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INTRODUCTION

Man is a language using animal with skeletal structure and brain mechanisms specialized for language. It is know that language functions are, to a considerable extent, unilaterally represented in one or the other of the cerebral hemispheres, most commonly the left. This implies the existence of a special, localized neural mechanism in speech and language processing. Characteristics of this neural mechanism are not still clearly specified. Most studies of neural basis of language have dealt with higher level language functions and their dissolution. An alternative approach which may prove fruitful is to investigate the lower level language functions, that is, to focus on production and perception of speech sounds.

The cerebral hemisphere controlling speech is said to be the dominant hemisphere. Hughlings Jackson in the 19th century introduced the concept of a "leading hemisphere". Research has indicated that in normal right handers the left hemisphere processes linguistic symbols and the right hemisphere processes non-linguistic symbols. Localization of language to one hemisphere has been a characteristic feature of human communication.

The theory of cerebral dominance put forth by Orton (1927), which was later developed by Travis in 1931 said, that in stutterers, lack of cerebral dominance creates mistiming of impulses to the bilateral speech muscles and that produced stuttering. Their cerebral hemispheres were said to be symmetrical.

However, left side of the human brains seems to especially organized for speech and language functions (Penfield and Roberts, 1959) and is larger than the right side (Geschwind and Levitsky, 1968). A basis for this left-right brain asymmetries for speech and language, is found in the anatomy of the auditory system, and is further supported by physiological and behavioural studies.

The cochlear nerve enters the brain stem at the level of Pons and medulla, and synapse with the dorsal and ventral cochlear nuclei. Fibers from the ventral cochlear nucleus cross the to the opposite Olivary (superior) complex while a smaller number of fibers project to the Olivary complex on the same side. Fibers from the dorsal cochlear nucleus also cross to join secondary fibers from the Olivary complex to form the lateral lemniscus extending to the inferior colliculus, where there is another smaller decussation of fibers. The pathway then projects to the medial geniculate body at thalamic level, and thence to the primary auditory area (Area 41, 42) in the cerebral cortex. The crossed nature of the system is such that the majority of the fibers entering the primary auditory cortex carry information from the contraletral ear. On the left, fibers from Areas 41, 42 project to the association area (Area 21, 22) and enter

Area 39 in the temporoparietal cortex; the so-called speech and language center of the brain. Fibers from the right auditory pathway, carrying information from the left ear project to the auditory association area and reach the homologous Area 39 in the right cerebral hemisphere. From this are fibers cross the Corpus – Callosum to enter the speech and language center in the left hemisphere. Thus, anatomically, two slightly different channels from two ears exist which can carry different information to the cortical speech center.

The left hemisphere of the human brain is for talking. It is not that the right hemisphere is incapable of listening, or even of doing whatever the brain needs to do for talking, but rather that each of the hemispheres different with regard to the events to which it listens and possibly also the content each controls in talking. In the broadest sense, the differences between the hemispheres are along these lines. For almost all of us, whether we are right handed or being to the left minority, the left hemisphere processes the kind of auditory events which constitute speech and human utterance. The right hemisphere is the processor of music, of mechanical noises, and of the other environmental auditory non-speech events (Eisenson, 1969).

There are many methods for finding out dominant or leading hemisphere. For example, Handedness, Eyedness, Footedness, and studies with Sodium amytal tests.

Wada and Rasmussen (1960) used Sodium amytal, a chemical blocking agent of neural impulses, to determine hemispheric dominance for language. Unilateral Sodium amytal injection to the carotid artery, while maintaining a speech task, always caused right and left hemiplegic, alternately. The speech task was interrupted concurrently with left cerebral dominance for language.

Traumatic lesions to the head have also been used as a basis for napping language areas of the brain. Conrad (1954) found more aphasic tendencies in motor speech when there were left side lesions ON THE MARGIN OF THE CENTRAL Sulcus and frontally; amnesia and sensory sound organization difficulties were found with lesions in the parieto-occipital areas. Russel and Espir (1961) reported almost the same findings as Conrad (1954), and indicated that the majority of individuals were left hemispheric dominant regardless of hand preference. Even very early observations, made by Dax (1836) and Broca (1861) have also noted the relationship between the temporal lobe lesions and aphasia regardless of hand preference. The belief of right hemispheric dominance with left handed individuals was held for many years, till that belief was questioned by Penfield and Roberts (1959), Geschwind (1968), and many others.

Nilner (1962) assessed the differences between the right and left temporal lobe lesions with the Seashore Test of Musical Talents and found a significant error increase in tonal memory and rhythm pattern errors, in subjects with right temporal lobe lesions. The study indicated a greater activity of the right hemisphere in processing the non-linguistic acoustic stimulations.

In a study by Basser (1962) with two groups of children, one group with sustained brain lesions before speech onset and the other after speech onset, showed no essential difference in the course of speech development between the earlier group and normals. In the second group with sustained lesions after speech onset, eighty-five percent of the group with left hemispheric lesion and only forty-five percent of the group with right hemispheric lesions revealed speech disturbances. The study also indicated that, in early childhood lesions, speech functioning was eventually confined to the healthy side and caused no aphasia, but patients with lesions acquired in later life exhibited aphasia following left hemisphrectomy and minimal or no aphasia with right hemisphrectomy.

In Summary, it can be stated that there is:

a) Left hemispheric dominance for speech and language processing,
b) Right hemispheric dominance for non-language acoustic processing and
c) Larger left hemispheres in human brains.

However, evidence is not easily gathered from normal subjects with intact nervous system, the support the view that the language processes are lateralized in the dominant hemisphere and those are the mechanisms responsible for the perception of speech.

Recently a technique has been available to support the view to a larger extent. This technique is the “Dichotic Listening”. This psycho-physical technique developed by Broadbent (1954) has assessed the hemispheric dominance for speech and language for normals, identifying the dominant hemisphere. It has been taken, to a large extent, as a valid measure for hemispheric language dominance.

Definitions and Terminology:

Dichotic Listening: A task wherein two different messages are fed to two ears separately but simultaneously.

Laterality Effects: Refers to ear differences in intelligibility under the same dichotic listening conditions.

Lateralization: Refers to the preferred ear when differences occur.

Intelligibility: is the number of correct identifications of the dichotic stimulus.

Voiced Speech sounds are those whose onset occurs with periodic vibrations of the vocal cords.

Unvoiced Speech sounds have their onset occurring with noise.

Alignment in dichotic listening is the time relation between selected stimulus parameters across the two channels.

Boundary Alignment is the simultaneous occurrence of the large amplitude periodic portions of the two speech waves.

Verbal are those stimuli using language coded symbols.

Natural Speech generated and recorded from a human vocal tract.

Synthetic Speech generated digitally or by terminal analog synthesizers.

Non-Verbal refers to music, clicks, tones, environmental noises, formant glides, or transitions. etc.

REVIEW

When two different words / messages are presented simultaneously to a listener, one to each ear, most people perceive more of the right ear messages accurately.

The above effect was first reported by Broadbent (1954). Kimura (1964) indicated that this right ear advantage (REA) was due to the dominance of the left hemisphere for speech. When pairs of contrasting digits were presented simultaneously to right and left ears, those presented to the right were more accurately reported. This REA was attributed to the functional prepotency of the contralateral pathway from the right ear to language dominant left ear.

The higher score for the ear opposite the dominant hemisphere than for the ear ipsilateral to it, was evidence using electrophysiological studies with animals, suggesting that the crossed pathways of auditory system are stronger than the uncrossed (Rosenweig, 1951; Tunturi, 1946). The same has been held true for man (Bocca, Calearo, Cassinari, and Migliavacca, 1955; Sinha, 1959). “Thus each ear has connections with the auditory receiving area in each hemisphere, but the pathways connecting the cars to their opposite hemispheres are apparently more effective than the ipsilateral pathways” (Kimura, 1967).

If the speech were to be represented in the right hemisphere, the opposite pattern of ear superiority should have occurred, since the left ear has all the favoured connections, which can bring about a left ear advantage.

Berlin and McNeil (1976) have reported that “Since 1954, nearly 300 separate papers pertaining directly or indirectly to dichotic listening and hemispheric asymmetry have been published (Thompson, Thompson, and Lowe, 1974). Reviews of theoretical issues related to dichotic listening (Stoddert-Kennedy and Shankweiler, 1970; Berlin, 1971, 1972; Berlin and Lowe, 1972) are now available. . . .”

Berlin and McNeil (1976) have out-lined six theories on the nature of dichotic right ear advantage (REA). They have tried to attribute the nature of REA to the morphologic and functional asymmetry of the brain, to the selective attention, to a memory or storage model, to the vocal-tract-gesture-coding, to the perceived source of auditory space and to the temporal sequencing. The present paper also plans to outline these six theories based on the assumptions and work of Berlin and McNeil (1976).

Morphologic and Functional Asymmetry of the Brain and Right Ear Advantage:

Strong anatomic support for the position that most normal listeners are left-brained for speech and language comes from Geschwind and Levitsky (1968). Their views were based on the post-mortem examinations of 100 human brains, exposing the upper surface of the temporal lobe on each side by a cut made in the plane of sylvian Fissure. They concluded that the area behind the Heschl's gyrus was larger on the left side in sixty five percent of the Brains, and larger on the right side in only eleven percent. The plenum temporal was, on the average, one third longer on the left side than on the right side. The area in question involves the auditory association areas classically called Wernicke's area, in the temporal convolution, known to be of major importance in language function. This area makes up a lager part of the temporal speech cortex. Geschwind and Levitsky (1968), have confirmed anatomic asymmetries which correlate with the dominance of the left hemisphere for speech and language function. the authors quite aware of the weakness of the non-availability of the data of language, speech, hearing, and handedness with their subjects, argue that, since about ninety three percent of the adult population are right handed and ninety six percent are left-brained for speech, it is reasonable to assume that their 100 subjects might have consisted primarily of those who were left-brained for speech (Berlin and McNeil, 1976).

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The left hemisphere dominance for speech becomes evident following an intracarotid amytal injection (Penfield and Roberts, 1959). The amytal usually disbles the portion of the cotext, producing a speech loss in conjunction with the right hemiparesis. Many other studies of similar nature have highlighted the nature of functional brain asymmetry in human beings with Convincing nature (Eg. Wada and Rasmussen, 1960; Milner, Taylor, and Sperry, 1968).

Milner, Taylor and Sperry (1968) observed the patients with midline section of the corpus callosum on competing number tasks and fond that patients had virtually no perception of speech in left ear in the dichotic mode, but they observed an 100% perception in both ears when they tested the ears individually. With the help of this simple technique, it can be concluded that while the right and left hemispheres have similarity in function, speech perception or expression, or both, are related predominantly to the left hemisphere (Berlin and McNeil, 1976).

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Selective Attention and Dichotic Right Ear Advantage:

Broadbent (1954), in his original description of dichotic listening performance, felt that his subjects were unable to process two incoming stimuli simultaneously, and they were alternating their attention from one channel to another at extremely fast rates. He noted that information fed to the right ear of ten elicited the first response; his conclusion then was that the normal listener could well have a response bias toward speech signals sent to the right ear (Berlin and McNeil, 1976).

Many other studies, which have studied the effect of selective listening and strategies on dichotic REA's, asking their subjects to listen selectively to one channel, found altered both the size and direction of REA. Cherry (1953), Moray (1959), Deutsch and Deutsch (1963), Triesman (1964), Deutsch, Deutsch, and Lindsay (1967), Triesman and Geffen (1968), Wilson, Dirks, and Cartelette (1968), Triesman (1960), Triesman and Riley (1969) and Gerber and Goldman (1971) are among those studies.

Berlin and McNeil (1976) added "This apparent supremacy of the right ear in dichotic listening cannot be ascribed solely to superior selective attention to one channel over another; we need additional information on why one channel seem to be able "to attend more closely" to speech information while the other channel seems "to attend more naturally" to non-speech acoustic information".

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A memory or storage model and Dichotic right ear advantage:

Studies by Kimura (1961) and Milner (1962), have reported that patients with left temporal lobe lesions have poorer verbal recall, while the poorer musical pattern recall has been attributed to the lesions of the right. They have also reported an increase in REA by lengthening the dichotic messages. Bakker (1970) has demonstrated that there was a superior right ear performance in a monaural listening task when the recall task was made long enough or complex enough with more time intervals.

There are many other studies which have studied the effect of memory or recall on the REA. (Darwin, 1969; Day, Bartelette, and Cutting, 1973; Yeni-Komshian, Gordon, and Sherman, 1973; Porter, MacCormick, and Guillory, 1974, Gallagher, Tobey, Cullen, and Rampp, 1976).

Day, Bartelette, and Cutting (1973) reported an excellent performance on segregation of item presented in rapid succession by both class report and ear report methods. They reported that there was an excellent performance as long as all the speech sounds went to one ear and non-speech went to the other. However, the ear report dropped substantially when speech and non-speech stimuli switched between ears, with maintenance of excellent performance in class report method.

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Yeni-Komshian, Cordon and Sherman (1973) examined the effects of the memory load on the REA by varying the time interval between stimulus presentation. The results pronounced a REA on a free ear order recall task and cued conditions as to which ear to report from, but this was not pronounced in experiments with larger delay conditions. They also found an increase in the accuracy of the left ear scores while the right ear scores remained the same by reducing memory load, by providing the subject with a chart listing all the stimuli. The right ear scores remained the same at both chart and no chart conditions. They concluded that the REA is not solely a perceptual phenomenon, but that the recall of verbal materials is lateralized and complements the perceptual asymmetry.

Darwin (1969) reported that the steady state fricatives, whether isolated or followed abruptly by a vowel were recalled equally well from either ear. But when appropriate transition was added, there was an improvement in recall from the right ear with no improvement in the left. This advantage for right ear remained when the fricative was removed but the transition left intact to give a stop-like sound. They add that the REA for recall of dichotically presented initial stops has been confirmed and a similar advantage found for release and unreleased final stops with the later influenced by the relative onset times of the preceding vowels within a dichotic pair. However, by contrast, no preference for either ear could be found in recall for isolated vowels of the same durations, as the stop transitions. “These results indicated that speech sounds only give an advantage for the right ear in a dichotic listening task when they contain formant transitions”.

Porter, McCormick, and Guillory (1974) report that even though the different tasks any implicate or reveal lateralization mechanism in different ways, an obvious difference between the two types of tasks, for example, is the presence of a memory component in the list recall situation. In comparison to the single – trialed type test, the presence of this memory component may influence observed laterality difference either indirectly by reducing overall identification performance or, more directly, by implicating language processing mechanisms which are lateralized differently than those involved in single trailed tasks

The first study by Porter, McCormick, and Guillory (1974) has evaluated the influence of memory factors by comparing the subjects’ performance on two tasks which differed in terms of the presence or absence of a delayed recall component, revealed a significant overall REA with singles (example, ba, da, ga) as compared to triplets which showed a significant “Serial Position Effect” showing a tendency toward a REA at different serial positions but not reaching a significance. They did find a effect over the results when there was an order of presentations task, stating either singles first, or triplets first

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and it was attributed to an overall higher performance as both left and right ear signals in whatever task the subjects happened to experience second. When the singles were experienced first, performance on both ears tended to be lower than singles were presented second.

In their second study (Porter, McCormick and Guillory, 1974) the subjects received monaural practice on singles and triplets. The subjects revealed significant REA's for both singles and triplets, and also revealed no significant serial position effects.

They (Porter, McCormick and Guillory, 1974) conclude that triplets presentation appeared to reduce overall performance on the CV pairs. The practice manipulations appeared to eliminate a serial position effect for the right ear and increase its performance by leaving the left ear scores unaffected. The order of presentation effects have overall poorer performance and smaller REA's in subjects who had the triplets first than those subjects who had the triplets second. They found a relatively stable right-left difference of 8% to 12% in all conditions, inspite of overall performance changing with accompanied monaural practice and dichotic experience.

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The study has an important implication for certain areas in research; in testing the children or subjects who are suspected of having different degrees of laterality or different speech processing abilities than normal adults, because such subjects may tend to have different speech processing abilities and memory capabilities which tend to obscure or attenuate ear difference in a dichotic task requiring list recall. "In fact, the involvement of memory for other factors may help to account for the contrastive pictures of developing laterality which are provided by single trial dichotic tasks on the one hand and dichotic-list type tasks on the other (porter and Berlin)" (Porter, McCormick and Guillory, 1974).

A recalling task of digits and CV stimuli which were administered by live-voice at a rate of 2 / second with two groups, one with clinically measured auditory processing deficits and other being normal children, revealed a depressed performance in the earlier, with an essentially identical memory processes displaying primary and recency effects in recalling digits. (Gallagher, Tobey, Cullen and Rampp, 1976).

Crowder (1973) has reported a recency effect in the recall of CV's, if the syllables of the series differed on vowels like /bi/, /bu/, etc. This effect in the recalling of CV/s was absent when the syllables contrasted on the initial stop consonant like /ba/, /da/ etc. This may be due to the categorical and continuous modes of processing reflected in differences in consonants (Categorical) and Vowels (continuous) discrimination. This categorical and continuous discrimination plays very important role in the retrieval of auditory information (Pisoni, 1974). Pisoni (1974) implied to prerequisites for auditory information retrieval. First being that the inputting of the signal should be without interference and the information should be of retrieval in nature.

However, the area needs a through research to explain adequately the effects of memory over REA and their relationship.

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Vocal Tract Gesture Coding and Dichotic REA:

Berlin, Lowe-Bell, Cullen, Thompson, and Loovis (1973) suggested that the REA's in 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.

Study of the evolution of the vocal tract in relation to the physiological requirements producing the sounds of speech suggests that the man has evolved special structures for speech production and has not simply appropriated existing structures designed for eating and breathing (Lieberman, 1968; Lieberman, Klatt, and Wilson, 1969). One may reasonably suppose that, he has also evolved matching mechanisms for speech perception. There is, infact, much evidence that speech perception entails peculiar processes distinct from those of non-speech auditory perception (Stoddert-Kennedy and Shankweiler, 1969)

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 tongue 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 stimulation of speech the tongue functioned better in working with the right ear than with the left ear. Such asymmetry was not revealed when the right hand was used. Sussman, MacNeilage and Lumbley (1973) have reported the similar effect as reported by Sussman (1971) using the jaw as a tracker.

Works of Milner (1962), Cheney and Webster (1966), and Shankweiler (1966) report a left-t ear superiority with melodic signals implying a right hemispheric dominance.

However, Berlin, Lowe-Bell, Cullen, Thompson, and Loovis (1973) try to explain the asymmetry found by Sussman (1971) on the basis of proximity between the left hemisphere auditory areas and the control centers for the movements of the Vocal Tract. They add that the proximity of the tongue and larynx areas in the left hemisphere 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.

Many studies have established a relationship between dichotic REA's and the presence or absence of perceived sequential vocal tract gestures. Shankweiler and Studdert-Kennedy ( ) found little REA for steady state vowels. Weiss and House (1971) revealed REA's for vowels in a consonantal context in their study which was interpreted to mean vowels "surrounded by transitions or acoustic correlates of vocal tract adjustments towards a given target."

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The interpretation of Sussman's work (1971) led one to hypothesize 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, 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…."

Papcun, Krashen, and Terbeek (1972) presented Norse code signals dichotically to Morse code operators and to subjects who did not know Morse code. Morse code operators showed REA indicating left hemispheric dominance for the perception of dichotically presented Morse code. Naïve subjects showed REA, indicating left hemisphere dominance (same as Morse code operators) when presented with a set of dot – dash patterns restricted to pairs of seven or fewer elements, counting each dot and dash as an element. But when presented with a list that contained longer stimuli naïve subjects showed left ear superiority, indicating a right hemisphere dominance. They hypothesize that pairs consisting of the "magical" number seven of fewer elements are perceived with reference to sub-parts, of which they are composed, but that longer stimuli force naïve subjects to adopt strategies involving the holistic qualities of the stimuli. Consideration of these findings in the light of other literature suggests that language is lateralized to the left hemisphere because of its dependence on segmental sub-parts and this dependence characterizes language perception as distinct from most other human perceptions. The lateralization of these Morse codes to the left hemisphere has been attributed to the translation of signals with rapidity into equivalents of vocal tract gestures by Berlin, Lowe-Bell, Cullen, Thompson and Loovis (1973).

Sussman, MacNeilage and Lubbley (1973) have also reported the above effects using jaw as a tracker.

There are some special conditions related to vocal tract motions, where the REA can be demonstrated without placing one's ears in a competitive situation. Abbs and Smith (1970) reported that delayed auditory feed back to the right ear was more critical, influencing the speech production than that of left ear. Their study was based on the assumption that externally produced speech could be perceived by the same system that a listener uses to monitor and perceive self-product speech.

Berlin, Porter, Lowe-Bell, Berlin, Thompson and Hughes (1973) have shown 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.

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Keeping the studies including that of Kimura (1964) reporting left ear advantage for melodies and non-verbal acoustic stimuli and studies reporting REA for the same stimuli in mind, it is possible to conclude paving way to further research about the notion 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." (Berlin, Lowe-Bell, Cullen, Thompson and Loovis, 1973).

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The perceived source of auditory space and right ear advantage:

Fodor and Bever (1965) revealed an earlier perception of clicks in the left ear than in the right ear by their subjects when they were asked to locate the position of click with respect to an ongoing sentence.

Berlin and McNeil (1976) attribute the above effect to a more efficient left-ear-to-right-hemisphere route processing non-verbal signals. However, the relative accuracy of the click placements was the same for either right click or the left click condition; it was the tendency of the left click condition to generate a perception of location earlier in the sentence than the right clicks, which led Bertelson and Tisseyre (1972) to an unusual but important set of experiments on the nature of this asymmetry. The first experiment in their four experiments, replicated the finings of Fodor and Bever (1965) closely, but not exactly (Berlin and McNeil, 1976).

Bertelson and Tisseyre (1972) attributed the effect to the place of origin of click or speech, which led them to design an experiment where the speech or clicks were given to the midline binaurally, at equal sensation levels, while the other stimulus was in either the left, the right, or in the midline, revealing that the click seem to come from a position to the left of the speech which tended an earlier location, not meaning more accurately,

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in the subjects when the speech was presented to the right ear and the click to the midline.

The above findings, again led Bertelson and Tisseyre (1972) to a third experiment where in full-head and half-head separation listening condition were created, in which the speech was clearly in one ear while the click in the other and the speech or click in the midline while the other stimulus was in one ear alone, respectively. A large asymmetry was revealed due to the perception of clicks to the left of the speech under full-head separations then in half-head separations. This finding led them to a fourth experiment with a double monotic condition where in both speech and click were presented to the mid-line revealing again the earlier perception of clicks coming form the left of the speech generating a more early perceptions than when the click was either to the right or seemed to come from the same source as the speech (Berlin and McNeil, 1976).

Bertelson and Tisseyre (1972) quite correctly pointed out that there was not enough data to relate the perceptual click asymmetry effect to the REA for speech; they suggested that it is doubtful that a single mechanism might explain both the REA for speech and the phenomenon they studied. Nevertheless, it is a provocative notion that the perceived temporal position of a stimulus is related to the position in space from which one believe the signal is coming. Such an observation needs more attention vis a vis dichotic listening.

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The large REA's experienced by Morse code operations for dichotically presented Morse code (Papcun, Krashner, and Terbeek, 1972) has been attributed to a general superiority of the left temporal lobe in handling temporal sequences (Berlin and McNeil, 1976).

Efron (1963) believed an active role of temporal lobe in processing all temporal sequences. Jerger, Weikers, Sharbrough, and Jerger (1969) reported poorer performance for temporal sequence judgment in both ears in a patient with bilateral temporal lobe involvement, with an ear asymmetry for most auditory tasks.

However, there is a dichotomy between two ears in the perception of verbal and non-verbal inputs which is not unequivocal. A left ear advantage has been reported in subjects attending to the nonverbal properties, like pitch and loudness variations of dichotic verbal output or in identifying the vowels in a non-verbal context (Nachshon, 1970; Spellacy and Blumstein, 1970). That is, the non-verbal aspects of verbal input are attended 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 an important sequential character (Lashley, 1961; Neff, 1964; Hirsh, 1967).

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Based on the study by Papcun, Krashen and Terbeek (1972), it is possible to assume a mediation of left hemisphere for sequentially patterned nonverbal sounds. The tasks involving sequential analysis of stimuli seem to be controlled by the left hemisphere. This assumption has the evidence derived from both clinical and experimental, studies showing that lesions of the left hemisphere selectively impair the perception of sequential visual and audio-visual stimuli (Efron, 1963; Goldman, Lodge, Hamma, Semmes and Mishkin, 1968; Cormon, 1971; Cormon and Nachshon, 1971), and that judgment of simultaneity of visual and tactual stimuli by normal subjects is similarly mediated by the left hemisphere (Efron, 1963).

Based on the above assumption Halperin, Nachshon and Cormon (1973) presented dichotic nonverbal stimuli with either two, one, or no frequency transitions between the stimuli with a sequential complexity, of frequency or of duration where the subjects were asked to identify the sets of sounds differing in sequential complexity. The number of frequency or duration transitions in a set of three sounds was defined as sequential complexity. The researchers expected that sequences with no transitions, in which all sounds were identical, to be more accurately identified by the left ear (Gordon, 1970), While the sets with sequential transitions to be identified by the right ear.

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Halperin, Nachson, and Carmon (1973) reported a left ear superiority in case of zero transition, similar to that of Gordon (1970) for between ears discrimination of pitch. A gradual shift from left ear to the right ear superiority was reported with increase in sequential complexity from one and then to two transitions, which is in accordance with the showing findings a significantly grater REA in perception of dichotic consonants which are more complexly encoded than vowels, than in perception of vowels (Studdert-Kennedy, Lieberman, Harris and Cooper, 1970).

Berlin and Lowe (1972) report that the left hemisphere may be active in organizing additional temporal order tasks, taking evidence from the reported difficulty in managing temporal sequences with two-click localization and lateralization tasks, filtered speech tasks in temporal lobe patients and aphasica.

However, before concluding one has to keep in his mind two studies by Schulhoff and Goodglass (1969) and Spreen, Spellacy and Reid (1970) who have demonstrated a left ear superiority in recognizing dichotic tonal sequences with normal subjects.

To conclude, the present paper thinks that the above theories should have some more concrete research to gain support keeping the contradictions found in between studies and by ruling them out.

SECTION- 2 LATERALITY EFFECTS IN DICHOTIC LISTENTING

Laterality effects refer to ear differences in intelligibility under the same dichotic conditions. These effects have been shown to be a function, under certain task difficult circumstances (Satz, Achenbach, Pattishall and Fennel, 1965; Bartz, Satz, and Fennel; 1967; Satz 1968), with a ceiling of very high- or low- over- all performance (Halwes, 1969).

The laterality effects for individual stop consonants and vowels, studied by Studdert-Kennedy and Shankweiler (1970) revealed an REA for the whole class of initial stop consonants with a weak and inconsistent lateralization for vowels in an arranged segregation of consonants and vowel, in an order of decreasing magnitude. They also found no relationship between laterality effects and item difficult with consonants arranged in rank of difficulty. They added that they did not find a difference in the degree of lateralization in feature perception, concluding that features were clearly and independently lateralized.

Studdert-Kennedy and Shankweiler (1970) account the laterality effect to the mechanisms of cerebral dominance and functional prepotency of the contralateral over the ipsilateral auditory pathways, suggested by Kimura (1961, 1964), with a strong corroborative support by Milner, Taylor and Sperry (1968), stating that cross-over of the pathways may account for a disadvantage or a loss to the cerebral hemispheres.

Broadly specifying the locus of loss, Studdert-Kennedy and Shankweiler (1970) assume "….that the controlateral pathways are equivalent, so that the two signals reach their respective hemispheres in equivalent states; there is, of course, ample opportunity for the signals to interact at sub-cortical levels, but presumably whatever loss such interaction may induce is induced equally on both signals. If we further assume that the two signals upon arrival in the dominant hemisphere are served by the same set of processors (…….), loss in the left ear signal must occur immediately before, during, or after transferred to the dominant hemisphere". In their study, they found evidence for this with a limited data revealing a general pattern of errors rather similar for the two ears, suggesting a differed degree of stress on left ear input, but the kind of stress was same for both ears. Similar findings have been reported by earlier study of speech perception through masking noise (Willer and Nicely, 1965; Singh, 1966).

Darwin (1969) found laterality effects with REA for format transitions which had no effect on the left ear. To conclude that, only the format transition cures are lateralized in dichotic listening, Darwin found an equal recall of steady state fricatives which were followed abruptly by a vowel, from either ear. He found an improvement in recall from the right ear with an addition of appropriate transition, REA was found to remain the same even with the removal of friction with transition left intact to give a stop-like sound. Darwin (1969) adds that speech sounds only give REA in a dichotic listening task when they contain format transition.

The study (Darwin, 1969) also suggests lateralizations of consonants are the independent lateralization of their component features. Any reduction in the laterality effect of one feature may lead to a reduction in the laterality effect of the consonants as a whole.

Trost, Shewan, Nathanson and Sant (1968) reported equal REA's for initial and final consonants in "natural" CVC syllables. Darwin (1969) reported strong REA for final consonants in dichotically presented synthetic VC syllables with format transitions. Studdert-Kennedy and Shankweiler (1970) reported REA for final consonants in "natural" speech stops.

The vowels embedded in a consonantal frame would show a greater REA than the synthetic steady-state vowels (Shankweiler and Studdert-Kennedy, 1967). However there seems to be little tendency toward to REA for the vowels. In short, the vowels display a weak, variable REA, and by this one distinguishes fowels from consonants for which a stronger REA is the rule, and also from musical and other non-speech sounds for which left ear is the rule (Kimura, 1964; Shankweiler, 1966; Chaney and Webster, 1965; Curry, 1967; Studdert-Kennedy and Shankweiler, 1970).

It is possible to push the vowels toward a non-speech left ear advantage by systematic manipulation of their spectral composition, musicalizing them, by reducing band-width of their formants and increasing their duration (Studdert-Kennedy and Shankweiler, 1970). But Darwin (1969) found no such effect by reducing the duration of vowels. He added that neither longer nor the shorter vowels show a significant ear advantage.

Darwin (1969), Heggard (1971) and Weiss and House (1973), have shown that a REA for vowels will manifest itself only when the listening condition is difficult.

In summary, laterality effect is the function under difficult dichotic listening tasks, due to the mechanisms of cerebral dominance and functional prepotency of the hemispheres. It seems to act differently for vowels and consonants because of their component features.

The trailing behind or lagging behind of a stimuli in terms of time in perception is called as "Lag Effect". Lowe (1970), and Lowe, Cullen, Thompson, Berlin, Kirkpatrich and Ryan (1970) varied the onset time between natural speech CV's upto 90 m.sec to 500m.sec, starting from 30 m.sec. The results showed a "trail" or "lag" effect in the 30 to 90 m.sec range agreeing with the findings of Studdert-Kennedy, Shankweiler and Schulman (1970). They found better identification of training syllable rather than the leading syllable in dichotic conditions. Berlin, Lowe-Bell, Cullen, Thompson and Loovis (1973) attributed this effect as due to a single left hemisphere speech processor being entered from two channels. This hypothetical processor requires a finite time of 30 – 90 m.sec to handle a CV accurately provided from another channel. Evidence for the above fact comes from Cherry and Taylor (1954). They found the speech perception was unaffected by short interaural time differences. They reported a continuous perception of speech signals by their subjects, even though, two dichotic channels were broken by 10 to 15 m.sec.

Dropping of intelligibility of speech syllables with an interruption of 50 -70 m.sec has been reported by studies of interrupted speech (Huggins, 1972; Gerber, 1972; Hopkinson, Bulger and Wang, 1972). This observation gives a strong basis to the suggestion made by Berlin, Lowe-Bell, Cullen, Thompson, and Loovis (1973), who observed overlapping of syllables in a range of 30 to 60m.sec and a gradual improvement in the perception of both lead and lag syllables with an interruption of 90, 180, 250 and 500m.sec. Hazemann, Oliver and Dupont (1969) and Happel (1972) suggested that * latency of * in less than 30msec, the responses recorded from the cortex ipsilateral to the side of stimulation arrived by way of corpus-callosum in the somato-sensory system. In contrast, long latency potentials were conveyed by the contralateral path. Thus a lag of 30msec or more to the left ear may take both ipsiolateral and contralateral information out of competition with the right ear information. The lag to the right ear can also be expected to improve it scores by virtue of freeing it from the suppression effects brought about by the left ear.

The effect of "switching" intrusion, or interruption is at peak at 30msec leading to a better perception of information of lag ears by suppressing performance at both ears. This lagging advantage is not seen in temporal lobectomees.

In summary, it can be said that the speech is processed for intelligibility due to the presence of lag effect which has been revealed in the above studies. The ears seem to perform better processing of signals when they are stimulated under a lag difference than at simultaneity.

SECTION -4 SIMULTANEITY AND DICHOTIC LISTENING

Simultaneity refers to the stimulation of ears with no switching intrusions in time bringing about a suppression in auditory pathways. The REA is the reflection of left hemisphere dominance in dichotic listening. It is expected that most people will show a greater REA for dichotic verbal tasks, because of the presence of a strong contralateral auditory pathway from the right ear to the left hemisphere.

Studdert-Kennedy and Shankweiler (1970) reported that not all the subjects showed a stronger REA for simultaneous dichotic listening task using CVC syllables. Similar finding was reported by Berlin, Lowe-Bell, Cullen, Thompson, and Loovis (1973) when they found that four of their twenty four subjects revealed a left ear advantage at simultaneity, using CV nonsense syllables. They also observed that the voiceless consonants were more intelligible than the voiced, especially in the voiced-voiceless pairs under simultaneity conditions. The voiced was found to become almost as intelligible as its voiceless counterpart when the voiced CV was trailed.

When normal listeners attend to a dichotic simultaneous speech there is a suppression in both auditory channels. That is, there is a 100% performance on monotic listening tasks, but a decrease in the performance of both the ears can be observed under dichotic simultaneous stimulation of both ears. The presence of an advantage in right ear over left ear in these tasks can be attributed to the efficient suppressing characteristics of the right ear over the left, in the competition.

Berlin, Lowe-Bell, Cullen, Thompson and Staffed in 1972, reported that the competition for a single hemisphere can take place, and they explained it on the basis of intensity difference between ears for speech. They found an improvement in the scores of unattenuated ears when the intensity of the speech was decreased in the competing ear. They found a REA even when the right ear was receiving the speech at 10 dB less intensity than at the left.

In summary, the simultaneity, that is, the simultaneous stimulation of both ears using different messages can bring about a suppression in both the auditory channels. Because of the presence of both the ear superiority for verbal tasks, a thorough investigation is advisable to expedite the definite effects of simultaneity over the ear performance. The area may also be able to throw some light on the ear performance of the stutterers, because even normals have presented a different performance on both dichotic simultaneity and lag effects. This may be able to add a new face to the stuttering faces already existing, by comparing the performance of stutterers performance with the normals performance on dichotic simultaneity and dichotic lag tasks. The stutterers may be able to show a dominance under the simultaneous dichotic stimulation with speech.

SECTION – 5 PHONETIC EFFECTS IN DICHOTIC LISTENING

The better perception of one consonant compared with the other consonant is called as phonetic effect in dichotic listening. Some consonants seem to elicit a better REA compared with other consonants. Lowe, Cullen, Berlin, Thompson, and Willett (1970) reported a more robust effect than REA in their study with 38 young male listeners. They found that the voiceless consonants were more intelligible than the voiced consonants, in an effort to determine the laterality effects for rhymed words in contrast with nonsense CV's. In a second experiment in the same study with 20 female listeners, they again found the better perception of voiceless consonants. They concluded that there was a difference in the perception of initially positioned voiced and invoiced consonants during dichotic listening tasks.

Hannah (1971) found unvoiced consonants more intelligible than the voiced. But it was not always true, in his study in an effort to find the effects of boundary slignments, place of articulation and voice onset time over the dichotic listening in 24 young female subjects using speech (synthetic) stimuli (CV's). He reported more intelligible identification of voiced items over unvoiced when either voice onset time or boundary alignment were simultaneous and onset trailed.

However this phonetic effect reported by Lowe, Cullen, Berlin, Thompson and Willett (1970) was well confirmed by Roeser, Johns, and price (1972). They said that the effect was so robust, if one were to systematically present voiceless consonants to left ear and voiced to the right during the dichotic listening task, the result would have shown a left ear advantage.

Berlin, Lowe-Bell, Cullen, Thompson and Loovis (1973) found that the voiceless consonants were more accurately identified than the voiced consonants regardless of the ear which perceived the voiceless. It amounts to say that the REA would have been overcome if the left ear was to receive the voiceless CV's when the voiced were in the right. They stated "Neither the phoneme pairs nor the voiced-voiceless effects interacted with either REA or the lag effect. The unvoiced consonants maintained essentially uniform intelligibility throughout 0 – 90msec experiment. The voiced consonants when competing with the unvoiced, did poorly with the invoiced, did poorly at simultaneity, but became more intelligible as the time separation."

The velars (Ka & ga) are found to be reported more correctly followed by the bilabials (pa and ba) and the apicals (ta & da) with least correctness.

In conclusion, an elaborative expeditory research seem to be necessary for confirming the phonetic effect to know its role in dichotic listening with different variation in the presentation of same consonant. That is, to establish the effects of consonant features variation of single consonant, by presenting one component feature to one ear while the other being presented to the other.

SECTION – 6 VOCALIC EFFECTS IN DICHOTIC LISTENING

Some vowels are found to be more accurately identified than the others irrespective of the ear which receive them. This process is called as "Vocalic Effect". It has been established that the right hemisphere processes the non-verbal acoustic stimuli and the left verbal (Kimura, 1961; Milner, 1962). Shankweiler and Studdert-Kennedy (1967) reported that consonants and vowels may be processed in grossly different locations. But evidence concerning the location of hemispheric processing of vowels, is found to be not conclusive (Chaney and Webster, 1966; Spellacy and Blumstein, 1970). However, Weiss and House (1973) attempted to demonstrate conditions under which vowels, as well as consonants, would lateralize to the right ear, demonstrating a left hemispheric dominance for the processing of all speech sounds with 13 listeners under dichotic listening tasks. The difference of 4 % to 8% between the ears of favour of right ear agreed with the differences for the speech materials other than the vowels by Bartz, Satz and Fennel (1967) and Wilson, Dirks and Carterrette (1968).

Weiss and House (1973) found a better identification of long vowels than the short vowels in both word and nonsense contexts. This difference as a function of vowel duration was not completely unexpected for them since, Pickett (1957) had reported that intelligibility of long vowels was better than that of short vowels.

When the responses to the various competitive pairs of vowels are examined, the more highly identified vowels are those usually described as being more intelligible in standard listening conditions. It has been found that /a/ was more successfully identified followed by /æ/ and that /e/ and /o/ hearing less correctly than /a/ and /æ/ but more correctly than /i/ and /u/. Similarly the examination of the short vowels reveals that /I/ and /U/ are identified more correctly than /I/ and /U/.

However, the gross differences in the identification of various vowels at an adverse signal-to-noise ratio conditions suggest that the errors made by the listeners should be studied because of the reminiscence characteristics of the vowels. Pickett (1957) pointed out that in poor listening conditions /i/ and/u/ were frequently confused with each other. This was true with the listeners of Weiss and House (1973).

In conclusion, it is necessary to expedite through research different psycho-acoustic parameters and vocalic parameters of vowels and their effects on dichotic listening tasks as there are very limited number of studies to evidence the site for hemispheric processing for vowels.

SECTION 7 EFFECTS OF VARYING INTENSITY ON DICHOTIC LISTENING

Berlin and Cullen (1975) reported that the absolute stimulus intelligibility as wellas the total number of the correct response, depended upon the speech material and the level of intensity at which it is presented.

Kirkpatrick and Ryan (1969) showed a REA which was held constant even when the left ear signal was 6 dB more intense than the right ear signal. Stafford (1971) reported a REA even when the speech to the left ear was 10dB more intense than the right. She varied the intensity in one ear keeping the signal in the other constant. She also reported a weakened score in the varied ear with an improved score in the unattenuated.

Dobie and Simmons (1971) showed the ear contralateral to a lesion performed more poorly despite intensity differences in favor of the poorer ear in a varied intensity dichotic task with brain damaged subjects. Roeser (1972) found REA for digits. CV's, and nonsense syllables presented dichotically at 10, 30, 50 and 70 dB SL with greatest difference occurring at 30 dB SL in normals. He found the decrease in REA only upto certain level with increasing intensity in the left ear, the REA was preserved even at the maximum 70dB SL level at left ear.

This asymmetry in favour of right ear as a function of intensity has been confirmed by the studies of Berlin, Lowe-Bell, Cullen, Thompson and Stafford (1972) and by Brady-Wood and Shankweiler (1973).

SECTION 8 EFFECTS OF SIGNAL-TO-NOISE RATIO IN DICHOTIC LISTENING

The S/N ratio affects the perception of dichotic speech stimuli as it does with the monaurally – or binaurally – presented speech stimuli (Berlin and Cullen, 1975). Berlin and Cullen (1975) reported a change in dichotic performance with a decrease in S/N ration from 30 dB to 0 dB in both channels. The REA remained the same as long as the S/N ratio remained equal in both channels of presentation, They also found that it was possible to obscure the REA by an altered S/N ratio of 12 dB difference in one channel.

Cullen, Thompson, Hughes, Berlin, and Samson (1974) reported that the total sum of the information processed by the dichotic listening task was roughly constant inspite of imbalanced S/N ratios.

Weiss and House (1973) presented their listeners with vowels in syllabic contexts at 0 and -10 dB S/N ratio condition to analyze their responses in terms of individual ears. They found 6% higher REA, on the average than the left ear in adverse condition (-10 S/N ratio) and also found no differences between ears in the more favourable listening condition (0 dB S/N ratio).

Berlin and McNeil (1976) reported that a monotically benign 18 dB signal-to-noise ratio in the right ear was sufficient to reduce its usual and expected advantage over the left ear.

SECTION- 9 EFECTS OF FREQEUNCY BANDWIDTH IN DICHOTIC LISTENING

In some of the above studies above, it is evident that some of the vowels were perceived better than others and some consonants were better perceived than the others (Shankweiler and Studdert-Kennedy, 1967; Weiss and House, 1973; Berlin, Lowe-Bell, Cullen, Thompson and Loovis, 1973). This has led to the concepts of vocalic and phonetic effects. These effects can be attributed to the effects of different varying frequency bandwidth of different vowels and consonants. Here we have to keep the study of Roeser, Johns and Price (1972) very much in our mind because the results may show a left ear advantage when presented with voiceless consonants to the left ear and voiced to the right.

Berlin and McNeil (1976) reported that the intelligibility of one channel can be decreased while the information transmitted in the other is increased, by reducing the frequency bandwidth. The out performance of right ears over left was observed when there was a high frequency cut off at 4000 Hz, followed by an equal ear performance when high frequency cut off was set at 3000 Hz and revealed a poorer performance of the right ear when frequency cut off was set at 200 Hz. The difference was found to be marked between the two channels, when the frequency was set at 1500Hz (Thompson, Samson, Cullen, and Hughes, 1974).

In conclusion, it may be interesting to conduct experiment to know what actually happens in the ear performance by presenting the same sound to both ears but spoken by different speakers. This may be able to throw some light on the frequency bandwidth perception in dichotic listening.

SECTION – 10 EFFECTS OF VARYING ONSET TIMES ON DICHOTIC LISTENING

In some of the above studies, it is observed that duration played an important role in the dichotic listening. That is, longer vowels were perceived better than the shorter vowel and a better performance when the duration was lengthened in the production of consonants (Weiss and House, 1973; Porter, McCornick, and Guillory, 1974; Darwin, 1969; Yeni-Komshian, Gordon, and Sherman, 1973; Bakker 1970; Day, Bartelette and Cutting, 1973; Crowder, 1973; Gallagher, Tobey, Cullen, and Rampp. 1976).

The concept of lag effect is mainly based on the onset times. The sounds having a later onset times seem to be perceived better than the sounds having the earlier on-set. This can be evidenced by the perception of unvoiced better and more intelligible than the voiced which have an earlier voice on set than the unvoiced (Kirstein, 1970; Studdert-Kennedy, Shankeweiler and Schulman, 1970; Berlin, Lowe-Bell, Cullen, Thompson and Loovis, 1973; Olsen, Noffsinger and Kurdzeil, 1973).

In general, it can be noted that the syllables arrived later, ie., having later onset times by 30 to 60 msec were better perceived than the syllables which arrived earlier. This may be because of the interruption of the later syllable when the earlier was being processed. This effect of temporality has thrown light on the performance of normal listeners and temporal lobe patients, the latter being unable to process this temporality.

SECTION – 11 EFFECTS OF MASKING IN DICHOTIC LISTENING

Different types of masking seem to have different types of effect on the performance of dichotic listening tasks (Samson, 1973; Cullen, Berlin, Thompson, Hughes, Berlin, and Samson, 1974; Berlin, Berlin, Hughes, and Dermody; 1976; Cullen, Berlin Berlin; 1975; Whittaker and Porter, 1976; Repp, 1975; Repp, 1976).

Samson (1973) reported significant differences in performance on dichotic listening tasks when the masking noise was introduced monaurally or binaurally. When she introduced a band-limited noise to one ear during dichotictests, there was linear suppression of the masked ear. She also reported a linear increase in performance in the unmasked ear. She used twenty-four right-handed adult female subjects. The presence of binaural husking showed a linear decrease in performance from – 18 S/N ratio to O S/N ration.

The slight REA observed is non-masked condition was also seen in monaural masking condition. The right ear performed consistently better in the binaural masking condition compared with the left. Unvoiced phonemes were perceived better than the voiced in monaural masking conditions, while the voiced better than invoiced in the binaural masking conditions.

Stafford (1971) observed a better performance of the right ear in monaural masking conditions in her study on intensity trade-off. The effect was attributed by her to the functions of single speech processor system.

Studdert-Kennedy and Shankweiler attributed the effect to left- hemispheric dominance when they observed slight REA's both at unmasked and binaural masking conditions.

Samson (1973) attributed the better perception of voiced phonemes during binaural masking condition than unvoiced as due to the information available in those phonemes. She said that it may be due the several affects information during masking that contained in the voiceless phonemes which contain more information then the voiced with redundant characteristics.

Above studies only reveal the effect of masking noise over the dichotic listening. But there are studies where consonants were masked using vowels (Repp, 1975), syllables masked by their format and fundamental frequencies (Repp, 1976; Whittaker and Porter, 1976).

Repp (1975) investigated the dichotic masking effects of vowel /a/ on CV syllables in an effort to find the CV masks in which the vowel was shortened and the effect of an isolated vowel mask. Hereported that the vowel exerted a clear masking effect, both when isolated and in CV context. The effect of less pronounced than the masking effect produced by consonants competing on CV. This difference, Repp (1975) said, may be due to the masking exertion by consonants on CV's at a central (phonetic) level, while vowel masking exertion was at a peripheral (auditory level). However, no studies seem to be thereto see the masking effect of one vowel over the other. It may be able to throw some light again in cases with temporal lobe lesions because of the peripheral masking characteristic of the vowels when compared with the central masking characteristics of the consonants.

SECTION -12 VARIATIONS OF AGE AND DICHOTIC LISTENING

The variations of age in dichotic listening can also be referred to as "Developmental Dichotic Listening". The area indicates the age at which the dichotic listening tasks show a hemispheric dominance for speech and language and how the changes occur in dichotic listening with the developmental changes with age and differences between the age groups.

Ingram (1975) reported that a right ear superiority was indicated on dichotic listening tasks at the age of as early as three years, suggestive of the left hemisphere dominance to certain extent for speech functions by that age. Japanese children showed a presumably left hemisphere dominance for speech by the age of as early as three with a right ear superiority, while the Canadian children acquired the same effects at the age of as early as four. This difference in age between Japanese and Canadian children can be attributed to the racial and socio-economical conditions those exist. Kimura (1967, 1963) had previously established that a REA appeared no later than the age of 6, for speech and language left hemispheric dominance, when she presented digits dichotically to her subjects.

Know and Kimura (1970) suggested that the cerebral localization for nonverbal stimuli was established by the age of 5 with a left ear score with their subjects between the ages of 5 and 8 years. The nonverbal environmental sounds were more correctly identified than the verbal. However, a number of verbal tasks demonstrated a REA. They attributed this to the established efficiency of the crossed pathways from the ear to the brain.

The above study demonstrate that the right and left hemisphere functional differentiation has begun by the age of 5. However, one has to keep the finings of Ingram (1975) also in mind.

Know and Kimura's (1970) study seem to get a strong support from Branch, Milner and Rasmussen (1964) suggesting that the lateralization of speech functions tends to transfer to the normally functioning right hemisphere when there were damages to the areas of the left hemisphere. This transfer takes place if there is damage to the language areas within the age of five. The speech function seem to remain in the same hemisphere (damaged), rather than shifting to the unaffected hemisphere.

Berlin and McNeil (1976) reported that the language skills as the children develop from the age of 5 to 13 can be reflected in the presence of REA suggesting the left hemispheric dominance. They do not believe that the changes in improvement can be reflected in the relative size of the REA. They observed a significant difference in the behavior of 5 and 7 year olds with 9, 11 and 13 year olds in the perception of voiced and unvoiced consonants. However the unvoiced consonant attended to be more intelligible than the voiced in the older age group as compared with the group of 5 and 7 year olds who demonstrated a reverse phenomenon, with no sex difference found in all the groups of children. Horning (1972) reported that the REA's for both elderly and young subjects were virtually identical. This, amounts to say that the children acquire the functional differences by the age of 5 and behave in the same manner as the elders behave for dichotic listening. However, the ability of the speech processor seem to correctly identify 2 simultaneous stimuli with increasing age.

SECTION 13 **DICHOTIC LISTENING, MUSIC AND OTHER NONVERBAL STIMULI**

It is a well established fact that the verbal stimuli are processed in the left hemisphere suggesting a REA and the non-verbal stimuli being processed in the right, indicating a left ear superiority for those stimuli (Kimura, 1961; Milner, 1962).

Milner reported that the tonal pattern perception was affected by right temporal lobectomy and intact with unilateral left temporal lobectomy patients. Shankweiler, (1966) found that the perception of dichotically presented melodies was selectively impaired in the right temporal lobectomy patients, whereas, the perception of digits was impaired in the cases with left temporal lobectomy. The study of Shankweiler (1966) seems to agree in total with Milner (1962) who used Seashore Test of Musical Talents for his study.

Kimura (1967) reported a significantly grater number of accurate identifications from the left ear than right in an identification task of dichotically presented melodies in 20 normal subjects. Eisenson (1969) indicated that the right hemisphere is the processor of non-verbal auditory stimuli, such as, musical tones and tonal patterns depending more on the right hemisphere activity.

Milner, Taylor and Sperry (1968) employed the dichotic listening technique to investigate the differential listening of right handed patients who had their two hemispheres disconnected in order to control intractable epilepsy. The subject were unable to report the verbal messages received by the left ear while different verbal stimuli were channelized simultaneously to the right ear. On the other hand, the same was true for the right ear to report non-verbal stimuli.

Van Lancker and Promkin (1973) reported that the tone words and consonants were better heard at the right ear with hums showing no ear preference in Thai speakers. But this was not reported with English speaking subjects where consonant words showed an unusual right ear advantage while tone words and hums did not revealing a racial difference.

Here, it is necessary to recall study by Papcun et. al., (1972) (cited under vocal tract gesture coding P.20). Consideration of the findings in the light of other literature on lateralization results, suggests that language is lateralized to the left hemispheres, because of its dependence on segmental sub-parts and that this dependence characterizes language perception as distinct from most other human perception.

Schulhoff and Goddglass (1969) have presented an orderly set of hypotheses, to study the interaction between the site of brain lesion and words, soue sequences or click stimuli. They anticipated a contralateral ear effect in normals with respect to dominant hemisphere, a decrement in performance at the contralateral ear in brain injured subjects, a bilateral decrement in performance for the recognition of words when left hemisphere is damaged and a decrement for musical tones when the right hemisphere is damaged. They studied three groups of subjects – one group with the ten subjects with right hemisphere damage, the other with the left hemisphere damage, and the third consisted of ten normal control subjects. The groups demonstrated the anticipated effects.

Cook (1973) studied the left and right hemisphere differences by presenting dichotic stimuli, in the form of music. He concluded that the number of musical phrases correctly recognized when presented to the left ear than those correctly recognized when presented to the right.

Blumstein and Cooper (1974) concluded that the right hemisphere is directly involved in the perception of intonation contours and that normal language involves the active participation of both cerebral hemispheres.

Berman et al (1974) believed that REA might be an artifact and it may some how develop because of the habit of listening first to the right ear, might be because of the factors related to the right handedness.

Spreen, et al (1970) studied the ability of 48 subjects to listen to musical stimuli dichotically to real left ear superiority. However, the size of the difference between cars tonal patterns and music decreased with the increasing length of the time interval during which the subjects had to keep two patterns stored in memory. This may be attributed to the adaptation of the stimuli by the ipsilateral hemisphere, because of practice.

The view of Spreen et al, (1970) canbe further supported by the study of Spellacy (1970). In his study, 64 subjects selected on the basic of REA in the recall of dichotically presented words were tested for the recognition of four kinds of dichotically presented nonverbal stimuli: music, timbre, frequency patterns, and temporal patterns. Recognition was tested following 5 sec and 12 sec intervals. He reported an left ear preference in the recognition of musical stimuli following the 5 sec interval, but found not ear differences in the remaining stimulus conditions.

There are many other studies reported in the back pages supporting the view of right hemispheric dominance for music and non-verbal stimuli. Keeping the strong left ear superiority for non-verbal stimuli in the mind, the masking effects on dichotic listening can be questioned to certain extent. That is, when the masking noise presented to the right care and its effects on REA, the masking noise may not have any effect on the REA under this condition. The controversy arises as to how the RE seem to be better for syllables under binaural masking conditions. These areas when related with masking may need much more research to support their stands.

SECTION 14 DICHOTIC LISTENING, DELAYED AUDITORY FEED BACK AND STUTTERING

The stutterers hemispheres are said to be symmetrical which leads to the lack of cerebral dominance creating a mistiming of motor impulses to the bilateral speech muscles, thus producing stuttering (Travis, 1936). In recent times, dichotic listening techniques have been used with normals and with stutterers for the purpose of finding a dominant or leading hemisphere.

Curry and Gregory (1959) conducted an experiment to study the performance of the stutterers on dichotic listening tasks, which were supposed to reflect cerebral dominance. Twenty stutterers and twenty non-stutterers were given one monotic listening task and three dichotic listening task, of which one was verbal and two were nonverbal. The non-stuttering adults showed, an expected tendency to do better with their right ear in the dichotic verbal tasks. The stutterers however, showed no significant laterality in favour of the left hemisphere.

The above results have been contradicted by Dorman and Porter (1975). In their study, sixteen right handed moderate to severe adult stutterers and twenty non-stuttering subjects were given dichotic nonsense syllable task to determine hemispheric specialization for speech. Both male and female stutterers evidenced REA's in syllabic identification similar in magnitude to those found in normals indicating no difference in cerebral speech lateralization between stutterers and non-stutterers.

Delayed auditory feed back as a dichotic listening task was used to find the laterality differences in auditory feedback control of speech in normals by Abbs and Smith (1970). In their study, 8 female subjects read 7 sentences under four conditions of delay of 0.0 secs, 0.1 secs, 0.2 secs, and 0.3 secs to each ear, at 90 dB SPL while at the same time the other ear received a masking noise of 85 db SPL.

Total speaking time and articulatory errors were noted down. There was no significant difference in total speaking time between delayed presentation to right ear and delayed presentation to the left ear. Articulatory errors indicated that, auditory delay in the right ear produced a significantly greater number of speech errors than delayed presentation to the left ear. These differences were found more at 0.2 sec and at0.3 sec delays. The result of this study support the finding that, the left hemisphere – right ear – processes linguistic symbols.

Parimala (1977) in her attempt to find the laterality effects of auditory feed back with 15 normals and 15 stutterers reported that the dichotic listening take can be used with DAF to evaluate cerebral dominance in normals and stutterers. She observed that the delay in right ear with normal auditory feed back to left ear produced significantly great number of speech errors than delay to left ear with normal auditory feed back to the right ear, showed a clear concept to left hemisphere dominance for speech in normals.

The study also noted, no significant difference in speech errors between two conditions, that is, right ear receiving delay and no delay in the left, and the vice-versa condition in stutterers. This showed the lack of clear cut dominance in stutterers.

Nandur (1976) developed a test to find out ear preference for music with dichotic stimuli. It had 13 events. In each event, one ear received a constant piece of tune and the other ear received the distorted version of the constant tune and two other distorted tunes, one at a time. Normals, stutterers and trained musicians were asked to find out, as to which one of the three distorted tunes resembled the constant tune in the other ear. The results indicated that there was significant difference between the two ears for the perception of music in normals, left ear scoring higher percentages which is indicative of right hemisphere dominance. Stutterers demonstrated no significant difference between ears, stating the fact that stutterers perform in a different manner compared to normals.

To conclude it should be noted that there are still contradictions exiting in the vast area of stuttering. The above studies are unable to resolve, why there is no stuttering in some left hander? Until the process of right-handedness and left-handedness exits a thorough conclusion in the area may not be possible. The studies with the normal right handers and normal left handers; and with stuttering right handers and stuttering left handers may be able to throw some light on the speech processes in stuttering.

Dichotic Listening in Dyslexic Children:

Sobatka (1973) studies 24 children with dyslexia, between the ages of 7 through 13. She owed essentially normal right ear advantages for both her normal group of subjects and dyslexic group, in a dichotic listening task using multiple string of digits tied together.

Berlin and McNeil (1976) reported that syllables were perceived better in some subjects and poorer in others.

This area again needs a thorough investigation as there are not enough studies to know what actually is the performance on the dichotic listening with great number of dyslexics.

Dichotic Listening in temporal lobe patients:

Dichotic listening has almost brought revolution in the area of diagnostic and clinical audiology. The patients those were unrecognized once, are now being recognized due to the availability of dichotic listening tasks.

Kimura (1961) used Broadbent’s (1954) dichotic format to study patients with temporal lobe lesions. She demonstrated the following results, when different digits were presented simultaneously to the two ears;

1. Unilateral lobectomy impaired the recognition of the digits arriving at the ear contralateral to the removal.
2. Overall efficiency, as measured by the total number of digits

but not by right temporal lobectomy. Patients with lesions in the left temporal lobe, before and after surgery, were inferior to those with lesions of the right temporal lobe.

Kimura (1961) interpreted these results to mean crossed auditory pathways and that these were more stronger and more numerous than the uncrossed auditory pathways.

Milner (1962) reported performance of subjects on the Seashore Measures of Musical Talents, stating that tonal pattern perception was affected by right temporal lobectomy but not the left.

Shankweiler (1966) reported that there was impairment of melodies with right temporal lobectomy, while the perception of digits was impaired in the left. Milner, Taylor and Sperry (1968) confirmed the same for verbal and nonverbal dichotic tasks inpatients who had their two hemispheres disconnected surgically.

For the study of shulhoff and Goodglass (1969) please refer back to section 13 p. 48.

Berlin (1976) suggested that the dichotic listening can be used as a more powerful tool inrevealing the lesions in either of the temporal lobe, corpus-calloosum, and /or the auditory areas of the thalamus, depending upon the performance of the REA in dichotic CV tasks.

Suggesting dichotic listening as diagnostic tool in evaluating the central auditory mechanism has been confirmed by many studies with similar attitudes to that of Berlin and his associates. Those are, by Cullen and Thompson (1974), Berlin and McNeil (1976), Berlin and Cullen (1975), Tobey, Cullen and Rampp (1976), Gallgher, Tobey, Cullen and Rampp (1976), Kimura (1967), Milner (1962), Milner, Taylor and Sperry (1968).

In conclusion, a) The right temporal lobe patients perform poorly on the nonverbal dichotic listening task, b) the left temporal lobe patients perform poorly on verbal dichotic listening task and c) that the dichotic listening can be utilized as a strong tool in the diagnostic and clinical audiology to evaluate the disorders in central auditory mechanisms.

SUMMARY AND CONCLUSIONS

1. Left hemisphere of the brain processes the verbal signals when presented dichotically. This can be seen because of the presence of REA for processing the verbal stimuli.
2. Right hemisphere of the brain process the nonverbal signals and music. Hence, there is a left era superiority for these stimuli.
3. The REA can be attributed to the morphological and functional asymmetry of the cerebral hemispheres.
4. The presence of REA can be said to be because of selective attention.
5. The presence of dichotic REA can also be attributed to the recalling ability of the subject for those stimuli.
6. The REA can be attributed to the presence of vocal-tract-gesture-coding for the nonverbal stimuli, where it is translated into equivalent of vocal tract gestures by rapid movements of the tongue, jaw trackers etc.
7. The REA can also be attributed to the perceived source of auditory space.
8. The REA can be said because of the general ability of the temporal lobe in handling temporal sequences.
9. Laterlity effects seemed to be the functions those bring about the intelligibility under difficult dichotic tasks.
10. The lag effects seems to play an important role in the intelligible perception of trailing syllables than the leading syllables in dichotic listening tasks.
11. The trailing syllables seem to be perceived better than the leading syllables.

12. The simultaneity seems to have an effect on dichotic listening, by suppressing the auditory pathways.
13. There seem to be better perception of unvoiced consonants than the voiced consonants contributing to a phonetic effect in dichotic listening.
14. The velars /ka/ and /ga/ are found to be perceived better than /pa/ and/ba/ followed by apicals /ta/ and /da/.
15. Some vowels are perceived better than the others.
16. Longer vowels seem to have a better perception then the shorter ones.
17. In perception of long vowels, /a/ has been most successfully identified followed by /æ/ with /e/ and/o/ hearing less correctly than /a/ and/æ/ but more successfully than /i/ and/u/.
18. In the perception of short vowels /   / and /   / are found to be more correctly identified than /I/ and /U/.
19. The variation in signal-to-noise ratio seems to vary the right ear performance but to a lesser extent when compared with the left.
20. The right ear seem to perform well than the left ear even when it receives a less intense signals than the left.
21. Different frequency bandwidths seem to have different effects on performance in dichotic listening.
22. The trailing syllable seems to be perceived more intelligibly than the leading. This may be due to the interruption of the trailing during the processing of the leading syllable.
23. The monaural masking during the dichotic listening seems to bring about a change in the performance of the masked ear because of near suppression.
24. The right ear consistently performs better under binaural masking conditions.

25. Under binaural masking conditions, voiced phonemes are perceived better than the unvoiced, but reverse holding true in monaural conditions.
26. Vowels seem to exert a clear masking on consonant syllables, but with less pronounced effects than the consonants competing on CV's.
27. No study seem to interrogate masking effects of one vowel the other, such studies may throw some light on temporal lobe lesion cases because of peripheral effects of the vowels. Comparing this with central level effects of the consonants may also throw some light on the function of central and peripheral auditory systems.
28. The functional differentiation of cerebral hemispheres seem to begin by the age of 5, with no sex difference.
29. Children below age of seven seem to perceive voiced consonants better than unvoiced, but with a shift to reverse, by the age of nine years.
30. Dichotic listening tasks can also be a carried out along with delayed auditory feed back.
31. There seems to no difference between the right and left ear performance in stutterers, both on verbal and nonverbal tasks, amounting to say that there is no difference between hemispheric performances. However, the area needs a through investigation.
32. There seems to be no difference in performance on dichotic digits between dyslexics and normals. This needs further research.
33. Patients with left temporal lobe lesions seem to perform poorly on verbal tasks with an impaired REA.
34. Patients with right temporal lobe lesions seem to perform poorer on dichotic nonverbal tasks with poor/impaired left ear superiority.
35. Finally, dichotic listening can be very effectively used as a strong diagnostic and clinical tool in evaluating the disorders of central auditory mechanisms.

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