SEGMENTAL AND TONAL PROCESSING IN CANTONESE

Hsuan-Chih Chen, Michael C.W. Yip, and Sum-Yin Wong

Department of Psychology, The Chinese University of Hong Kong

ABSTRACT

In a tone language, such as Cantonese, both segmental and tonal distinctions between words are pervasive. However, previous work in Cantonese has demonstrated that in speeded-response tasks, tone is more likely to be misprocessed than is segmental structure. The present study examined whether this tone disadvantage would also hold after the initial auditory processing of a syllable had been done. Cantonese listeners were asked to make same-different judgments on two sequentially presented open syllables along a specific dimension (i.e., onset, rime, tone, or the whole syllable) according to an instruction which was visually presented at the acoustic offset of the second syllable. Manipulating whether the difference between two syllables was in onset, rime, or tone resulted in equally robust effects across the various decision tasks on performance, indicating that tone functions as effectively as segmental structure in spoken-word processing once the related information of a syllable is encoded.

1. INTRODUCTION

A syllable can be divided into syllabic components such as various kinds of segmental information (e.g., onset, rime, consonant, vowel, and coda) and suprasegmental, or prosodic, features (e.g., stress or tone). It may be difficult for speakers of English to imagine, but the tone of a syllable can be as important as the segmental quality of a syllable in a tone language such as Cantonese. However, although tonal distinctions between words are pervasive in tone languages, how this prosodic dimension is processed in spoken-word recognition is not as yet well understood.

In fact, very few studies have examined lexical tone in spoken-word processing. Recently, Cutler and Chen [1], using both lexical decision and syllable comparison tasks, found that lexical tone distinctions were more likely to be misprocessed than were segmental distinctions. Using the same syllable comparison task, they found a similar result with listeners who knew no Cantonese and were native speakers of Dutch. These results thus seem to suggest that the tone disadvantage is a perceptual phenomenon and is due to the initial auditory processing of acoustic stimuli.

However, the relevant psychological research also suggests that the advantage of segmental over tonal information appears not only at the perceptual stage but also at other stages of information processing. For example, Taft and Chen [2] found that homophone judgments for written characters in Mandarin were made less efficiently when the pronunciation of the two characters differed only in tone, as opposed to in vowel; a similar pattern of results was found in another experiment in Cantonese. These results suggest that the tone disadvantage may also appear when the phonological information of a character is retrieved and used.

The present study aims to further investigate the processing of segmental information and lexical tone in Cantonese. Specifically, we conducted this study to examine whether the disadvantage for the processing of tonal information in comparison with segmental information would also appear after a syllable had been fully encoded. In order to assess the processing of segmental and tonal information after the initial encoding of acoustic stimuli, we asked subjects to make various kinds of same-different judgments on two syllables according to an instruction presented at the offset of the stimuli.

2. METHOD

2.1. Participants

Sixteen subjects were recruited from the introductory psychology subject pool at the Chinese University of Hong Kong. All participants were native speakers of Cantonese, and none reported a history of hearing loss or speech disorder.

		Comparison Type			
Mismatch	Example	Onset	Rime	Tone	Syllable
None	*piu4-piu4*	same	same	same	same
Onset	*piu4-liu4*	different	same	same	different
Rime	*piu4-pei4*	same	different	same	different
Tone	*piu4-piu5*	same	same	different	different
Onset-rime	*piu4-lei4*	different	different	same	different
Onset-tone	*piu4-liu5*	different	same	different	different
Rime-tone	*piu4-pei5*	same	different	different	different
Onset-rime-tone	*piu4-lei5*	different	different	different	different

Table 1: Sample stimuli used in the experiment and correct responses for the onset, rime, tone, and syllable comparisons.

2.2. Materials

Sixty-four pairs of open syllables were constructed by using 8 existing syllables in Cantonese. Among the 64 pairs, eight involved two identical items. The remaining 56 pairs included seven types of eight pairs each that were made up by two items that differed in either one or more syllabic components, as illustrated in Table 1.

The same set of 64 pairs of syllables served as stimuli for the onset, rime, and tone comparison conditions. Thus, for each type of the subsyllabic comparison, there were 32 positive pairs and 32 negative pairs. Although the same set of stimuli was also used in the syllable comparison condition, however, in order to have equal numbers of positive and negative trials in this condition, each pair of eight identical syllables was repeated seven times. Consequently, there were 56 positive pairs and 56 negative pairs in the syllable comparison condition.

All stimuli were recorded by a female native speaker of Cantonese and digitized at a sampling rate of 22 kHz and stored on computer for presentation.

2.3 Procedure

Subjects were tested individually in a quiet room. They heard the stimuli, in pairs, at a comfortable level through headphones. The subjects were instructed to decide whether or not the two syllables in each pair were identical in a given dimension (i.e., onset, rime, tone, or the whole syllable), by pressing one of the two response keys (labeled YES and NO) in front of them, and to respond as quickly and accurately as possible.

The experiment included a practice session, which was always the first session, and eight experimental sessions. Each of the experimental sessions consisted of 38 trials, with seven positive and seven negative trials for the syllable comparisons together with four positive and four negative trials for each of the onset, rime, and tone comparisons. The order of experimental sessions was counterbalanced across subjects. However, the order of presentation trials within each session was randomized for each subject individually.

Each trial started with the presentation of a short (300-msec) warning tone, followed by a 400-msec pause. Immediately after the pause, two syllables were presented one after another with a 250-msec

interstimulus interval. At the acoustic offset of the second syllable, a message was visually presented at the center of the computer screen for 2 sec indicating the type of comparison to be made.

Stimulus presentation, timing, and response collections were under the control of a Power Macintosh 7600/132 computer running the PsyScope experimental control program developed by Cohen, MacWhinney, Flatt, and Provost [3].
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3. RESULTS AND DISCUSSION

Mean reaction times (RTs) for correct responses, measured from the onset of the visual instruction, and mean error percentages in each condition were calculated for each subject and for each item. Since the RT and error data were generally consistent with each other, only the response time results are described here. Furthermore, the results reported here are supported by analyses of variance across subjects and items.

To assess the possible effects of task, we compared the data for two identical syllables in different comparison tasks (the mean RTs are shown in Table 2). This analysis revealed that responses were generally faster when making a syllable comparison than when making a comparison based on a syllabic component.

	Comparison Type			
Correct Response	Syllable	Onset	Rime	Tone
Yes	537585	773	820	
No	959	1347	1901	1642

Table 2: Mean RTs (in milliseconds) as a function of comparison type and correct response for two identical syllables.

Moreover, among the three syllabic components, an onset comparison between two syllables was generally easier and more accurate than was a rime or tone comparison, but no significant difference was found between the rime and tone comparisons. These results suggest that listeners do not automatically segment a perceived syllable into its syllabic components and that onset can be processed more efficiently than either rime or tone.

To assess the effects of alternating each of the three subsyllabic dimensions separately, we conducted *t* tests on responses collapsed across the two conditions for each dimension in which that dimension was the same for each pair versus those collapsed across the two comparable conditions in which it was different. For instance, to assess the effects of rime difference in the onset comparison task, we contrasted responses in the none and tone conditions (in both of which vowel was the same in the two syllables) with those in the rime and rime-tone conditions, which differed from the first two just in adding in each case the rime difference. Results showed that an alternation in any syllabic components resulted in consistent and robust effects on performance: Correct "same" responses were generally less efficient when any one of the three syllabic components differed than when it did not.

Furthermore, there is evidence to show that lexical tone and rime are not processed independently with each other. When subjects' attention was focused on the rime of two syllables (i.e., in the rime comparison task), the magnitude of the tone effect was larger than the magnitude of the onset effect (the difference between the two effects was about 180 msec). Likewise, when the focus was on the tone, a greater rime effect was found as compared to the effect of onset; the difference was about 140 msec. However, rime and tone had similar effects in the onset comparison task.

In conclusion, three main findings emerged from the research. First, task demand affected the results of syllable comparisons. The responses were generally faster and more accurate when using the whole syllable as the basis of decision than when using a syllabic component such as rime or tone as the basis, indicating that subsyllabic units are not automatically available even when the corresponding syllable has already been encoded. Second, the onset tended to be processed more efficiently as compared to the rime. Note that the onsets and rimes used in the present study comprise nothing but consonants and vowels, respectively. This result is consistent with recent results from other studies on the processing of consonants and vowels in different languages using

distinctive tasks (e.g., Cutler & Otake [4]; Van Ooijen [5]) and is in line with the view that listeners consider vowels as potentially unreliable objects. Finally, and most relevant to the present question of interest, all three syllabic components contributed significantly to results in the various comparison tasks. Thus, differences of tone have robust effects on processing as do segmental differences. This is in line with the phonological priming results found in prior work by Cutler and Chen [6] with a lexical decision task, suggesting that lexical tone functions as effectively as segmental structure in spoken-word processing once the related information is encoded.

4. ACKNOWLEDGEMENTS

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5. REFERENCES

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