Neural responses to tonal and segmental gaps in Mandarin Chinese

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Introduction: In this study, we conducted a passive listening ERP experiment to see if the results of previous behavioral experiments could be replicated (e.g., [1,2,3], among many others). In the literature, it has been repeatedly shown that speakers are able to access fine-tuned, gradient judgments about the acceptability of nonce words in their native languages. Regarding Mandarin Chinese, however, there is a complication that hypothetical words may come in two types, namely, (i) Segmental gaps (SG) refer to impossible or non-existing CV or VC combinations, e.g., [ki1] and (ii) Tonal gaps (TG) mean (more than) one of the four lexical tones may be absent in a meaningful monosyllable, e.g., [su3], while [su1], [su2] and [su4] are real words. It is not surprising to see that Mandarin speakers treat TGs as more real-ish words, whereas SGs are much more often rejected as a possible word. As a matter of fact, the prediction is borne out in results of previous behavioral studies [1,2,3]. Thus, our main research goal is to explore if there is evidence for a gradient neural response based on the different types of nonce words in Mandarin Chinese. This is not a trivial issue because it has been reported that results of the behavioral experiments may be completely absent in a neurophysiological experiment (e.g., [4]).

Method: Eleven right-handed native speakers of Taiwanese Mandarin with normal hearing participated in the experiment. A go/no-go task was integrated with the passive listening paradigm to keep the subjects attentive. Participants were asked to press a button only if they hear a pure tone. The critical stimuli consist of 80 TGs, 80 SGs, and 80 attested syllables chosen from all possible combinations of open syllables with the onsets [p, p^h, m, f, t, t^h, n, l, k, k^h, x, ʐ]. The electroencephalography was recorded with 32 Ag/AgCl-sintered electrodes connected to a Neuroscan SynAmps2 amplifier. The data were time-locked to the onset of the auditory stimulus. Epochs were extracted from -150 ms to 750 ms, low-pass filtered (30 Hz) and baseline corrected to the pre-stimulus period. Those with artifacts were rejected by visual inspection. Mean amplitude, 15% and 50% fractional area latencies (hereinafter FAL) were measured in the time window of 300-500 ms at 9 electrodes (FC3, FCZ, FC4, C3, CZ, C4, CP3, CPZ, CP4) using the ERP Measurement Tool in the ERPLAB package [5].

Results: The grand average ERP waveforms from 4 selected electrodes were plotted in Figure 1. A negativity which has the typical centroparietal distribution of the N400 (Figure 2) developed around 250 ms and dominated the 300-500 ms window in all conditions. Friedman tests performed on the data from each electrode revealed significant differences between the 15% FALs for the three conditions at FC3 and CZ. Post-hoc comparisons using Wilcoxon-Nemenyi-McDonald-Thompson tests showed that 15% FAL was shorter for TGs than that for real words at FC3 and that it was shorter than that for SGs at CZ. Similarly, significant differences between the 50% FALs for the three conditions were found at FC3, FCZ, C3, and CZ. Post-hoc comparisons showed that 50% FAL for TGs at these electrodes were shorter than that for real words. In addition, 50% FAL was shorter for TGs than that for SGs at CZ and FC3. As for the mean amplitude, no significant difference between conditions at the group level was observed.

Discussion: One of our principal findings is that there is *no* statistically significant difference of the amplitude of N400 across SG, TG and real words, even though the amplitude of the N400 component has been shown to be affected by the lexical status [6] and phonological well-formedness [4]. In other words, our participants do not exhibit a gradient neural responses to the well-formedness and attestedness of the stimuli (cf. [4]). Nevertheless, a closer examination reveals that the main differences between TGs and the rest of the stimuli (i.e., SG and real words) lie in the *latency* of N400, suggesting that upon hearing a potential word, our participants first analyzed an attested combination of tone and segmental makeup or an unattested combination. Taken together, these findings seem to lend *limited* support to a pre-lexical phonological processing, according to which stimuli are first checked against phonotactic restrictions before being subjected to a full lexical search. One possible explanation is that the co-occurrence restrictions on CV syllables (e.g., *[ki]) are not encoded in UG, unlike the Sonority Sequencing Principle (SSP), which induces a significant N400 effect in English (e.g., [4]). Another possibility is that the phonotactic, but not the tonotactic, restrictions are processed at a later point, but this is not confirmed in the present study.

Conclusion: Our results, albeit inconclusive, suggest that tone plays a role in phonotactics as well, in addition to other types of violations at the segmental level.

Finally, in the conference, we shall report results from a similar ERP experiment using the lexical decision paradigm.

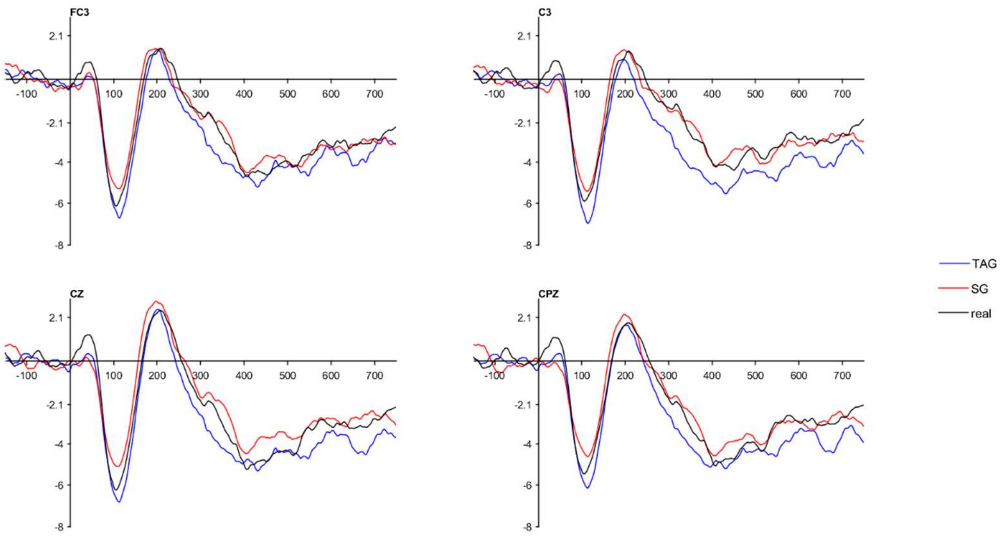

Fig.1 The grand average ERP waveforms of the three conditions.

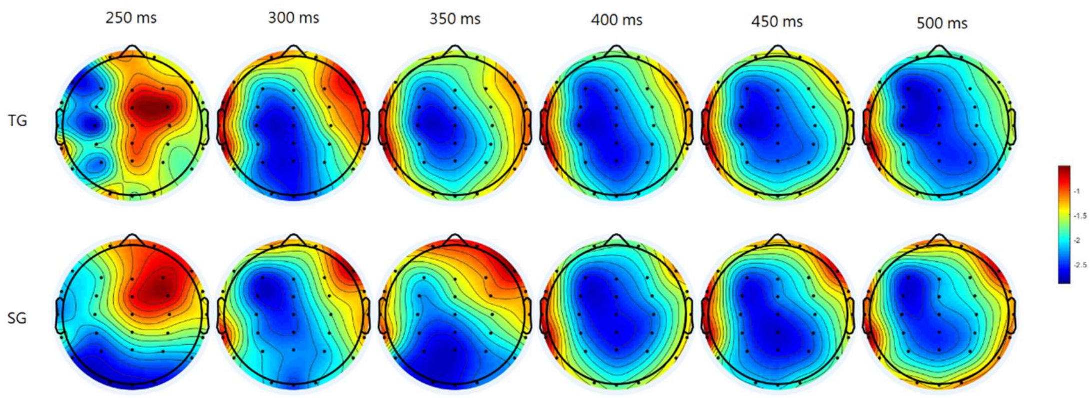

Fig.2 Topographic maps for the TG (top) and SG (bottom) conditions.

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