

Title: Processing Tone and Vowel Information in Mandarin: An eye-tracking study of contextual effects on speech processing

Authors: Xizi Deng, Henny Yeung, Ashley Farris-Trimble

Keywords: Spoken word recognition, Contextual effects, Eyetracking, Mandarin Chinese

Abstract:

Prior work has examined how lexical tones compare to vowels and consonants in accessing to different lexical representations in Mandarin. These previous studies have suggested that, overall, segmental information is given priority over tone information as measured in reaction time tasks (Cutler & Chen, 1997; Sereno & Lee, 2014; Wiener & Turnbull, 2015). There is one situation where tone information plays a more important role than segments in lexical access, which is when target words are embedded in highly constraining semantic contexts, i.e. idioms and sentences (Ye & Connine, 1999; Liu & Samuel, 2007). Online processing of speech information can be measured from eye gaze in a visual world (Allopenna et al., 1998), which can yield insights into how speech information is used by listeners to identify visual referents. Here we examined the eye gaze of native listeners of Mandarin Chinese, asking how rime and tone information is used in online speech processing. Prior work has examined this question using isolated words, but the effects of context have not previously been explored in eye-tracking. In the current study, we investigated when and how top-down contextual effects constrained real-time processing in eye gaze, and whether it would have a different impact on activating tonal and rime information in a type of semantically constraining context, i.e. classifier-noun agreement in Mandarin Chinese, where a classifier functions as the head of a nominal phrase, categorizing a class of nouns based on some of their primary perceptual properties, which are intrinsically related to the objects denoted by the nouns (Tai, 1992).

Twenty-four native Mandarin speakers were tested in two classifier contexts, high-constraint classifiers, which can only take one or two nouns as their complement, and low-constraint classifiers, which can take more than three nouns as their complement. In each trial, participants heard a classifier-noun phrase and were required to select a match for the noun from a visual array including a target item (ke4 “class”), a phonological competitor (tone: kuang4 “mine”; rime: ke2 “shell”), and two unrelated distractors.

Results from an adjusted trial-by-trial analysis using a linear mixed effects model, where the factors of context types (high and low constraining classifier) and object types (a target item, a competitor or a distractor) were fixed factors, revealed that during the classifier window, average looking time to the target item and the phonological competitor was significantly greater than that to the distractors ( $p < .0001$ ) in both context types and the fixations to the target was significantly greater relative to the competitor only in high-constraint context ( $p < .0001$ ) but not in low-constraint context ( $p = .32$ ). In addition, another mixed effects model was run during the same time window, where the factors of context types (high and low constraint classifiers) and competitor types (tone or rime) were the fixed factors. Here, more distraction from a tone competitor than a rime competitor was found only in high-constraint context ( $p = .0001$ ) but not in low-constraint context ( $p = .06$ ).

The results indicated that there was an early top-down activation of the target noun and its phonological competitors, and that listeners actively used available contextual information to predict the upcoming word even before the acoustic signals were available. This provides evidence for an interactive model of lexical access (Federmeier et al., 2007).

Furthermore, the results extended the application of previous findings (Ye & Connine, 1999; Liu & Samuel, 2007) to classifier-noun agreement, suggesting an earlier and stronger anticipation for hearing the tonal information than the rime information in a predictive context. The study complements literature in speech perception in a sense that information at segmental and suprasegmental levels were planned at dissociative stages, not only for production, but also for preparation of perception. Furthermore, it has also provided insight on the role of lexical tone in the construction of a perception model for a tonal language such as Mandarin Chinese.

## References

- Alloppenna, P. D., Magnuson, J. S., & Tanenhaus, M. K. (1998). Tracking the time course of spoken word recognition using eye movements: Evidence for continuous mapping models. *Journal of Memory and Language*, 38, 419–439.
- Boersma,
- Cutler, A., & Chen, H.-C. (1997). Lexical tone in Cantonese spoken-word processing. *Perception & Psychophysics*, 59(2), 165–179. doi: 10.3758/bf03211886
- Federmeier, K. D., Wlotko, E. W., Ochoa-Dewald, E. D., & Kutas, M. (2007). Multiple effects of sentential constraint on word processing. *Brain Research*, 1146, 75–84. doi: 10.1016/j.brainres.2006.06.101
- Liu, S., & Samuel, A. G. (2007). The role of Mandarin lexical tones in lexical access under different contextual conditions. *Language and Cognitive Processes*, 22(4), 566–594. doi: 10.1080/01690960600989600
- Sereno, J. A., & Lee, H. (2014). The Contribution of Segmental and Tonal Information in Mandarin Spoken Word Processing. *Language and Speech*, 58(2), 131–151. doi: 10.1177/0023830914522956
- Tai, J. H. (1992). Variation in classifier systems across Chinese dialects: towards a cognition- based semantic approach. *Chinese Language and Linguistics*, 1, 587-608.
- Wiener, S., & Turnbull, R. (2015). Constraints of Tones, Vowels and Consonants on Lexical Selection in Mandarin Chinese. *Language and Speech*, 59(1), 59–82. doi: 10.1177/0023830915578000
- Ye, Y., & Connine, C. M. (1999). Processing Spoken Chinese: The Role of Tone Information. *Language and Cognitive Processes*, 14(5-6), 609–630. doi: 10.1080/016909699386202