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## English Lexical Stress in Awareness and Production: Native and Non-native Speakers

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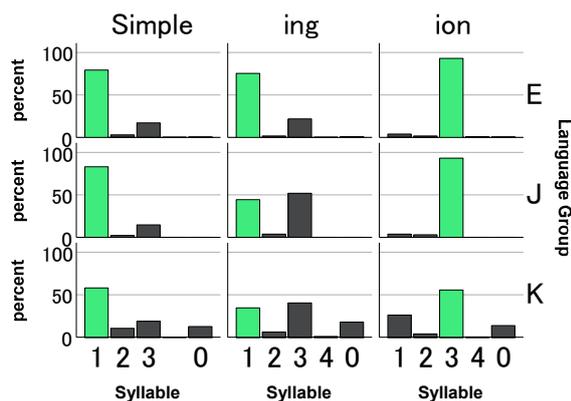
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This study aims to clarify how the consistency between English primary stress patterns of which speakers are aware and those inferred from the acoustic properties in their speech differs among English native speakers (ENS), Tokyo/Keihan Japanese learners of English (JLE) and Seoul Korean learners of English (KLE), and considers the effect of their L1. English is a stress accent language in which word-initial primary stress is predominant ([1]). It also has subsidiary stress, too. Japanese is a pitch accent language in which about 14% of homophones are distinguished by pitch accent ([2]) and no subsidiary accent exists. The preferred accent position of morphologically complex and longer words in Japanese is not word-initial but rather word-medial ([3]). Seoul Korean, on the other hand, lacks lexically distinctive accent ([4]). We clarify how these differences in lexical accent systems among the three native languages affect the point mentioned above.

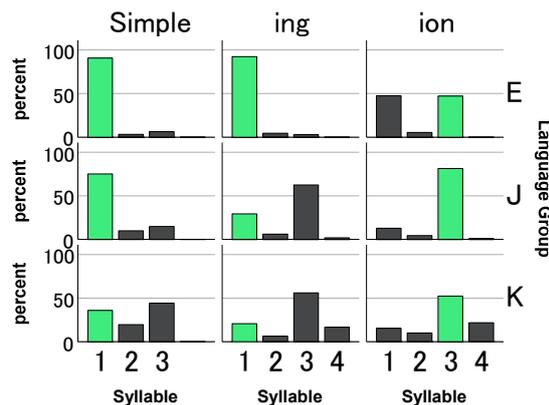
We conducted a paper-based stress-assignment task and a production task with 12 ENS, 14 JLE and 11 KLE. Although the paper-based task is a rehash of [5], the production task is new to this study. 19 triplets of morphologically related words (57 words) were adopted: three-syllable verbs ending with *ate/ute* whose prescriptive main stress falls on  $\sigma_1$  (e.g., *DO.mi.nate*), inflected verbs with the “stress-neutral” suffix *-ing* (e.g., *DO.mi.na.ting*), and derived nouns with the “stress-shifting” suffix *-ion* where  $\sigma_3$  is stressed (e.g., *do.mi.NA.tion*). In the paper-based task, the participants were asked to place a stress mark above the vowels of syllables that they considered primarily stressed. In the production task, they read aloud the 57 words embedded in carrier sentences, which was followed by forced segmental alignment (MFA3.0 by [6]) and acoustic analyses utilizing PLSPP (the Pauses and Lexical Stress Processing Pipeline by [7]). For each vowel interval, PLSPP first took (a) the mean of F0, (b) the max intensity value and (c) the duration. It secondly obtained the average of the speaker-normalized percentile values of (a), (b) and (c) for each vowel interval. The average score is called GS (Global Score) henceforth. Finally, it estimated the syllable containing the vowel with the highest GS to be acoustically most prominent.

The results of the paper-based stress-assignment task are summarized in Fig. 1. The stress assignment by ENS was predominantly prescriptive for all the three forms. JLE preferred the prescriptive stress patterns for the simple and the *-ion* forms, whereas they were divided into  $\sigma_1$ -stress and  $\sigma_3$ -stress for *-ing*, which may be because they are influenced by their L1 preferring word-medial accent in morphologically complex words. KLE’s pattern was more varied with “zero” stress and  $\sigma_2$ -stress, which implies that KLE have difficulty in acquiring English lexical stress patterns: they have set up the lexical accent parameter so that lexical accent is not encoded in the phonological representation ([8]) because their L1 lacks lexically distinctive accent.

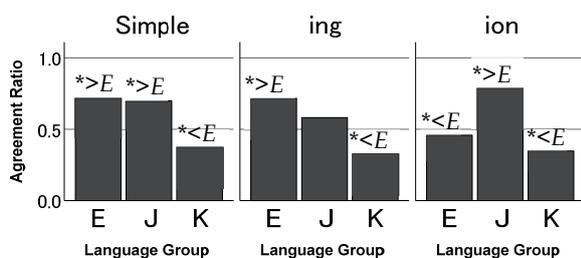
Fig. 2 summarizes PLSPP’s prominence estimation. Fig. 3 shows the ratio of agreement between PLSPP’s estimation and the stress-assignment in the paper task. As for ENS, despite their uniformly prescriptive performance in the paper task for all the three forms, only the simple and the *-ing* forms with  $\sigma_1$ -stress obtained PLSPP’s prominence estimation that matched their stress-assignment: about half of the *-ion* forms with  $\sigma_3$ -stress were estimated to have  $\sigma_1$ -prominence. ENS, however, still distinguished *-ion* from *-ing* by the GS of  $\sigma_3$  even when they were equally estimated to have  $\sigma_1$ -prominence by PLSPP (Fig. 4). It is because  $\sigma_1$  carries secondary stress in the *-ion* forms, and the secondarily stressed  $\sigma_1$  may have become acoustically more prominent than the mainly stressed  $\sigma_3$  due to analogy from the fact that word-initial main stress is predominant in English ([1]). In contrast, as for JLE’s simple and *-ion* forms, for which they assigned prescriptive stress in the paper task, PLSPP’s prominence estimation was in agreement with the prescriptive stress patterns regardless of whether they are of  $\sigma_1$ -stress or  $\sigma_3$ -stress (Figs. 2-3). That is, unlike ENS, they uniformly gave greater acoustical highlight to  $\sigma_3$  than to  $\sigma_1$  in the *-ion* forms. It is not surprising, considering that JLE is used to highlight only one syllable in their L1. KLE’s ratio of agreement between the acoustically prominent and the stress-assigned syllables was low across the three forms (Fig. 3), which is consistent with the discussion above.



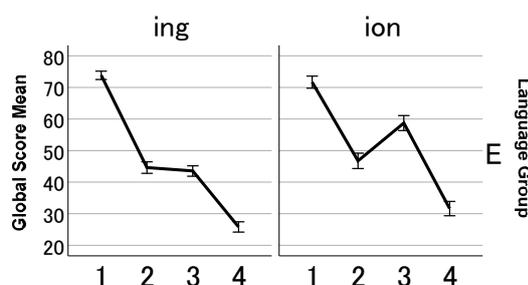
**Fig. 1.** Stress-assigned syllables (results from the paper-based stress-assignment task)  
 Note: “Simple” means the verb forms without suffixes. The numbers on the *x* axis represent syllables (e.g., “1” means that the stress mark was assigned to  $\sigma_1$ , and likewise for the rest of the syllables). “0” means no stress was assigned to any of the syllables. The syllables with green bars are of prescriptive stress.



**Fig. 2.** Syllables estimated to be acoustically most prominent by PLSP (results from the production task)  
 Note: The numbers on the *x* axis represent syllables (e.g., “1” means that  $\sigma_1$  was estimated to be acoustically most prominent, and likewise for the rest of the syllables). The syllables with green bars are of prescriptive stress.



**Fig. 3.** The ratio of agreement between the stress-assignment (paper-based task) and PLSP’s prominence estimation (production task)  
 Note: “\*<E” and “\*>E” mean significantly smaller and significantly greater than the expected respectively according to the residual analyses following *chi*-square tests ( $\chi^2(2)=66.73, p<.001$  for Simple;  $\chi^2(2)=66.21, p<.001$  for ing;  $\chi^2(2)=101.6, p<.001$  for ion).



**Fig. 4.** The mean GS of the syllables in the *-ing* and the *-ion* forms when they were estimated to have  $\sigma_1$ -prominence by PLSP (ENS only)  
 Note: The numbers on the *x* axis represent syllables, and error bars show 95% confidence intervals.

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