Early Processing Research of Tibetan Two-syllable Words’ Tone in Lhasa

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Abstract. In this study, the tone of the Tibetan dialect in the pinyin language was taken as the research object. The experimental design is based on the Oddball paradigm stimulus sequence stimulated with tone 55. When the deviations stimuli tone 53, 13 and 114 are randomly presented in the sequence, the brain has a significant negative deflection in the ERP induced by the pre-attention phase deviation stimulus compared with the standard stimulation-induced ERP, and a larger mismatch negativity occurred in the left auditory cortex compared to the right, which is consistent with the results of studies on patients with impaired brain. That is to say, the vocabulary and tone processing shows the advantage of the left hemisphere.

1. Introduction

According to previous research, great progress has been made in the neural mechanism and hemispheric superiority of brain processing speech prosody information, but there is still much debate. First of all, in the research content, most of the previous studies combined tone and intonation. For example, Jackson Gandour (2004) confirmed that Chinese tones and intonations are nested in multiple regional asymmetries. Ren guqin et al. (2011) found that "intonation attached to second tone of Chinese character is only after filtering out the verbal information of the experimental stimulus, the words pitch and sentence pitch conditions will induce MMN". There is an interaction between vowel sound quality and affective prosody in accent (Tong et al.). Secondly, in the research object, previous studies mainly focused on the English, Spanish and other phonetic languages in Indo-European family, as well as the Chinese in Sino-Tibetan language family. However, there are few studies on the brain sensory processing of minority languages (especially Tibetan) in Sino-Tibetan language family. Thirdly, in terms of technology, most of the previous studies have adopted techniques such as FMRI or PET. Although they have high spatial resolution, their temporal resolution is relatively low, making it difficult to determine the impact of time variation. This study uses ERP technology and Oddball paradigm, focusing on different intonations, different tones, and different accents of two-syllables, and exploring the neural mechanisms and the hemisphere superiority of verbal rhythm information (tone, intonation and stress) of Tibetan Lhasa dialect in the pre-conscious processing stage.

2. Experimental Method

2.1. Experimental subjects
Ten Lhasa Tibetan college students (5 males and 5 females) were selected as subjects, whose native language was Tibetan, between 18 and 22 years old, normal hearing and no language defects or injuries.

2.2. Experimental design
In this study, single factor experimental design was adopted, and the independent variable was the comparison type. Among them, there are 4 levels of tone cognition, namely, tone55, 53, 13 and 114. There are 3 levels of intonation cognition, namely, statement tone, question tone, and exclamation tone; there are 4 levels of accented cognition: unaccented, first syllable stress, second syllable stress, and last syllable stress. Two groups of experiments were designed for each subject, the difference being that the order of stimulation presented was reversed.

2.3. Test paradigm
Stimulation sequences were programmed using the Odd-ball paradigm (Figure 2.4). The subject started the experiment after making a button reaction according to the prompt "Please press 1 to start". The corresponding time length of "+" appeared in the middle of the screen first (tone stimulation: 500ms; Intonation and stress stimulation: 400ms), then the speech material was played by headset (tone stimulation 300ms; Intonation stimulation 600ms; Stress stimulation 800ms), the corresponding time length of "+" followed. By analogy, the stimuli are random.

3. The amplitude and latency of the total average original ERP waveform
Figure 1 shows the overall average waveform of ERP induced by standard and deviant stimuli. Average amplitude of the original wave was analyzed with double factor analysis of variance (3 experimental conditions (statement tone, interrogative tone, exclamatory) X9 electrodes (F3, C3, P3, FZ, CZ, PZ, F4, C4, P4)). The results showed that the main effect of stimulation was significant, \( F(1,179) = 421.580, P<0.01 \). A simple comparison found that the average amplitude of ERP induced by deviant stimulation (-0.744uV) was significantly greater than the average amplitude of ERP induced by standard stimulation (2.110uV), that is, the ERP induced by deviant stimulus is more negative than that induced by standard stimulus, which indicates that MMN can be induced by random deviated stimulus appears in standard stimulus sequence. At the same time, the main effect of the electrode was significant \( F(8,179) = 5.281, P<0.001 \), multiple comparisons revealed significant differences between the three sets of electrodes: F3 and P3 (P<0.018), C3 and P3 (P<0.018), FZ and P3 (P<0.001), that is to say, the ERP induced by the stimulation on these three sets of electrodes is more negative than the ERP induced on the other electrodes. In addition, the interaction between the stimulation and the electrodes was significant, \( F(8,179) = 2.932, P < 0.004 \). The simple analysis found that the amplitude of the average amplitude (-0.591uV) of the ERP waveform induced by deviation on the four electrodes (F3, P3, C3 and FZ) was more negative than that of the average amplitude (2.114uV) of the ERP waveform induced by standard stimulation, in other words, during the process of the brain perceiving speech stimuli, there is a significant interaction between the stimulus and the electrode.

Latency period of the original wave was analyzed with double factor analysis of variance. The results showed that the main effect of stimulation was significant, \( F(1,179) = 100.809, P<0.001 \). According to the simple analysis, the average latency of the ERP crest induced by deviant stimulation (213.667ms) is longer than that of the ERP crest induced by standard stimulation (164.422ms), indicating that the brain was more difficult to process deviated stimuli in the pre-attentive processing stage than that induced by standard stimuli. The main effect of the electrode is not significant, \( F(8,179) = 0.456, P=0.85 \), that is, the effect of the electrode on the change of latency is not significant. However, the interaction between the electrode and the stimulus \( F(8,179) = 0.964, P<0.11 \), reaching a significance level. Moreover, the latency period of the deviation stimulus at the observed electrode was longer than that of the standard stimulus, in other words, the two factors, stimulus and electrode interact with each other in affecting latency changes. Comparing the average latency of the left and right hemispheres of the brain, it was found that although the difference between the average latency
of the left hemisphere (187.533 ms) and the average latency of the right hemisphere (189.367 ms) was not obvious. However, the difference between the average peak latency of the right hemisphere deviated stimulus (214.733 ms) and the average peak latency of the standard stimulus (164 ms) is greater than the difference between the mean peak latency of the left hemisphere deviated stimulus (211.467 ms) and the average peak latency of the standard stimulus (163.6 ms).

Fig. 1 The total average ERP contrast waveform between deviant stimulus and standard stimulus of Lhasa intonation on electrodes F3, FZ, F4, C3, CZ, C4, P3, PZ, P4 in the Oddball paradigm. Among them, the horizontal axis represents time (-100-500 ms) and the vertical axis represents amplitude (-20-30 Hz); The solid line represents standard stimulus and the dotted line represents deviant stimulus. It can be seen from the figure that the ERP induced by the deviant stimulus at 240 ms is more negative than the standard stimulus-induced ERP.
4. The amplitude and latency of the total average difference wave MMN

Figure 2 shows the total mean waveform of the differential wave MMN obtained from the deviation-stimulated ERP minus the standard-stimulated ERP. The amplitude of the total mean difference wave MMN was analyzed with double factor analysis of variance (3 experimental conditions (statement tone, interrogative tone, exclamatory) X9 electrodes (F3, C3, P3, FZ, CZ, PZ, F4, C4, P4)). The results showed that the main effect of stimulation was significant, F (1,179) = 569.536, P<0.01. A simple comparison found that the average amplitude of ERP induced by deviant stimulation (-0.97ms) was significantly greater than the average amplitude of ERP induced by standard stimulation (2.11ms), which indicates that the ERP induced by deviant stimulus is more negative than that induced by standard stimulus. At the same time, the main effect of the electrode F (8, 179) = 5.546, P < 0.001, reached a significant level. Multiple comparisons showed that there were significant differences in the electrodes P3, FZ, CZ, PZ, F4, and P4 (P<0.05). In addition, the interaction between the stimulation and the electrode was significant, F (8, 179) = 3.805, P < 0.001. A simple analysis found that the ERP waveform amplitude (-2.096uV) induced by the deviant stimulus on the electrodes F3, C3, P3, PZ was significantly more negative than the standard stimulus-induced ERP waveform amplitude (2.88uV), it is shown that there is a significant influence between the stimulus and the electrode during the brain's perception of speech stimuli.

Latency period of the difference wave MMN was analyzed with double factor analysis of variance. The results showed that the main effect of stimulation was significant, F (1,179) = 24.048, P<0.001. According to the simple analysis, the average latency of the ERP crest induced by deviant stimulation (182.889ms) is longer than that of the ERP crest induced by standard stimulation(164.422ms), indicating that the brain was more difficult to process deviated stimuli in the pre-attentive processing stage than that induced by standard stimuli. Although the peak latency (194.60 ms) of the bias stimulus on the observed electrode was longer than the peak latency of the standard stimulus (153.20 ms), the main effect of the electrode was not significant, F(8,179)=0.706, P=0.686, moreover, the interaction between the electrode and the stimulus F(8,179)=1.526, P=0.152, did not reach a significant level. It is indicated that not only the influence of the electrode on the latency period is not significant, but also the two factors of stimulation and electrode do not affect each other in the change of the peak latency of the difference wave MMN. Comparing the average latency of the left and right hemispheres of the brain, it was found that although the difference between the average latency of the left hemisphere (171.667 ms) and the average latency of the right hemisphere (175.3 ms) was not obvious. However, the difference between the average peak latency of the right hemisphere deviated stimulus (186.6ms) and the average peak latency of the standard stimulus (164 ms) is greater than the difference between the mean peak latency of the left hemisphere deviated stimulus (179.733 ms) and the average peak latency of the standard stimulus (163.6 ms).
Fig. 2 The total average difference waveform MMN is obtained by Deviation stimulus minus standard stimulus on the electrodes F3, FZ, F4, C3, CZ, C4, P3, PZ, P4 in the Lhasa intonation in the Oddball paradigm. Among them, the horizontal axis represents time (-100-500ms), and the vertical axis represents amplitude (-20-30Hz); the solid line represents the standard stimulus, and the broken line represents the difference wave MMN. From the total average waveform, it can be found that the differential wave MMN induced ERP is more negative than the standard stimulus-induced ERP at 200 ms.

5. Conclusion
In this study, the tone of the Tibetan dialect in the pinyin language was taken as the research object, and the Oddball pattern stimulus sequence was designed with statement as the standard stimulus. Deviation-stimulated ERP is more negative than standard stimulus-induced ERP when deviation-stimulated interrogative sentences and exclamation sentences are randomly presented in the sequence, which is consistent with the findings (Kimmo Alho et al., 1998). In other words, the deviate stimulus can induce a significant mismatch negative (MMN). However, there were significant differences in the origin of tone conditions. Kimmo Alho et al. (1998) believed that MMN of the left auditory cortex was more negative than that of the right auditory cortex, that is, the advantage of
speech processing in the pre-attention stage is shown in the left hemisphere, which means the speech processing in the pre-attention stage mainly presents the left hemisphere superiority. In this present study, combined with the analysis of the brain's maximum activation region of the mean difference wave MMN, it was found that the main brain source activated by the tonal condition in the brain is located in the precentral gyrus of the right hemisphere (coordinates are X=31.0, y=20.8, z=83.8). Therefore, in the pre-attention stage, the processing advantage of the brain for the Lhasa dialect condition is presented in the right hemisphere.

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