

# An ERP study on categorical perception of lexical tones and nonspeech pitches

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## Abstract

The study investigates the electrophysiological signature for Categorical Perception (CP) of lexical tones. Mandarin level and rising tones are the targets and nonspeech counterparts, using pure tones with the same pitch contours, are synthesized as controls. The results show that in lexical tone condition, across-category deviant elicits Mismatch Negativity (MMN) but within-category deviant does not. In pure tone condition, neither deviant elicits significant MMN. The result indicates CP of lexical tones can be observed by MMN signal. It also suggests that before listener does the overt decision, brain activates differently to lexical tones from nonspeech pitches.

**Index Terms:** MMN, categorical perception, lexical tones

## 1. Introduction

Pitch contours distinguish lexical meaning in a tone language. Previous behavioral results on CP of Mandarin lexical tones support the linguistic mechanism [1]. But the behavioral studies can not show a clear picture of temporal course for CP.

In this study, we investigate the neurophysiologic indices for CP of lexical tones in the pre-attentive stage.

## 2. Experiments

The Event-Related Potentials (ERP) experiments are conducted to investigate a) whether or not brain activates differently to across/within-category stimuli before listener making overt decision; b) in the same stage, whether or not brain responses differently to speech and nonspeech even though both of them have the same pitch contours.

### 2.1. Method

Nineteen right-handed native Mandarin speakers (11F, 8M, aged 23~31) participated. All of them have normal hearing based on self-report.

Pitch contours for three speech and nonspeech stimuli are the same as those used in [1] and shown in Fig.1 d). Both standard and within-category deviant are heard as Mandarin word 衣 /yi1/ 'clothes', while across-category deviant is heard as 姨 /yi2/ 'aunt'. The boundary is determined by results obtained from [1] and confirmed by behavioral post test. Three nonspeech stimuli (within-cat. dev.; across-cat. dev. and standard), using pure tones, are synthesized with the same pitch contours. Speech and nonspeech presented in different blocks with showing probability for deviants is 1/9 each.

EEG signals are recorded from 128-channel EGI system. The sounds are delivered through Philip headphones SHG5000 in the classical passive listening odd-ball paradigm[ref. 2]. Self-selected silent movies are presented via an IBM laptop to distract subjects' attention from speech stimuli. ERP waves are re-referenced to average-mastoid.

### 2.2. Results

MMN signal peaked around 148ms is only present in across-category deviant in speech condition but absent in nonspeech condition. The ERP waves at Fz site are shown in fig.1 a) and

b). Paired t-test shows the amplitude of MMN elicited by across-category deviant is larger than that elicited by within-category deviant in speech condition with  $p < .05$ . Topographic map of this difference is shown in Fig.1c). A 2-way repeated ANOVA with factor of condition (speech vs. nonspeech) and another factor of deviant type (across-category and within-category) confirms a significant interaction effect ( $p < .05$ ) at right central parietal region in the MMN time window.

## 3. Conclusions

The results show that early neural activity correlates with CP of lexical tones. Moreover, in the same pre-attentive stage (the observation time window of MMN [2]), speech can be distinguished from nonspeech, even when they are based on the same pitch contours. Our results from audition are complementary to findings in vision based on CP of the color spectrum [3]; both show that perception is influenced by language very soon after the stimuli are received.

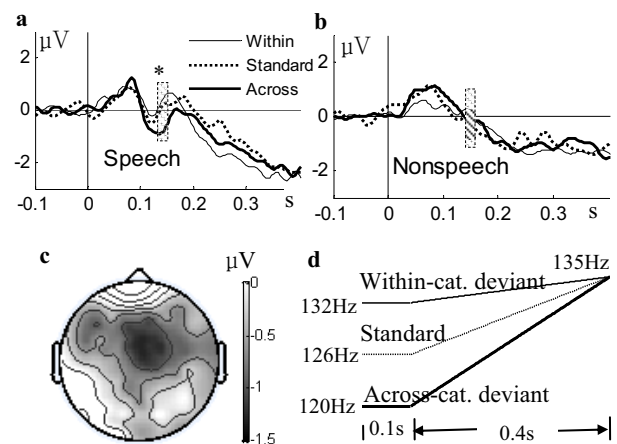


Figure 1: ERP waves elicited from 3 types of stimuli at Fz site in speech condition a) and nonspeech condition b). Shaded areas show the MMN windows ( $148\text{ms} \pm 12\text{ms}$ ). The '\*' indicates  $p < .05$  from paired t-test comparing across-category and within-category. Topographic map for this difference over the MMN windows in speech condition is shown in c). Pitch contours for 3 types of stimuli for both speech and nonspeech are shown in d)

## 4. Acknowledgement

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## 5. References

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