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Are Tonal and Non-Tonal Languages Lateralized Differently in Bilingual Tonal Language Speakers?

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Abstract

Introduction

All languages use intonation to express emphasis, emotions but not every language uses tone to distinguish meaning. When this occurs, tones are equally important, as phonemes and they are referred to as "tonemes". Languages that make use of tonemes are called as "tonal languages". Research indicates varied results for the laterality effect using tonal stimuli compared to consistent right ear advantage (REA) for the non-tonal verbal stimuli. These findings cannot be generalized to tonal languages which are spoken in India which varies in many aspects compared to other tonal languages studied, hence an attempt has been done to study the laterality effects for Indian tonal language (Manipuri).

Aim

To investigate the lateralization of tonal and non-tonal languages in bilingual tonal language speakers using dichotic listening task.

Method

Test materials

72 English and 96 Manipuri words served as stimuli. Dichotic stimulus was prepared using

adobe audition software version-3. A total of 4Manipuri dichotic tracks (first track was for practice) and 3 English tracks were prepared where each track had 12 pairs of monosyllabic words.

Procedure

30 female subjects with mean age of 25 years participated in the study with normal speech-language and hearing ability with right handedness.Two tasks were carried out dichotic listening and free recall task of auditory capacity. The number of correct responses was scored and percentage was calculated.

Results

The scores obtained were subjected to statistical analysis using SPSS version10 software. Multiple paired sample't' test was used to compare mean scores of both the ears for English and Manipuri languages. Results of't' test in dichotic task showed that there was a significant difference between the scores of right and left ears for English with p value0.02 ($p<0.05$), but for the Manipuri language this difference was not appreciated with a significance value0.495 ($p<0.05$).The results for the free recall task clearly indicated high scores for stimuli presented through right ear ($p=0.000$)for English and in Manipuri there was no significant difference obtained for scores between both ears($p=0.604$).

Conclusion

Results of the present study clearly indicated REA for English and no specific ear advantage for Manipuri in both dichotic and free recall tasks. Findings support that language processing in left hemisphere especially for non-tonal languages. Equal scores for both ears for tonal language(Manipuri) can be attributed to participation of both hemispheres in processing tonal stimuli, which can be contributed to the participation of right hemisphere for processing the tonal aspects (contrast variations in pitch, durations and stress) of the language.

Key Words: Right ear advantage, dichotic listening task, auditory capacity.

Introduction

Tone refers to the use of pitch in language to distinguish words. All languages use intonation to express emphasis, emotions but not every language uses tone to distinguish meaning. When this occurs, tones are equally important, as phonemes and they are referred to as "tonemes." Languages that make use of tonemes are called as "Tonal Languages". In tonal language each syllable has an inherent pitch contour thus minimal pairs exist between syllables with the same segmental features but different tones, thus in a tonal language contrastive variations in pitch at the syllable or word level are used to distinguish the lexical meaning of words, and it is the distinguishing feature from a non-tonal language.

The tonal language is an important category of languages, which includes varied kinds of Chinese languages (such as Mandarin, Cantonese, Taiwanese), South-East Asia languages (such as Thai, Vietnamese), Swedish, and Norwegian. Most of the languages of South-East Asia and Africa are tonal languages. Compared with English and some other European languages, tonal languages have a unique but important property, tone information. Speech Recognition of tonal languages depends not only on the phonetic composition but also on the lexical tone pattern (Moen, I 1993). For example, in Chinese language, words with same syllable sequences but different tones have different meanings. So without tone information, the speech recognition accuracy will not be good, especially where tones are the only distinguishing features.

Specific language-related tasks like word production and comprehension always involve some portions of the human brain. Earlier accepted hypothesis was that only two classical parts of brain broca's and wernicke's areas deal with language. This was discarded with the evidence of involvement of other brain parts in language related tasks.The other hypothesis is that only left hemisphere is responsible for language. It is true that left hemisphere is dominating but the right hemisphere also finds role in language (Mundhra 2005)**.**

Dichotic listening is an effective and non-invasive means to study hemispheric laterality for speech perception. Several researchers documented the existence of a cerebral dominance effect in dichotic listening, indicating a pre-existing ear asymmetry in normal right-handed listeners in which the scores for Right ear were consistently higher than the scores for the Left ear (Broadbent 1954,Kimura and Bryden1961., Zenker. et al, 1972, Linda mood, et al. 1979).Dichotic listening has been a component of many auditory processing assessment protocols following the introduction of dichotic digits by Broadbent in 1954.

In Dichotic speech tests two different auditory stimuli will be presented to the two ears simultaneously. Right- handed subjects typically have a better response to stimuli presented to their right ear than to those presented to their left ear (Zenker. et al, 1972). This response pattern is called the Right Ear Advantage (REA) and is dependent upon the difficulty of the listening task. Dichotic speech tests can include a variety of stimuli such as: nonsense syllables, digits, monosyllabic words, spondaic words or sentences. Dichotic listening experiments have shown that different sorts of input show different ear preferences. Subjects with left-hemispheric language lateralization, which possibly constitute more than 95 percent of the population are more accurate in reporting items arriving at the right ear than items arriving at the left ear when the input is verbal (Linda mood, et al. 1979).

There are two explanations of these ear advantages in dichotic listening:

(1) The structural theory describes the advantages to anatomic properties of the auditory system. Kimura (1961) explains the right ear advantage for verbal stimulus by the fact that the right ear is connected to the language dominant left hemisphere of the brain and the left ear to the right hemisphere through the contra lateral pathways. She claims that the contralateral pathways are more preponderant than the ipsilateral pathways which constitute the link between the ear and the hemisphere on the same side.

(2) According to attentional theory by Kinsbourne (1970) laterality effect is due to lateralized cortical functions, but it also emphasizes the influence of attention in priming a particular hemisphere. An expectation of verbal stimuli, for instance serves to prime the language dominant hemisphere and make it extra sensitivity.

Current evidence indicates that neither of these two views, in their most extreme forms, is entirely correct. If attentional mechanisms were all that was relevant, then one would predict that it would not be possible to activate both the left and the right hemisphere simultaneously. According to Bryden (1963), however, one can obtain right ear advantages for verbal material and left ear advantages for non-verbal material at the same time. On the other hand, it is proven that attentional factors do make some difference; the same dichotic stimuli that produce an left ear advantage when one expects non-verbal stimuli, can produce a right ear advantage when one expect stimuli (Blumstein and Spellacy, 1970). It, therefore, seems that both structural and attentional components are relevant to the production of dichotic laterality effects.

Gandour (1956) reported that right hemisphere is engaged when prosodic functions span larger temporal domains such as clauses or sentences. In case of spoken language users, auditory speech processing activates right hemisphere. Morexcaux (1981) demonstrated electrophysiologic correlates of perceptual asymmetries for dichotic tasks using tonal stimuli in subjects who demonstrated the right ear advantage for verbal non-tonal dichotic stimuli but clear left ear advantage was observed for dichotically presented tonal stimuli. Similar study done by Best (1985), to evaluate the processing of tonal and non-tonal language syllables on perceptual laterality in speakers of Mandarin and English, and it was found that significant responses were more in right ear than left ear across both languages but right ear was significant for the English test and only marginally significant for Mandarin test.

In case of bilinguals, it was believed that all the languages (more than two languages also) are localized in the same cerebral areas (Mundhra, 2005). But this had a controversy. It is proved by some experiments that brain areas recruited for language 1 (primary language or the mother tongue) learning and processing are different from those recruited for language 2 (second language acquired). The anatomical separation of grammar and phonology in bilinguals varies according to age and manner of language acquisition. In early bilinguals (who adopted language 1 and language 2 from childhood) no exhibition of different areas for different languages was shown, while in late bilinguals (who adopted language 2 in adult age) language1's grammar and phonology motor maps.

Evans, et al. (2002) found that for participants from a dual language environment, both early and late acquisition of a second language resulted in a left hemispheric localization of language 2. Their data revealed increased right hemispheric involvement for later learned language 2 in a single language environment Francis, Desmond (1992) examined brain activation of bilinguals of English and Spanish language users. They found that the semantic activation for both the languages occurred in the same cortical location. They inferred that learning a new language, even after a decade, does not require the addition of a new semantic processing system or the recruitment of a new cortical region. Such evidences suggest a common cortical representation for language 1 and language 2 when levels of proficiency in both languages are comparable.

Need For the Study

Research indicates varied results for the laterality effect using tonal stimuli compared to consistent right ear advantage for the non-tonal verbal stimuli. These findings cannot be generalized to tonal languages which are spoken in India which varies in many aspects compared to other tonal languages studied. Hence an attempt has been done to study the laterality effects for Indian tonal language (Manipuri).

Aim of the Study

To investigate the lateralization of tonal and non tonal languages in bilingual tonal language speakers using dichotic listening task.

Objectives

1. To test the lateralization of tonal language (Manipuri).
2. To test the lateralization of non tonal language (English).

Method

Test Materials

For both Manipuri (tonal) and English stimuli a total of hundred (100 for each language) monosyllabic words were chosen from text books of 2nd-5th grade children. All the words were given for familiarity checking by native Manipuri speakers and a final list of seventy two (72) English and ninety-six (96) Manipuri words were made.

Dichotic Stimulus

All the words were recorded in sound treated room. A microphone SSD-HP 202 dynamic stereo mic 105dB/mV was mounted on a stand, the height of which was adjusted for the speaker, the mic was connected to a personal computer for recording. The recording was done using PRAAT software version 5.04 with a sampling frequency of 16 kHz. A native Manipuri female speaker was instructed to read the list of words as they could naturally speak.

Dichotic stimulus was prepared using adobe audition software version-3. The stimulus was edited so that the onset of the stimulus coincided; silent interval was given to the end of stimuli so as to equalize the duration. The stimulus was prepared with inter-stimulus duration of 500 ms (Strouse, C. et al., 2006). A total of 4 Manipuri dichotic tracks (first track was for practice) and 3 English tracks were prepared where each track had 12 pairs of monosyllabic words.

Subjects

A total of thirty (30) subjects were evaluated ranging in age from 20-25 years. Subject inclusion criteria are given below.

Inclusion criteria:

Normal hearing sensitivity (PTA less than or equal to 15 dB HL)
Native Manipuri speakers and using English as second language.
Fluent speakers of both Manipuri and English language.
Normal speech and language skills
No history of any neurological or motor deficits.
Right handedness

Instrumentation

The stimuli were stored and played using a computer. Stimuli were presented through Moser Baer headphone MB-390, which had a frequency response of 20Hz-20 kHz.

Procedure

A. Dichotic listening test

Instruction: Participants were instructed that they are going to listen to the stimulus presented in both ears simultaneously. In the first task they were asked to attend to the stimulus heard in the right ear while ignoring the stimulus heard in the left ear to find the scores of the right ear. Similarly after an interval (two days), again the stimulus were presented and the subjects were asked to concentrate to the stimulus heard in the left ear while ignoring the stimulus heard in the right ear and left ear responses were obtained. This was carried out for both English and Manipuri stimuli. Participants were asked to respond by repeating it back.

Scoring: Responses were audio taped and analyzed for correct responses of each ear in both conditions. The total number of correct responses was scored and percentage of correct responses was also calculated for each ear.

B. Auditory capacity

Instruction: This was a free recall task, in this first Manipuri stimuli were presented and the subjects were instructed to listen to the stimulus presented to both the ears simultaneously and they were asked to repeat back the words without any ear or sequence specifications. Similarly English stimuli were also presented and responses were recorded.

Scoring: The audio taped responses were analyzed for number of correct responses. The right and left ear responses were obtained from the total scores.

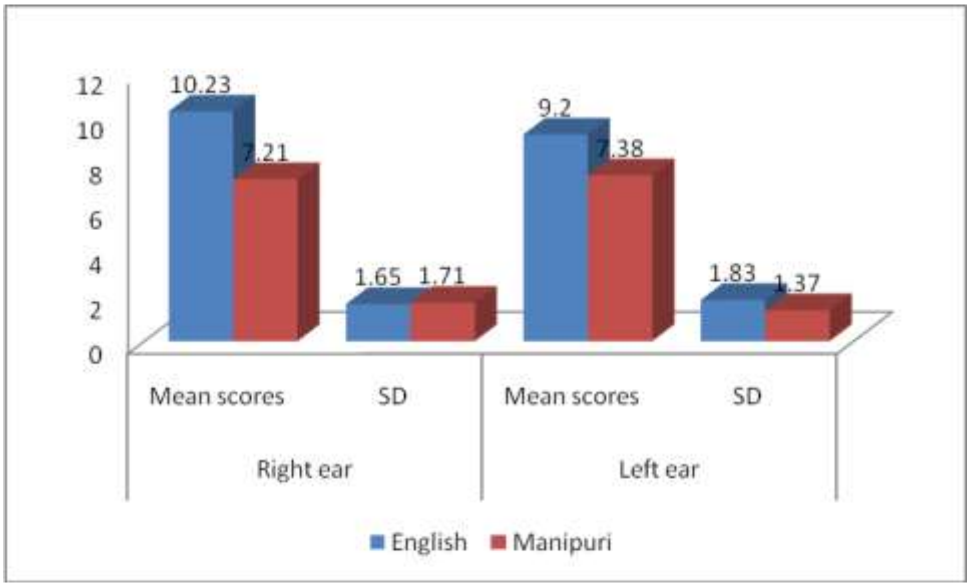
Results

The scores obtained were subjected to statistical analysis using SPSS version10 software. Mean and standard deviation was calculated for the scores obtained. Multiple paired sample't' test was used to compare mean scores of right and left ears for both English and Manipuri languages.

Table 1: Scores of dichotic listening task

	Right ear		**Left ear**		**p(significance)P<0.05**
	Mean scores	**SD**	**Mean scores**	**SD**	
English	10.23	1.65	9.20	1.83	0.02
Manipuri	7.21	1.71	7.38	1.37	0.495

Table 1 gives the mean scores of correct responses and standard deviation (SD) for the dichotic listening task for both Manipuri and English language where the maximum mean score that could be obtained was 12. Results of't' test in showed that there was a significant difference between the scores of right and left ears for English with p value 0.02 ($p<0.05$), but for the Manipuri language this difference was not appreciated with a significance value 0.495 ($p<0.05$). These values have been depicted in graph 1.



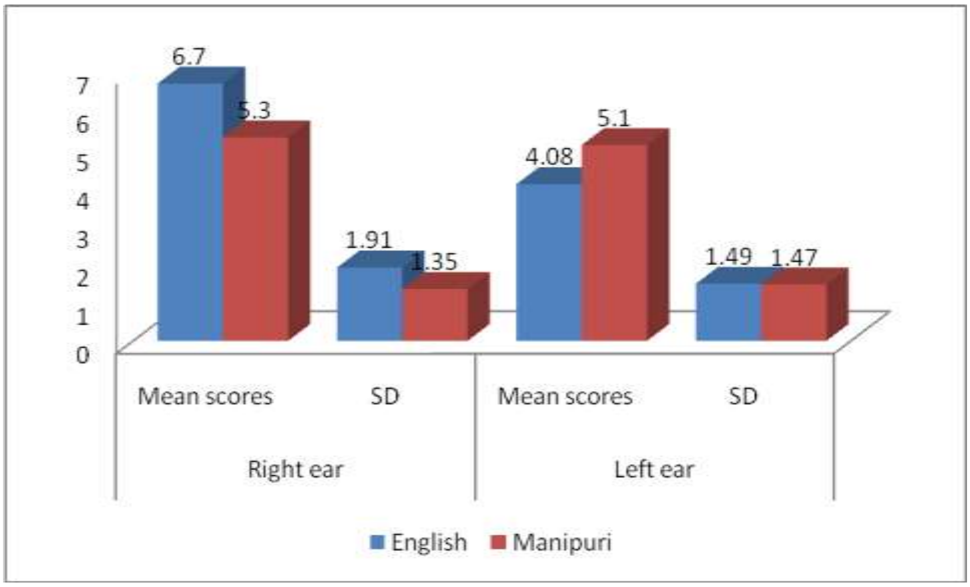
Graph1: Scores of dichotic listening task

The total correct score was obtained for auditory free recall task(auditory capacity), these scores were again analyzed for the responses given from the stimuli presented to left ear and right ear separately. Finally a list of right and left ear scores was obtained. Table 2 gives the mean and standard deviation for scores of the each ear from the results of the auditory capacity task. The results clearly indicated high scores for stimuli presented through right ear (p=0.000) for English and in Manipuri there was no significant difference obtained for scores between both ears(p=0.604). These values have been depicted in graph 2.

Table2: Scores of auditory capacity

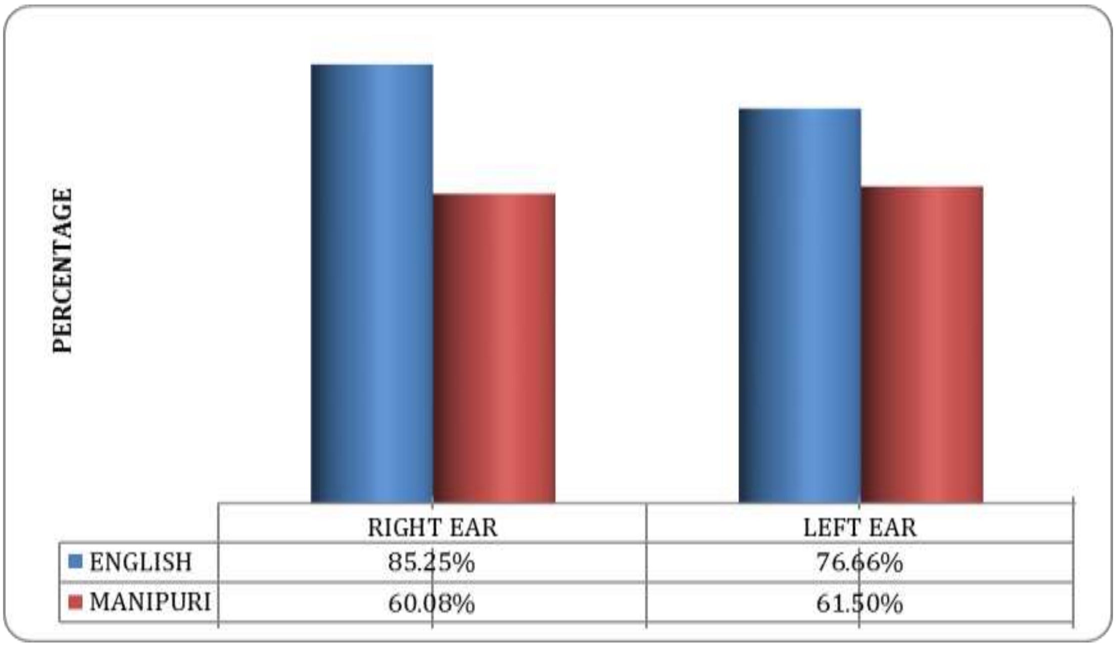
	Right ear		**Left ear**		**p(significance) P<0.05**
	Mean scores	**SD**	**Mean scores**	**SD**	
English	6.7	1.91	4.08	1.49	0.000

Manipuri	5.3	1.35	5.1	1.47	0.604



Graph2: Scores of auditory capacity

The percentage of correct responses was obtained for dichotic listening and auditory free recall task and the results have been depicted in the graph 3.



Graph3: Percentage scores of dichotic listening task

Discussion

Results of the present study clearly indicated right ear advantages for English indicating the processing of the presented stimuli in the left hemisphere. This finding is in consonance with the previous findings by several researchers who documented the existence of a cerebral dominance effect in dichotic listening, indicating ear asymmetry in normal right-handed listeners in which the scores for right ear were consistently higher than the scores for the Left ear (Broadbent 1954, Kimura and Bryden1961., Zenker. et al, 1972, Linda mood, et al. 1979).

No specific ear advantage was found for Manipuri which was a tonal language in both dichotic and free recall tasks. Equal scores for both ears for tonal language can be attributed to participation of both hemispheres in processing tonal stimuli. Similar results has been obtained by Gandour (1956) who stated that hemispheric lateralization depends on the relationship between the control of F0 and timing also the size of temporal domain over which prosodic patterns extend crucially which determines the way the signal is processed in the brain ,hence accounting the role of right hemisphere in language processing.

Although the results of the present study showed higher scores for the left ear for the tonal language stimuli, these differences were not statistically significant. These findings does not clearly support the notion that right hemisphere is dominant for processing for the tonal stimuli and hence does not completely support the precious findings of Morexcaux (1981), who demonstrated electrophysiologic correlates of perceptual asymmetries for dichotic tasks using tonal stimuli in subjects who demonstrated the right ear advantage for verbal non-tonal dichotic stimuli but clear left ear advantage for dichotically presented tonal stimuli. These differences in the results could be attributed to methodological differences, the acoustic properties of the tonal stimuli of different tonal languages. Future studies are indicated to understand these factors in Indian tonal languages.

Conclusion

The equal participation of both ears thus indicating equal participation of both hemispheres and lack of left hemisphere dominance for processing tonal language can be contributed to the participation of right hemisphere for processing the tonal aspects (contrast variations in pitch, durations and stress) of the language. Further research is indicated to study laterality effects in tonal language processing utilizing more sophisticated methods and correlating with the acoustic properties of tonal stimuli which calls the participation of right hemisphere.

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