase the performance of the right ear, leaving the left ear scores unaffected.

Studies with Dichhaptic Stimulation:

Hemispheric differences in the processing of linguistic and nonlinguistic materials have been studied using the tactual modality also. The method is called “dichotomous stimulation” or “dichhaptic stimulation” or “dichotomous manual tasks”.

Witelson (1974) compared relative hemispheric processing abilities using the tactual modality. She presented objects of various shapes dichhaptically, that is, one object to each hand at the same time for tactual exploration. She found her subjects reporting a left hand superiority / advantage for recognition of spatial forms, and found no difference on verbal forms (letters). She concluded that the finger movements were controlled by the contralateral hemisphere (right) and leading to right hemispheric processing of the spatial abilities.

Buffery and Gray (1972)demanding simultaneous drawing of a circle with one hand, and a square with the other, concluded that left hand was superior to the right hand in this task, to suggest a right hemispheric specialization.

Witelson (1976) observed an LHA for boys on a dichhaptic task involving perception of meaningless shapes. The difference between hands was not observed in a group of girls. The same findings on similar task was reported by Levy and Reid (1976).

Witelson and Gibson (1976) reported no difference between two hands of their subjects who were presented with a dichhaptic task involving a particular shape, that is, circle enclosing a dot.

La Breche, Manning, Gobble and Markman (1977) studied

> “Two groups of congenitally deaf and two groups of hearing right handed subjects. The groups identified the pairs of nonsense shapes and letters after simultaneous bilateral tactual exploration. In responses to shapes, left and right hand pointing to multiple choice arrays were compared. Three response modes, writing, and left and right, and finger spelling,

> were compared for letters. A tendency for right tactual field superiority for shapes was observed in all groups. Groups initially exposed to letters showed significant right field superiority across response modes for shapes. No right-left asymmetries were observed for letters. Differences due to deafness were not observed".

Millar (1975) studied the effects of phonological and tactual similarity on serial object recall by blind and sighted children. She administered the serial recall tasks to thirty blind children and sixty sighted children.

> "The tasks contained easily named subjects differing; (a) in name sound and tactual characteristics; (b) in name sound, but similar in feel; and (c) in feel, but similar in name sound."

Significant call decrements were found for tactually similar, relative to dissimilar series for both the blind and the sighted subjects. The blind and the sighted showed recall decrements for phonologically similar compared to dissimilar lists. She concluded that_/both tactual and phonological encoding of tactually presented material by children.

_/ the results demonstrated.

Hermelin and O' Connor (1971) presented nonshapes and letters dichhaptically to groups of blind and sighted children. They observe that there was a left hand superiority for nonsense shapes and no hand difference for letters among both groups. They concluded that these inputs were processed by the nondominant hemisphere, and be treated as spatial items.

Nachshon and Carmon (1975) tested hand preference in sensorimotor discrimination tasks with eighty right handed subjects. One set of experiments compared the abilities of the two hands to perform sequential tasks. The other set compared spatial abilities of the two hands. Within each set one experiment involved unimanual performance, and the other bimanual. The results showed that the subjects performed better with their right hands on the bimanual sequential tasks, and better with their left hand on the bimanual spatial task. No hand preference was observed on the unimanual tasks. The results are interested as reflecting the differential sensorimotor dominance of the left and right hemisphere for sequential and spatial task, respectively.

These studies using dichhaptic stimulation using nonsense shapes and letters have shown equivocal results among different groups of the population. The studies have utilized less linguistic and less meaningful spatial items as stimuli. Hence, a definite conclusion can not be drawn in favour of the non dominant hemisphere processing the spatial linguistic – meaningful stimuli.

Studies using Braille:

Braille stimuli requires spatial processing of the dot arrangements and therefore, left hand superiority reflecting the right hemispheric specialization for spatial processing of Braille is excepted.

Most of the studies have found a left hand superiority on some performance measures of Braille reading for various groups of individuals (Critchley, 1953; Harris, Wagner and Wilkinson, 1976; Hermelin and O'Connor, 1971; Rudel, Denckla and Saplten, 1974). However, others have found no differences or even right hand superiority in some instances (Fertsch, 1947; Hermelin and O'Conner, 1971; Lowenfeld, Abel and Hatlin, 1969; Rudel, Denckla and Spalten, 1974).

Hermelin and O'Connor (1971) found that right handed old blind children read Braille faster and more accurately with their left hand than the right. They concluded that these inputs were processed by the nondominant hemisphere for language, that is, the right hemisphere.

Critchley (1953) has also observed the same results. Both the studies have utilized the rate of reading the Braille as a measure.

Critchley (1971) however, has reported two cases of tactile alexia among the blind. One of the cases had bilateral parietal lobe damage with more disturbance in reading Braille using the left hand. The second case had a left parietal lobe damage with left hand disturbances in reading Braille. These cases, to certain extend, suggest that there is an ipsilateral dominance for Braille processing when there is no competition between the hands.

Witelson (1977) says that Braille reading involves some spatial and holistic processing. But Braille is also a language, and it is mainly a phonetically coded language, with different dot patterns representing different phonemes or speech sounds. Sequential processing is also an important factor in Braille reading, at the level of both the word and sentence. Therefore, left hemisphere processing must also be involved. Thus, the cognitive processes, or more precisely, the balance between the different cognitive processes involved in the reading of Braille are not obvious.

Witelson (1977)adds that

> “Within this framework, the inconsistent results of hand asymmetry in reading Braille may seem more understandable.”

As many studies are not available to the present investigator, the relationships between the Braille reading and the hand asymmetry are inconclusive. However, there seem to be no studies which have used Braille in a dichhaptic task.

To summarize:-

1. It is generally concluded that the linguistic functions are lateralized to the left hemisphere, in majority of people.

2. Dichotic studies have indicated that there is an REA for meaningful linguistic stimuli and a LEA for non-meaningful – nonlinguistic stimuli.

3. However, there are studies which slow that when nonlinguistic stimuli become linguistic, they are processed in the left hemisphere.

4. Dichhaptic studies have shown that spatial relationships are lateralized to the right hemisphere; and ,

5. Studies using Braille for the study of dominance are inconclusive as to determine the dominance for Braille.

CHAPTER III: MATERIALS AND METHODS

The idea of the study was to present two lists of words to both the hands and to both the ears, to find the differences between the performances of the hands and those of the ears on a Dichhaptic Braille Reading and a Dichotic Listening Task respectively. Four lists of familiar words were necessary.

It was decided that we should have seven words in each list because it has often been indicated that most individuals can conveniently recall only seven words when the words were unrelated.

The following were necessary:

a) Four Lists of Words:

1. Familiar Kannada words (disyllables) of equal complexity were chosen as the items.

2. Lists of these words written in Bharati Braille, which is the Kannada Braille Script, was to be one of the modes of presentation.

3. Tape recordings of these four lists, was the other mode of presentation.

b) Blind Subjects:

1. Adults were selected to ensure a settled vocabulary and reading ability and more importantly stabilized laterality, with an education of minimum eighth standard.

Preparation of the Materials:

a) Four Lists of Words:

i) Twenty eight familiar Kannada bisyllabic words of equal complexity were chosen randomly from the lists of words used in the Kannada Articulation Test (Babu et al, 1972). They were selected, because they have already been checked for their familiarity.

ii) Four lists of seven words each were then prepared by assigning the randomly chosen words to different lists randomly based on lots, to obtain equality among the lists.

The lists of words are shown in Table A, Table B, Table C and Table D, representing List I, List II, List III, and List IV respectively.

Preparation of the Bharati Braille Lists:

A senior blind teacher wrote the four lists of familiar words into Bharati Braille (that is, Kannada Braile).

These Lists are given in Table E, Table F, Table G and Table H.

Tape Recordings of the Lists:

Tape recording of the lists was necessary for the dichotic Listening Task.

Instrumentation: A dual channel Sonnet Tape Recorder with its microphone (Model Phillips) was used for tape recording.

Recording: The speech recording of the lists was done using hifidelity dichtron magnetic tape. A young male speaker (the present investigator), whose native language is Kannada read the words for recording the lists.

Table I, shows the number of lists and the channel on which they were recorded.

Right Channel	Left Channel
List 1	List 2
List 3	List 4

TABLE I

The lists were recorded with a three second pause between each successive word. The two lists 1 and 2 were so recorded that there was a general overlap between the words of list 1 and those of list 2. The same was true of the recorded lists of 3 and 4.

The overlapping of the words in the words was to obtain the simultaneity in the presentation of words to the ears in the Dichotic Listening Task.

TABLES.

TABLE A

	List 1	
ಕೋಳಿ	ko:ḷi	hen
ಏಳು	e:ḷu	seven
ಡಬ್ಬಿ	ḍabbi	box
ಆಮೆ	a:me	~~rabbit~~ tortoise
ಬಸ್ಸು	bassu	bus
ದಾರ	d̲a:ra	thread
ಟೋಪಿ	ṭo:pi	cap

TABLE B

	List 2	
ಚಕ್ರ	tʃakra	wheel
ಮಂಚ	mantʃa	cot
ಬ್ಲೇಡು	bl̲e:ḍu	blade
ನಾಯಿ	na:yi	dog
ಕಾಲು	ka:l̲u	leg
ಮೂಗು	mu:gu	nose
ಪೆನ್ನು	pennu	pen

TABLE C

List 3

ಕುರ್ಚಿ	kurtʃi	chair
ಸೂಜಿ	su:dzi	needle
ಕಾರು	ka:ru	car
ಎಮ್ಮೆ	emme	buffaelo
ಮೀಸೆ	mi:se	moustache
ಆನೆ	a:ne	elephant
ಎಲೆ	eḻe	leaf

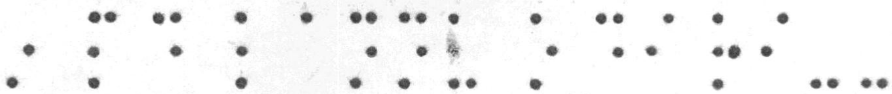
TABLE D

List 4

ಇಲಿ	iḻi	rat
ಜಡೆ	dzaḍe	plight
ಊಟ	u:ṭa	meal
ಬೆಲೆ	beḻe	price
ಚಂದ್ರ	tʃanḏra	moon
ಗಿಣಿ	giṇi	parrot
ಬೀಗ	bi:ga	lock

TABLE E

Braille List 1



(READ THE FOLLOWING WORDS)

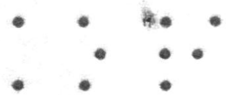
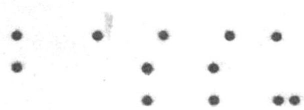
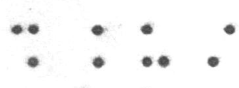
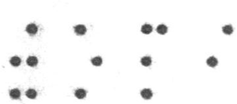
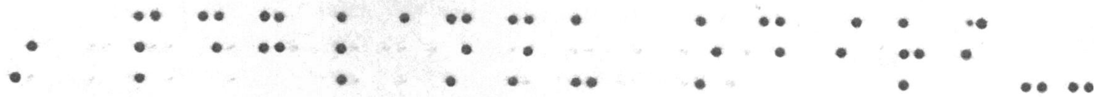
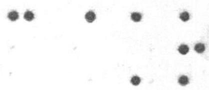
	ko:ḷi	hen
	e:ḷu	seven
	ḍabbi	box
	a:me	rabbit
	bassu	bus
	ḏa:ri	road
	ṭo:pi	cap

TABLE F

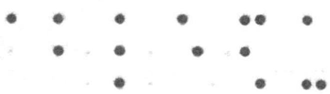
Braille List 2

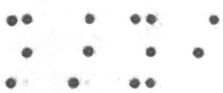


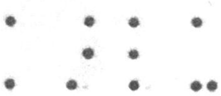
(READ THE FOLLOWING WORDS)

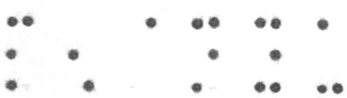
 tʃakra — wheel

 mantʃa — cot

 b<u>l</u>edu — blade

 na:yi — dog

 ka:<u>lu</u> — leg

 pennu — pen

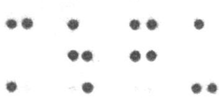
 mu:gu — nose

TABLE G

Braille List 3

(READ THE FOLLOWING WORDS)

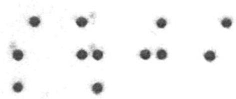
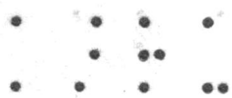
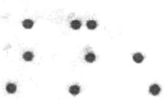
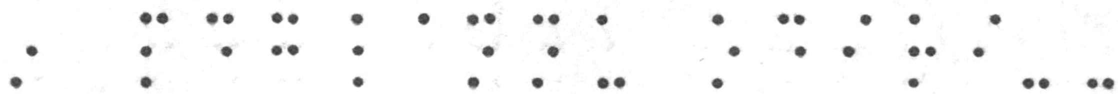
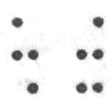
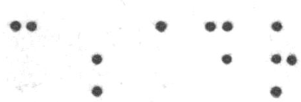
	kurtʃi	chair
	sudzi	needle
	ka:ru	car
	emme	buffaelo
	mi:se	moustache
	a:ṉe	elephant
	eḻe	leaf

TABLE H

Braille List 4



(READ THE FOLLOWING WORDS)

	il̲i	rat
	dzaḍe	plight
	u:ṭa	meal
	bel̲e	price
	tʃand̲ra	moon
	giṇi	parrot
	bi:ga	lock

METHOD

SUBJECTS:

Ten congenitally blind young male adults in an age range of sixteen to twenty years were selected for the study. All the subjects had completed eighth standard or higher. Table J shows the age and education of the subjects.

TABLE J

SUBJECT	AGE	EDUCATION
1	17	9^{th} Standard
2	16	8^{th} Standard
3	18	9^{th} Standard
4	17	8^{th} Standard
5	18	10^{th} Standard
6	18	8^{th} Standard
7	17	9^{th} Standard
8	20	10^{th} Standard
9	16	8^{th} Standard
10	16	8^{th} Standard

ADMINISTRATION:

A quiet room with electric plug points, in the blind school was selected for the administration of the tasks.

The administration of the tasks was done in the following manner:

a) Administration of the Dichhaptic Braille Reading Task.
b) Administration of the Dichotic Listening Task.

a) Administration of the Dichhaptic Braille Reading Task:

The following instructions were given to the subjects, individually:

ಈಗ ನಾನು ನಿಮಗೆ ಎರಡು, ಬ್ರೈಲ್ ನಲ್ಲಿ ಬರೆದಿರುವ
ಲಿಸ್ಟ್ ಗಳನ್ನು ಓದುವುದಕ್ಕಾಗಿ ಕೊಡುತ್ತೇನೆ.
ಇವುಗಳನ್ನು ನೀವು ನಿಮ್ಮ ಮನಸ್ಸಿನಲ್ಲಿಯೇ
ಓದಿಕೊಳ್ಳಿ. ಎರಡು ಲಿಸ್ಟ್ ಗಳಲ್ಲಿ ಒಂದನ್ನು
ನಿಮ್ಮ ಎಡದ ಕೈಗೆ ಮತ್ತು ಇನ್ನೊಂದನ್ನು
ಬಲದ ಕೈಗೆ ಕೊಡಲಾಗುವುದು. ಎರಡು
ಲಿಸ್ಟ್ ಗಳಲ್ಲೂ ಏಳು, ಏಳು, ಪದಗಳನ್ನು

ಬರೆಯಲಾಗಿದೆ. ಈ ಎರಡು ಲಿಸ್ಟ್‌ಗಳನ್ನು, ಎರಡು
ಕೈಗಳಿಂದ ಒಂದೇ ವೇಳೆಯಲ್ಲಿ ಓದಬೇಕು.
ನೀವು ಓದಿದ್ದನ್ನು ಚೆನ್ನಾಗಿ ಜ್ಞಾಪಕ-
ದಲ್ಲಿಟ್ಟುಕೊಳ್ಳಿ. ಜ್ಞಾಪಕದಲ್ಲಿ ಇಟ್ಟುಕೊಂಡದ್ದನ್ನು,
ನಾವು ಕೇಳಿದ ತಕ್ಷಣ ನಮಗೆ ಹೇಳಬೇಕು.

(Now I am going to present you with two lists written in Braille for reading. You should read those lists to your self. Out of these two lists, one will be presented to your left hand and the other to the right. Both the lists contain seven words each written in Braille. You should read these lists simultaneously using both the hands. Try to keep everything you read in your mind/memory. You recall and tell us the words you memorized, as soon as we ask you.)

After giving the instructions, the subject was asked to repeat the given instructions, so as to make sure that the subject has following the instructions. If the subject had not followed the instructions, he was instructed again and his doubts were clarified.

Then the lists were presented to the subject for Dichhaptic Braille Reading. The lists presented to the right hand and the left hand of the subjects are listed in Table K.

The subject was asked to practice on the following sentences “Read the Following words”, as many times as possible till he obtained simultaneity between the two hands in beginning and ending the sentences. The sentence, which was written in Bharati Braille, was there in the beginning of all the lists.

In addition to this, while the subject read the lists using both the hands, utmost care was taken to obtain and maintain simultaneity in reading between the two hands.

Recording of Responses:

As soon as the subject completed reading the experimental material, he was asked to recall and report the words he read. The responses were recorded against the words using tick (√) marks in the check lists which were meant for recording the responses.

After the administration of the Dichhaptic Braille Reading task, the subject was administered the Dichotic Listening Task.

B) Administration of the Dichotic Listening Task:

For the administration of the speech stimuli to both the ears simultaneously.

A dual channel Sonnet Tape Recorder with TDK – 39 Bar phones were used.

The following instructions in Kannada were given to the subjects individually, before presentation:-

"ಈಗ ನಾನು ನಿಮ್ಮ ಎರಡು ಕಿವಿಗಳಿಗೂ,
ಅಕ್ಷರಗಳನ್ನು ಒಂದೇ ಬಾರಿ ಕೇಳಿಸುತ್ತೇನೆ.
ಒಂದೊಂದು ಕಿವಿಗೂ ಏಳೇಳು ಪದಗಳ ರೀತಿ
ಒಟ್ಟು ಹದಿನಾಲ್ಕು ಪದಗಳನ್ನು ನೀವು ಒಂದೇ
ಒಂದು ಬಾರಿ ಕೇಳುವುದರಿಂದ ಬಹಳ ಎಚ್ಚರ-
-ವಹಿಸಿ ಕೇಳುವುದು ಒಳ್ಳೆಯದು. ಹಾಗೆ ಕೇಳಿದ
ಪದಗಳನ್ನು ನೀವು ಬೇಗನೆ ಜ್ಞಾಪಕದಲ್ಲಿಟ್ಟು-
ಕೊಳ್ಳಿ ಮತ್ತು ನಾವು ಕೇಳಿದ ತಕ್ಷಣ
ಜ್ಞಾಪಕದಲ್ಲಿಟ್ಟು ಕೊಂಡ ಪದಗಳನ್ನು ನಮಗೆ
ಹೇಳಿರಿ.

(Now I am going to present you with twolists of words simultaneously to your ears. Each ear will receive seven words, that is, fourteen words in total for both the ears. It will be better to concentrate on listening to these words carefully as they are going to be presented to you only once. Keep these words in your memory, well and report them when we ask you to do so).

After giving the instructions, the subject was checked for his understanding of the instructions, as it was done in the administration of Dichhaptic Braille Reading Task.

For establishing equal loudness, the lists other than those were used for experimental presentation, were used. That is, if the subject was presented lists 1 and 2 for experimental verification, he was presented lists 3 and 4, for establishment of equal loudness between the ears. The loudness between the ears was fixed using the volume controls for the left and right channels in the tape recorder. This was done for all the subjects.

Then the lists were presented simultaneously for Dichotic Listening Task, after checking for the equal loudness between the ears.

The lists, thus presented to the right and the left ears of all the subjects are shown in Table K.

TABLE K

SUBJECT	RIGHT HAND	LEFT HAND	RIGHT EAR	LEFT EAR
1	List 3	List 4	List 1	List 2
2	List 3	List 4	List 1	List 2
3	List 3	List 4	List 1	List 2
4	List 1	List 2	List 3	List 4
5	List 1	List 2	List 3	List 4
6	List 3	List 4	List 1	List 2
7	List 3	List 4	List 1	List 2
8	List 1	List 2	List 3	List 4
9	List 1	List 2	List 3	List 4
10	List 1	List 2	List 3	List 3

Table showing the lists those were received by the hands and the ears.

Recording of Response:

As soon as the subject completed the Dichotic Listening Task, the subject was asked to recall and report the words he heard. The responses were recorded, as they were recorded in the Dichhaptic Braille Reading Task.

Data, thus collected were then analyzed and Processed using appropriate statistical measures.

CHAPTER IV: RESULTS & DISCUSSIONS

1. Hand and Bar Performances in the Present Study:

The individual performances, both in terms of scores and percentage of scores on Dichhaptic Braille Reading task are shown in Table L. In general, there was an RHA. Subject 10 showed an LHA. The score range of right hand performance was between 42.87 percent and 85.74 percent. The left hand performance showed a score range of 2 to 5, that was, between 28.58 percent and 71.45 percent.

TABLE L

SUBJECT	RIGHT HAND		LEFT HAND		DIFFERENCE	
	Score	**Percent**	**Score**	**Percent**	**Score**	**Percent**
1	4	57.16	3	42.82	1	14.29
2	6	85.75	5	71.45	1	14.29
3	5	71.45	2	28.58	3	42.87
4	5	71.45	3	42.87	2	28.58
5	4	57.16	3	42.87	1	14.29
6	5	71.45	3	42.87	2	28.58
7	5	71.45	4	57.16	1	14.29
8	5	71.45	4	57.16	1	14.29
9	5	71.45	4	57.16	1	14.29
10	3	42.87	5	71.45	2	28.58

Table showing performance of ten subjects on Dichhaptic

Braille Reading

The mean percentages of performances of the right hand and the left hand are shown in the Table M. The right hand had a mean percentage of 67.16 and the left hand had a mean percentage of 51.44. The difference of 15.72 percent was significant at 0.02 level of significance with a critical ratio of 2.74.

TABLE M

HAND	MEAN % GE	DIFFERENCE	STANDARD DEVIATION	CRITICAL RATIO	LEVEL OF SIGNIFICANCE
RIGHT	67.16	15.72	11.18		
				2.74	0.02
LEFT	51.44		13.09		

Table showing mean percentages, mean percentage differences Standard deviations and significance of difference between the right and the Left Hands.

The RHA in nine of the ten subjects indicated left hemispheric specialization for Braille processing in those subjects. The Right Hemispheric Specialization for Braille was indicated by an LHA, in subject 10.

The individual performances of all the subjects on Dichotic Listening Task are shown in Table N. The scores of right ear were in a range of 1 to 5, that was, between 14.29 percent and 71.45 percent. The left ear had a score range of 1 to 3, that was, between 14.29 percent and 42.87 percent

TABLE N

	RIGHT EAR		LEFT EAR		DIFFERENCE	
SUBJECT	**SCORE**	**PERCENT**	**SCORE**	**PERCENT**	**SCORE**	**PERCENT**
1	4	57.16	3	42.82	1	14.29
2	4	57.16	2	28.58	2	28.58
3	4	57.16	1	14.29	3	42.87
4	3	42.87	1	14.29	2	28.58
5	3	42.87	2	28.58	1	14.29
6	4	57.16	3	42.87	1	42.87
7	5	71.45	3	42.87	2	28.58
8	4	57.16	3	28.58	2	28.58
9	3	42.87	1	14.29	2	28.58
10	1	14.29	3	42.87	2	28.58

Table showing the performance of the 10 subjects on
Dichotic Listening

The subjects, in general, showed an REA. But subject 10 was exceptional and showed an LEA.

The mean percentages of performances of the right and the left ears are shown in the Table O. The mean percentages of performances of the right ear was 50.02 and of the left ear was 30.01. The difference of 20.01 was significant at 0.01 level of significance with a critical ratio of 3.08.

TABLE O

EAR	MEAN % GES	MEAN %GE DIFFERENCES	STANDARD DEVIATION	CRITICAL RATIO	LEVEL OF SIGNIFICANCE
RIGHT	50.02		15.43		
		20.01		3.08	0.01
LEFT	30.01		11.87		

Table showing Mean percentages, Mean percentages Difference, Standard Deviations, and Significance of difference between the right and the left Ears.

Nine of the ten subjects, showed an REA indicating a left hemispheric specialization. But subject 10, showed an LEA, indicating a right hemispheric specialization.

Nine of the ten subjects showed an REA on dichotic listening task. This falls in line which other studies in dichotic listening. (Kimura, 1961, 1967; Lake and Bryden, 1976 and many others).

In general, most of the subjects in the present study showed an RHA and REA. This indicated a left hemispheric specialization for linguistically meaningful stimuli.

However, subject 10, showed an LHA and an LEA indicating a Right hemispheric specialization. He claimed to be a right hander. Observations of his behaviour corroborated with his claims. He seem to be one of those rare individuals with a right handedness and right hemispheric specialization. This possibility has been accepted by the studies of Berlin and McNeil (1976) and by Lake and Bryden (1976) and Annette (1977).

Most of the subjects, nine of ten in this study have shown a definite RHA. It is concludable that the linguistic functions are still in the left hemisphere, which is the dominant hemisphere. This is confirmed here by laterality patterns and REA.

However, several researchers have implied the conclusion that the right hemisphere is dominant for spatial – linguistic behaviour, such as Braille (Hermelin and O'Conner, 1971; Millar, 1973; Spalten, 1974; Lowenfeld; Abel and Hatlin, 1969; Witelson, 1977).

There are several differences between those studies and the present study. These differences might have contributed to the discrepancy between the findings.

1. Subject Differences:

The present study has utilized congenitally totally blind subjects. Where as, other studies have used both normally sighted and Blind subjects.

Among the blind subjects in those studies, it is not known, whether they were acquired or congenitally blind. the amount of blindness and the age of onset of blindness are not known.

The present study used only young male adults. Other studies have utilized subjects from both the sexes and of different age groups.

2. Methodological Differences:

a. Stimuli Differences:

The present study used Braille as the testing stimuli for dichhaptic presentations. Where as, other studies have used Braille reading as only a factor in selecting subjects. For dichhaptic presentations, they have used only non-sense shapes and letters.

b. Mode of response – Differences:

The present study demanded an immediate recall and report after the off-set of dichhaptic presentations, as a response. Where as, in the other studies the mode of response was either visual or multiple choice.

C. The present study has compared two modalities –viz- auditory and somesthetic.

It is observed that the other studies have restricted themselves primarily to the spatial mode. They also relied on proficiency of Braille Reading as an indicator of localization of Braille processing.

They have identified that the right hemisphere (the non-dominant hemisphere) processes the spatial relationships.

The present study which used decidedly linguistic task demonstrated that even spatial tasks are processed in left hemisphere (dominant) when they become lingusitc.

Subject 10, showed a right hemisphere dominance for Braille. It has been already said that the he might be one of those rate individuals with right brainedness and right handedness.

The finings of Dichhaptic Braille Reading are in consonance with similar studies in Dichotic Listening using other stimuli (Papcun, et al, 1974; Sussman, Mac Neilage & Lumbley, 1975; Van Lancker and Fromkin, 1972; Bever and Chairello, 1974; Gates and Bradshaw, 1997 a, 1977 b; Robinson & Solomon, 1974; Cook, 1973).

As there was a right hand advantage (REA) on Dichhaptic Braille Reading Task and right ear advantage (REA) on Dichotic Listening Task, the statement that:

> “There will be a right hand advantage (RHA) for Braille in the Dichhaptic Stimulation with a right ear advantage (REA) on Dichotic Listening Task”.

was retained at 0.02 level of significance.

The present study, has forced dichhaptic perception in congenially totally blind subjects and has found consistency between dichhaptic and dichotic performances of linguistically meaningful stimuli.

The significantly great RHA and REA might be because the tasks in the present study demanded the memory, and the recall of the stimuli. The finings are in consonance with the findings of other studies in Dichotic Listening.

Oscar-Berman, Goodglass and Donnenfield (1974) have concluded in their study that storage mechanisms (memory) may be more sensitive to laterality (hemispheric) differences than the perceiving and reporting mechanisms,

Studies in Dichotic Listening tasks demanding memory have revealed in increase in the Right ear scores (Darwin, 1969; Day, Bartelette & Cutting, 1973; Yeni-Komshian, Gordon, and Sherman, 1973; Gallagher, Tobey, Cullen and Rampp, 1976; Berlin and McNeil, 1976).

Subject 10, showed an LHA and LEA. It was implied that the linguistic processing was shifted to the right hemisphere (his dominant hemisphere) in this subject. The reason might be that he is one of those with right brainedness and right handedness. In a normal distribution, nearly zero percent to eight percent of the population will be right brained with right handedness (Annette, 1975; Berlin and McNeil, 1976). This either due to the cultural pressure toward dextrality or due to the unknown reasons (Annette, 1975).

2. Shift of Processing Hemisphere and Meaningful Linguistic Stimuli: A Model.

Based on the finings of other studies with sighted and the blind and those of the present study, the following “Shift of Processing Hemisphere” model is proposed.

The Model has four phases: Phase I, Phase II, Phase III and Phase IV.

Phase I:

The non-sense shapes indicate a right hemispheric processing when presented dicchaptically. This has been indicated by several studies (Witelson, 1974, 1976; Levy and Reid, 1976).

Phase II:

It is presumed that the geometric shapes, to certain extent, become meaningful. Hence, both spatial and linguistic analysis become necessary. However, the stress will be still on spatial nature. When these shapes are dichhaptically presented, there will be no difference in performances between the right and left hands to suggest the equal performance of both the hemispheres. But tendency will be more towards the right hemisphere.

Witelson and Gibson (1976), have reported no hand difference on a unilateral guided stimulation of a circle enclosing a dot using haptic modality to conclude that there was not difference between the hands to indicate equal performance of both the hemispheres.

Phase III;

Pairs of single letters when presented dicchaptically, indicate an involvement of both the hemispheres in processing with a tendency to the left. These letters do not become linguistically meaningful many a times. They will be partially linguistic and partially spatial in nature. However, the tendency is towards linguistic. Hence, as in the Phase II, equal involvement of both the hemispheres in processing them.

This has been indicated by a study (Witelson, 1974).

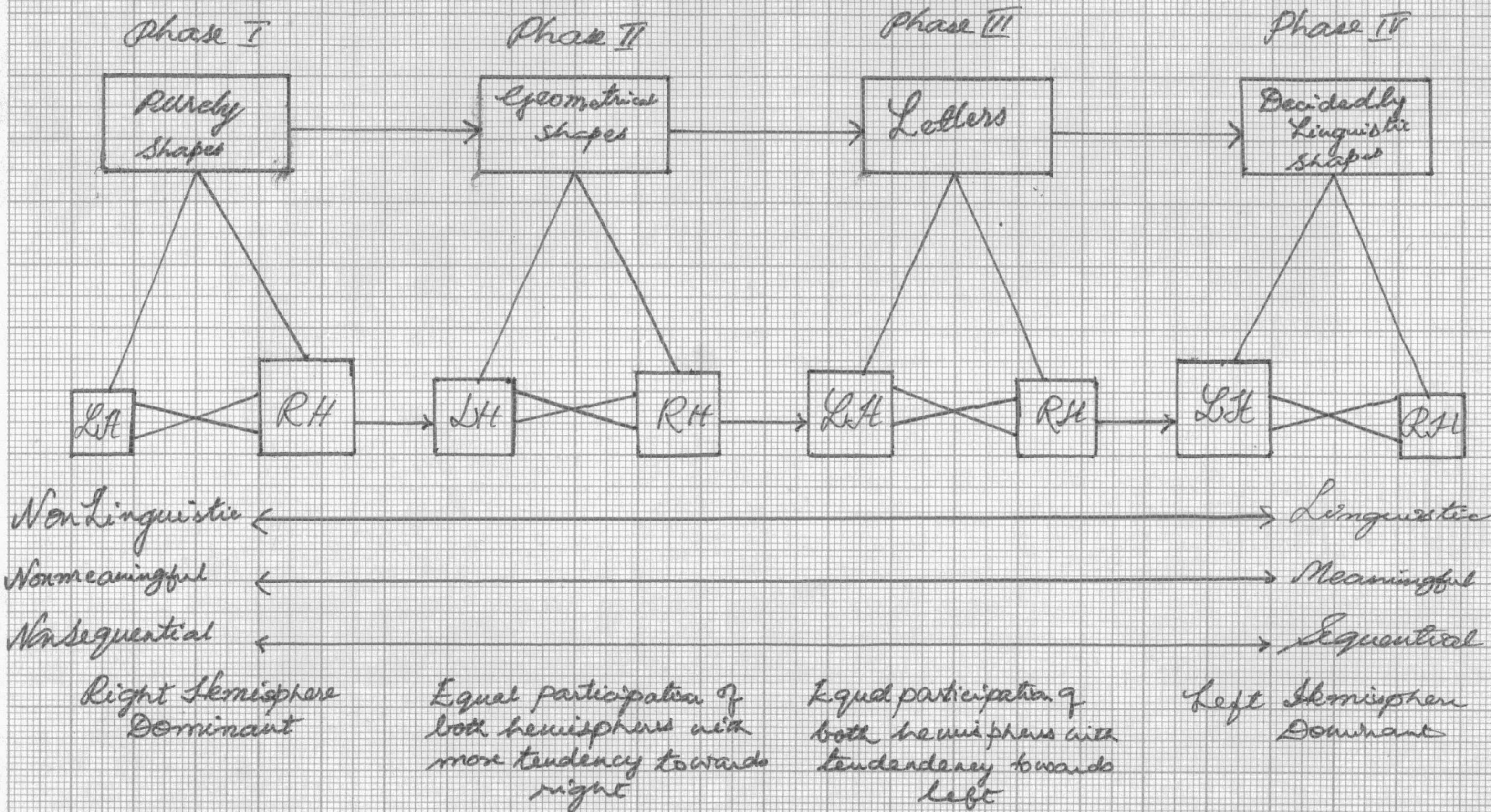
Phase IV:

Left hemisphere processing for decidedly linguistic meaningful stimuli.

It must be remembered that in right hemispheric dominant people, the reverse would be true, purely spatial are predominantly processed in left hemisphere and the decidedly linguistic in the right hemisphere.

If a normally non-linguistic, non-meaningful, non-sequential, spatial stimulus becomes linguistically – meaningful to an individual, the processing will shift to the linguistically dominant hemisphere.

In the present study, this phase has been confirmed by using Braille Dichhaptically with blind subjects. Nine of the ten subjects in the present study have shown an RHA on Dichhaptic Braille Reading task using Braille words. The RHA indicates a left hemispheric specialization for this spatial – linguistic ability. Subject 10, showed LHA, indicating processing for the Braille in his dominant (left) hemisphere.



"Shifting of Processing Hemisphere and Linguistic Meaningfulness"

MODEL

3. Right Hands better than Right Ears and Left Hands better than Left Ears on Competition:

On competition, the right hands performed better than the right ears and the same was true with the left hands and the left ears, in the present study. This was true with all the subjects.

Table P, shows the mean percentages of performances of the right hands and the right ears on the Dichhaptic Braille Reading and the Dichotic Listening tasks respectively. The difference of 17.42 percent was significant at 0.02 level of significance with a critical ratio of 2.69.

TABLE P

MODALITY	MEAN % GES	MEAN %GE DIFFERENCES	STANDARD DEVIATION	LEVEL OF SIGNIFICANCE
RIGHT HAND	67.16		11.18	
		17.14		0.02
RIGHT EAR	50.02		15.43	
		CRITICAL RATIO: 2.69		

Table showing the Mean Percentages, Mean percentage Difference, Standard Deviations, Critical ratio and level of significance of difference for the right hand and the right ear.

Table Q, shows the mean percentages of performances of the left hands and the left ears on the Dichhaptic Braille Reading and the Dichotic Listening Tasks, respectively. The difference of 21.03 percent was significant at 0.01 level of significance, with a critical ratio of 3.64.

TABLE Q

MODALITY	MEAN % GES	MEAN %GE DIFFERENCES	STANDARD DEVIATION	CRITICAL RATIO	LEVEL OF SIGNIFICANCE
LEFT HAND	51.44		13.09		
		21.43		3.64	0.01
LEFT EAR	30.01		11.87		

Table showing the Mean Percentages, Mean %ge difference, Standard Deviations, Critical ratio and level of significance of difference for the left hand and the left ear.

It is hypothesized:

a) that the better performance of the hands over the ears might be because the somesthetic mode is stronger than the auditory mode, in analyzing the stimulus material.

b) that the competition is more effective in the crossed auditory modality than in the crossed somesthetic modality.

c) that there might be presentation errors in the dichhapticity may not have been maintained as effectively as dichoticity.

4. Laterality and hand and Ear performances:

All the ten subjects in the present study reported right handedness. They reported that they used their right hands most frequently in routine activities and in writing Braille with stylus and stencil. The hand and the ear advantages on Dichhaptic Braille Reading and Dichotic Listening task respectively are shown in Table R.

Nine of the ten subjects, in the present study showed an RHA and an REA. Subject 10, though a right hander showed an LHA and an LEA. He falls in line with the two subjects with no familial sinistrality showing LEA, reported by Lake and Bryden 91976) in their study. He confirms the existence so the right hemispheric specialization in right handers.

It is concludable, that in a majority of the right handers the left hemisphere is specialized for processing of the meaningful linguistic stimuli. However, subjects with right hemispheric specialization and right handedness are also seen.

5. Hand Proficiency in Reading Braille and the Hand and the Ear Performances on Competition:

Nine of the ten subjects, in the present study reported a left hand proficiency in reading Braille. They reported that they read the Braille scripts in those hands faster and better than in their right hands.

The reported left hand proficiency in reading Braille by none of the ten subjects in the present study is in consonance with the subjects of the study by Hermelin and O’Conner (1971).

Hermelin and O’Conner (1971) reported that their subjects (blind) read Braille faster and more accurately with their left hands than the right. Based on their findings, they suggested that Braille is processed in the non-dominant hemisphere for language.

But Table R, shows that all the subjects who read Braille faster with their left hands showed an RHA and an REA. Subject 10, who reported and right hand proficiency, showed an LHA and an LEA.

TABLE R

SUBJECT	LATERALITY	HAND PROFICIENCY	HAND ADVANTAGE	EAR ADVANTAGE	SPECIALIZED HEMISPHERE
1.	Right	Left	RHA	REA	Left
2.	Right	Left	RHA	REA	Left
3.	Right	Left	RHA	REA	Left
4.	Right	Left	RHA	REA	Left
5.	Right	Left	RHA	REA	Left
6.	Right	Left	RHA	REA	Left
7.	Right	Left	RHA	REA	Left
8.	Right	Left	RHA	REA	Left
9.	Right	Left	RHA	REA	Left
10.	Right	Right	LHA	LEA	Right

Table showing Laterality, Hand Proficiency for Reading Braille, Hand Advantage on Dichhaptic Braille reading, Ear Advantage on Dichotic Listening and hemisphere Specialized for all the subjects.

In other words, the hand reported superior was ipsilateral to the hemisphere, which was dominant and which processed Braille in a dichhaptic task.

It is hypothesized that the ipsilateral somesthetic pathway becomes stronger in monhaptic Braille reading. This indicates a ipsilateral specialization for Braille reading.

To summarize, the following:

1. Spatial – linguistic materials are processed in the language dominant hemisphere.

2. The performance of the hands are better than the ears on competitive tasks.

3. In a majority of the right handers the left hemisphere is specialized for processing the meaningful linguistic stimuli. But, there can be subjects with right hemispheric specialization and right handedness.

4. shifting of the processing hemisphere depends upon the linguistic-meaningfulness and sequential characteristics of the given stimulus.

CHAPTER V: SUMMARY AND CONCLUSIONS

Ten congenitally totally blind male adults were administered Dichhaptic Braille Reading and Dichotic Listening Tasks. The performance of the hands on Dichhaptic Braille Reading were compared with the performances of the ears on Dichotic Listening. The study was to examine the hemispheric specialization for spatial – linguistic stimuli, such as Braille.

Nine of the ten subjects, showed an RHA and an REA on tasks involving simulations reception of stimuli by the right and the left. This suggested a Left hemisphere specialization both for spatial-linguistic and auditory linguistic meaningful stimuli.

One of the subjects, showed an LHA and an LEA indicating a Right hemisphere specialization for language in a right hander.

Performances of the right hands and the right ears indicated the better performance of the hands over the ears. The same was true with the left hands and the left ears.

It was hypothesized that it might have been either because the somesthetic modality was stronger than the auditory modality in analyzing the materials or because of the differences in the competition achieved in the pathways of both the modalities.

All the ten subjects reported right handedness. Nine of the ten subjects, indicated left hemispheric specialization for linguistic processing. One of the subjects, indicated a rare right hemispheric specialization for linguistic processing, eventhough he was a right hander.

Nine of the ten subjects reported a left hand proficiency in reading Braille and showed an RHA on Dichhaptic Braille Reading Task. One of the subjects reported right hand proficiency but showed an LHA.

It was hypothesized, that the ipsilateral pathways might become stronger in perceiving spatial – linguistic stimuli, such as Braille in the absence of competition from the other side.

Based on the findings, a model of “Shift of Processing Hemisphere and Meaningful Linguistic Stimuli” was proposed. The model indicated that the hemispheric specialization for a given stimuli is dependent upon the linguistic – meaningfulness of that particular stimuli.

Four phases of the model were described.

To conclude, the more linguistically meaningful the stimulus, the greater the specialization of the left hemisphere for that particular stimulus.

Limitations of the Present Study:

1. Only ten subjects were tested.

2. Only words were presented for both Dichhaptic Braille Reading and Dichotic Listening Tasks.

3. Tests were not administered to validate the Handedness and Hand Proficiency for want of time. The handedness and hand proficiency were based on the reports from the subjects and from observations.

Recommendations for Further Research:

1. The study can be repeated with more subjects.

2. The study can be carried out with the sinistral blind subjects to note the differences between the right and the left handers.

3. The blind subjects who have neuro – pathological histories can be studies. This may

help in constructing diagnostic tools based on Dichhaptic Braille Reading and Dichotic Listening Tasks.

4. The study can be repeated using Braille letters and sentences and shapes. This may provide further validation of the proposed model.

5. Studies can be done with children of different age groups, to note the age of establishment of hemispheric specialization for Braille.

6. Neurophysiological studies should be done using Braille as Stimuli both in monhaptic and dichhaptic conditions. This may help in testing the hypothesic, that the ispliateral pathways will be stronger in the Braille Reader under monhaptic conditions.

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