Tone lateralization is affected by both linguistic roles and physical properties

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Whether tones in tonal languages are processed in the left hemisphere is a question under debate. It touches upon the key issue of how our brains are functionally organized, namely, does the functional organization of the brain depend on the nature of the tasks, such as language or music, or the physical properties of the input signals, such as slow-changing spectral cues or fast-changing temporal cues.

Tone is used to distinguish lexical meanings by pitch variations. According to the "*task-dependent*" view, tone perception should be left lateralized, because it bears language function and the left hemisphere is the language dominant side. However, the "*cue-dependent*" view predicts that tone perception should be right lateralized, since the right hemisphere has an advantage in processing pitch changes, which are the physical properties of tones. There is supporting evidence for both of these views. For example, two behavioral studies [1,2] using the **dichotic listening** paradigm have shown a right ear advantage (REA, left hemisphere advantage) on tone perception, whereas a recent **ERP** (Event-Related Potential) study [3] using the MMN (Mismatch-Negativity) paradigm has shown a right hemisphere advantage on tone perception around 200 ms after the stimulus onset under the preattentive condition.

Here we conduct an **ERP** experiment, which has a high temporal resolution, to examine tone lateralization following the **dichotic listening** paradigm. We examine the effects of both the ***semantics*** and the ***physical property***. We adopt a 2×2 design, with real and pseudo-syllables as two levels in the factor of the semantics and tone and stop-consonant dichotic trials as two levels in the factor of the physical property.

Thirty-two native Mandarin subjects with normal hearing have participated in the experiment. In the experiment, subjects first hear two different syllables in their two ears simultaneously. After seeing the indication of "left" or "right" on the screen, subjects are asked to identify both the initial consonant and the tone of the syllable that they hear in their left or right ear.

The results support that both the ***semantics*** and the ***physical property*** affect tone lateralization. By measuring the differences of the P200 (a positive peak around 200 ms after the stimulus onset) peak amplitude between the homologue left and right electrodes, C3 and C4, a two-way repeated-measures ANOVA shows a significant main effect of the semantics ($F(1,31) = 8.437$, $p < .007$) and a significant main effect of the physical property ($F(1,31) = 5.560$, $p < .025$) (see Fig. 1).

Given the evidence that the linguistic role and the physical property affect tone lateralization, we argue that the functional organization in the brain is an adaptive system affected by both tasks and input signals. The "*task-dependent*" and the "*cue-dependent*" views complement each other to form a more complete picture of speech perception.

[1] Van-Lancker, D., & Fromkin, V. (1973). Hemispheric specialization for pitch and tone: Evidence from Thai. *Journal of Phonetics, 1,* 101–109.
[2] Wang, Y., et al. (2001). Dichotic perception of Mandarin tones by Chinese and American listeners. *Brain and Language, 78,* 332–348.
[3] Luo, H., et al. (2006). Opposite patterns of hemisphere dominance for early auditory processing of lexical tones and consonants. *PNAS, 103(51),* 19558–19563.

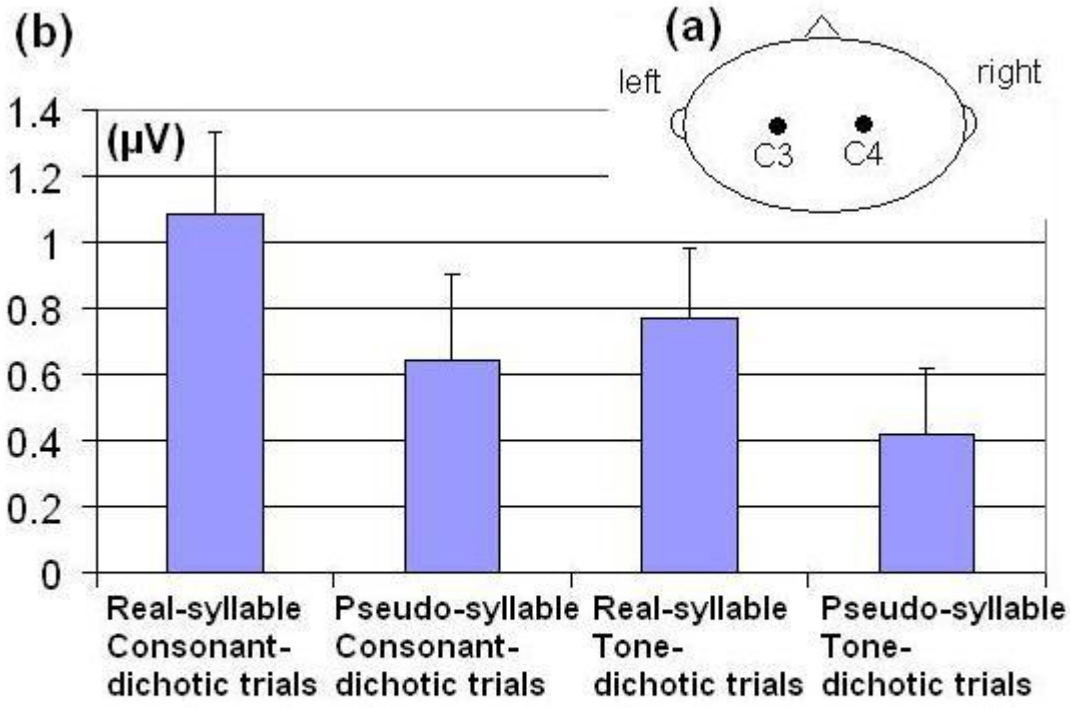

Fig. 1. (a) An illustration of the positions of electrode C3 and C4.
(b) The mean value of the differences of the P200 peak amplitude between C3 and C4 under each condition.
(Each error bar denotes one standard error.)