Late ERP components in Taiwanese tonal violations in compounds

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Main text: This study investigates how different types of tonal violation in compounds in a tonal language are processed by native speakers, using event-related potentials (ERP) and a naturalness judgment task. In languages where a certain prosodic feature is distinctive (e.g., the stress in English), speakers must process different patterns of that prosodic feature (e.g., compound stress in English, which signifies that a sequence of words constitutes a compound word rather than a phrase). However, little is known about how neural activities reflect language processing when prosodic information does not correspond to the information in one's grammar or lexicon. This study manipulates different types of tonal violation in Taiwanese Southern Min (henceforth, Taiwanese). Taiwanese is a language in which tones distinguish meaning. Unlike Mandarin or most other variations of Chinese, every non-final tone automatically changes to its designated sandhi tone (see Figure 4) irrespective of the tone type or any phonological feature of the following morpheme in most cases of Taiwanese compounding. In other words, every morpheme has two possible tonal forms: the basic tone and the sandhi tone. However, it is debatable whether the basic tone and the sandhi tone are both memorized in the speakers' lexicon as variants of a morpheme. [1][2] If that is the case, encountering either tone (in any syllabic position) may lead to accessing the same morpheme. In this case, violation types concerning the sandhi rule are likely to be processed differently from other kinds of violations such as the lexical violation, which can be interpreted only as a different morpheme. To substantiate whether there is a difference between the sandhi rule violation and other kinds of violations, four conditions were tested with disyllabic words composed of two monosyllabic morphemes, where the final syllable is the target: (a) no violation, that is, a congruent form that correctly follows the sandhi rule. (b) sandhi violation, where tone sandhi has been erroneously applied to the final syllable; (c) lexical violation, where the final syllable's tone is realized with another existent tone other than the sandhi tone; (d) non-existent tone violation, where the final syllable is given a tone that does not exist in the language (see Table 1 for further information about the stimuli).

Twenty-five adult native Taiwanese speakers were presented with a picture and corresponding sound stimulus lasting 2000ms and asked to judge the word's naturalness (the result of naturalness judgement is shown in Figure 1) while their brain activity was recorded using a 64-channel electroencephalography (EEG) (Figure 2 and 3). Among all violation conditions, a wide-spread late posterior negativity was observed in the permutation analysis around 1000 ms after the offset of the whole stimulus compared to the baseline (the congruent condition) and the effect was marginally significant. The amplitude of the late positivities differed among the three conditions from 2400 ms, and the difference became remarkable between 2800 - 2996 ms (LME, backward Helmert coding: the sandhi violation[compared with the baseline]: β = 0.60, SE = 0.12, $p < 0.01$; the lexical violation[compared with the sandhi violation]: β = 1.03, SE = 0.12, $p < 0.01$; the non-existent violation[compared with the lexical violation]: β = 0.68, SE = 0.13, $p < 0.01$; see Figure 1): namely, all violation conditions elicited robust positive components, and there was a difference among the sandhi condition, the lexical condition, and non-existent conditions. These results lead us to two conclusions. First, tone violations could trigger late ERP components compared to congruent forms (i.e., no violation) in Taiwanese compound processing in general. Second, while the widespread negativity and positivity was commonly observed across the violation conditions, there was a difference of amplitude between sandhi violation and lexical violation. This result could be interpreted to suggest that the basic form and the sandhi form in Taiwanese are stored as variants of the same morpheme in the lexicon. This is consistent with the results of the naturalness judgment task, in which the sandhi violation condition is rated as more natural than the lexical violation condition (see Figure 2 and 3).
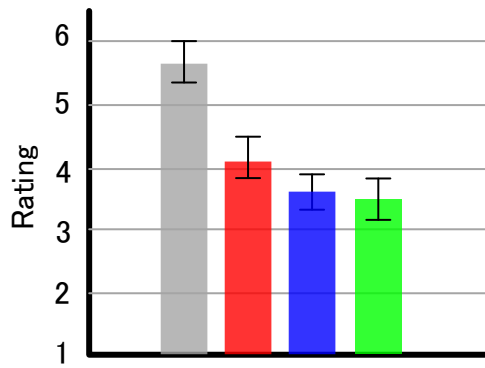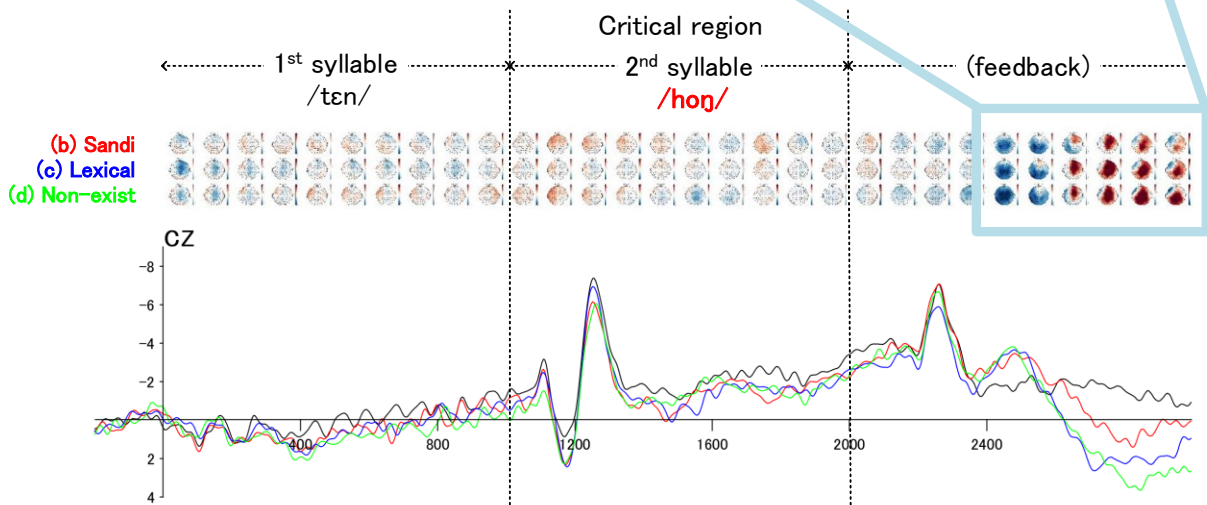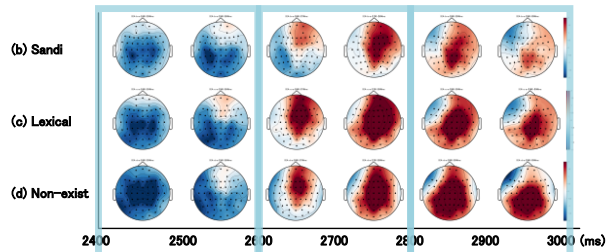
Figure 1. Results of the naturalness judgment task

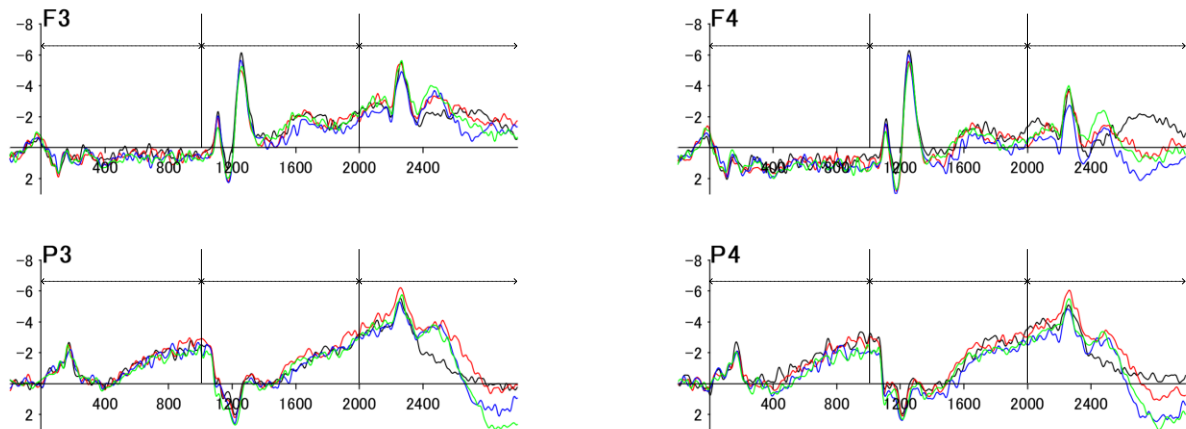Figure 2. The waveforms of CZ and the topography of the ERP results

Figure 3. The ERP waveforms of F3, F3, P3, P4 (0 - 2996ms)

References

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Introduction of Taiwanese Tone Sandhi

Taiwanese Southern Min (henceforth, Taiwanese) is a tone language with seven lexical tones [1], in which five tones for non-checked syllables, and two tones for checked syllables which ends with a voiceless plosive [p], [t], [k], or [ʔ]. Lexical tones for non-checked syllables include three contour tones: HL, ML, MH; and two level tones: H, M. Taiwanese is known for its complex tonal system where every tone becomes another existing tone when preceding another syllable.

In the present study, we refer to lexical original tones as basic tones while changed tones as sandhi tones. This tonal change occurs in most non-final positions and follows a lexical chain shift. For example, an H tone becomes an M tone when followed by another syllable and an M tone becomes an ML tone, but not vice versa. Intriguingly, this tonal change is only related to the presence of the following syllable. Unlike Mandarin tone sandhi, which is only triggered by two continuous MLH tones, Taiwanese tone sandhi does not refer to the characteristics of the following tone in most cases.
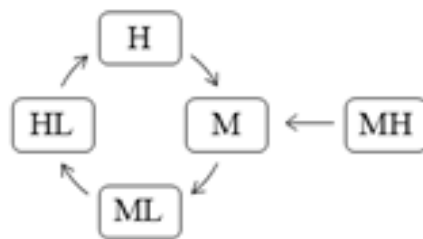

Figure 4. Tonal chain shift in Taiwanese

Table 1. The conditions in the experiment

a. Congruent
- tɛn M + hoŋ H → [tɛn ML hoŋ H]
  ('electric') ('wind')   ('electric fan')

b. Sandhi Violation(over-generalized)
- tɛn M + hoŋ H → [tɛn ML hong M]

c. Lexical Violation
- tɛn M + hoŋ H → [tɛn ML hoŋ HL]

d. Non-existent Base Tone (^{MHL} is not a legal tone in Taiwanese)
- tɛn M + hoŋ H → [tɛn ML hoŋ MHL]