Abstract

This study investigated what factors are used by native speakers and Japanese learners of English when they determine the position of stress in producing and perceiving disyllabic English nonwords. Syllable structure (vowel length and number of consonants) and lexical class affected both groups, but in different ways. Phonotactic legality of intervocalic consonants influenced native speakers alone. The results are also discussed regarding the difference between production and perception tasks and the influence of Japanese syllables and lexical properties on learning English stress patterns.

Index Terms: stress, syllables, phonotactics, lexical class

1. Introduction

It has long been recognized that prosody plays an important role in the recognition and production of spoken language. Specifically, people utilize word accent or stress for such tasks as detecting words in a stream of speech (e.g., Cutler & Norris [1]) and segmenting words into syllabic units (e.g., Ishikawa [2]).

Languages differ in their prosodic properties. Although English and Japanese phonologically share the word-level accent systems, they differ in how accent is phonetically realized on words. English realizes phonological accent using stress, i.e., with a combination of pitch, vowel duration, and intensity, while Japanese relies solely on pitch to make lexical distinctions. In addition, all content words in English have accent (disregarding discourse-based deaccentuation), but Japanese counterparts are often unaccented, accounting for the lack of alternation between accented and unaccented syllables in Japanese. The way people perceive speech sounds seems to depend on the prosodic structure of their native language. Ishikawa [3], for example, found that Japanese learners of English lack sensitivity to the alternation of strong and weak syllables in English sentences compared with native speakers of English.

Although the role of stressed syllables in language processing is well recognized, it is not clear yet what factors contribute to the decision of stress position and how this is done. Only a few studies have empirically investigated the knowledge of English stress placement by native and non-native speakers. Guion et al. [4], using auditorily-presented materials with CVCV C syllable structure, demonstrated that stress placement on nonwords by native English speakers was affected by syllable structure, lexical class, and phonological similarity of real words. Guion et al. [5] and Guion [6] replicated this study using Spanish-English bilinguals and Korean-English bilinguals respectively. These studies found that although both native speakers and second language learners showed significant effects from phonologically similar words, non-native speakers stress differences did not affect Korean bilinguals significantly and syllable structure had much reduced impact on Korean and Spanish bilinguals. Guion et al. attributed their results to L1 transfer; a phrase-level prosodic system in Korean and general preference for initial syllable stress in Spanish.

The present research investigates how native English speakers and Japanese learners of English deal with primary stress on two-syllable nonwords in both production and perception tasks. The factors to be examined are lexical class, syllable structure (vowel length and number of consonants (see Kelly [7])), and phonotactic legality of intervocalic consonants (see Ishikawa [8]).

2. Method

2.1. Materials

Seventy-five nonwords were created as stimuli. They consisted of two syllables with two intervocalic consonants. There were five types of stimuli in terms of syllable structure.

Type 1 acts as a standard type (e.g., bopken); Type 2 has a long vowel in the first syllable (e.g., boopken); Type 3 has a long vowel in the second syllable (e.g., boopken); Type 4 has two consonants in the onset of the first syllable (e.g., bropken); Type 5 has two consonants in the coda of the second syllable (e.g., bopken).

In addition, the phonotactic legality of intervocalic two consonants was factored in as follows.

Class 1: Clusters are illegal both word-initially and word-finally (e.g., bopken); Class 2: Clusters are legal only word-finally (e.g., bopken); Class 3: Clusters are legal only word-initially (e.g., bopken).

A male native speaker of General American English recorded the stimuli. First, he read nonwords in isolation and then read them either with first- or second-syllable stress in the noun and verb sentence frames. The noun frame was “I like to ____.” (e.g., I like to bopken.) The verb frame was “I like to ____.” (e.g., I like to bokpen.) These stimuli were also arranged to appear on a computer screen for production tasks. All the nonwords used are listed in Appendix.

2.2. Participants

Sixteen native speakers of English (graduates and undergraduates at the University of Hawaii) and sixteen Japanese learners of English (undergraduates at Kyoto Women's University) participated in the experiments. All the Japanese participants had taken TOEIC (the Test of English for International Communication) at least once and their average score was 565, with a range between 470 and 630. Their English proficiency based on their TOEIC scores was considered to be intermediate. All the participants were paid for their participation.

2.3. Procedure

In the production task, participants were asked to read
 aloud nonwords in isolation (“bopken”) or sentences which embedded the nonwords used as nouns (“I like a bopken.”) or verbs (“I like to bopken.”) which appeared randomly on a computer screen. After producing each word or sentence, the participants indicated, using the computer keyboard, whether they placed the primary stress on the first or second syllable of the nonwords. Participants’ voices and keyboard responses were recorded. The total number of trials for this task was 225 (75 word frames and 150 sentence frames).

In the perception task, participants heard pairs of sentences through headphones. Each pair contained a nonword produced with either 1st or 2nd syllable stressed. These two pronunciations were embedded in either a noun frame or a verb frame. (For example, a pair consisted of “I like a BOPken.” and “I like a bopKEN.”) After hearing each pair, the participants answered, using the computer keyboard, which sentence sounded more natural as an English sentence. The tasks were designed to elicit judgments for American participants.

3. Experiment 1: Native speakers of English
3.1. Production task
Figure 1 shows the proportions of first syllable stress for American participants.

3.2. Perception task
Figure 2 shows the proportions of initial stress preference for American participants.

First, it was found from the results of Type 1 used as a standard type (no long vowel, no two-consonant onset or coda) that American participants generally preferred to place main stress on the first syllable in two-syllable nonwords. For example, for the word-alone condition of Class 1 in Type 1 (e.g., bopken), 82.5 percent of their responses favored the trochaic stress pattern.

The arcsine-transformed values of these proportions were submitted to an ANOVA with three factors of lexical class (noun or verb), syllable structure (5 types), and phonotactic legality of intervocalic consonants (3 classes). For the word-alone condition (no factor of lexical class), the effects of syllable structure [F1(4, 60)=14.51; F2(4, 60)=12.49, both p<.0001] and phonotactic legality of intervocalic consonants [F(2,30)=5.42, p<.005; F(2, 60)=3.38, p<.05] were significant. The interaction of the two factors was not significant, indicating independent influences of syllable structure (vowel length and number of consonants) and phonotactics of intervocalic consonants on stress placement. Post hoc Tukey-Kramer tests with a 0.05 significance level revealed the following comparisons: Regarding syllable structure, participants had more initial stress on Type 2 than Types 5 and 3, on Types 4, 1, and 5 than Type 3. As for intervocalic phonotactics, Class 3 (e.g., boplen) had more second-syllable stress than Class 1 (e.g., boppen).

For the noun or verb frame condition, the effects of lexical class [F(1, 15)=5.55, p<.05; F(2, 120)=11.62, p<.001], syllable structure [F(4, 60)=21.75; F(4, 120)=48.77, both p<.0001], and intervocalic phonotactics [F(2,30)=3.92; F(2, 120)=4.07, both p<.05] were significant. No two-way or three-way interaction among the factors was significant, indicating their separate influences on stress assignment. Post hoc tests revealed the following results: Noun frames had more first-syllable stress than verb frames. Participants had more initial stress on Type 2 than Types 1, 5, and 3, on Types 4 and 1 than Types 5 and 3, and on Type 5 than Type 3. Class 3 attracted more second-syllable stress than Class 1.
standard type (no long vowel, no two-consonant onset or coda) that American participants typically preferred main stress on the first syllable in two-syllable nonwords.

The arcsine-transformed values of these proportions were submitted to an ANOVA with three factors of lexical class (noun or verb), syllable structure (5 types), and phonotactic legality of intervocalic consonants (3 classes). The effects of syllable structure $[F1(4, 60)=3.40, p<.05; F2(4, 120)=4.11, p<.005]$ and intervocalic phonotactics $[F1(2,30)=4.94; F2(2, 120)=4.94, both p<.05]$ were significant. The effect of lexical class was not significant (p>.4 for both F1 & F2), suggesting the same degree of influence of noun and verb frames. No two-way or three-way interaction among the three factors was significant, indicating their separate influences on stress assignment. Post hoc tests revealed the following results: Participants preferred more initial stress on Types 4, 2, and 1 than Type 3. Class 3 (e.g., bopken) attracted more second-syllable stress than Classes 1 (bokpen) and 2 (bopken).

4. Experiment 2: Japanese learners of English

4.1. Production task

Figure 3 shows the proportions of first-syllable stress for Japanese participants.

![Figure 3: Proportion of first-syllable stress for production tasks by Japanese speakers.](image)

It can be seen that the results of Type 1 used as a standard type that Japanese learners of English also tended to place main stress on the first syllable in two-syllable nonwords. The arcsine-transformed values of these proportions were submitted to an ANOVA with three factors of lexical class (noun or verb), syllable structure (5 types), and phonotactic legality of intervocalic consonants (3 classes). For the word-alone condition (no factor of lexical class), the effect of syllable structure $[F1(4, 60)=8.99; F2(4, 60)=13.51, both p<.0001]$ was significant. However, the effect of phonotactic legality of intervocalic consonants was not significant (p>.1 for both F1 & F2), indicating little influence of intervocalic phonotactics on Japanese participants. The interaction of the two factors was not significant, either. Post hoc Tukey-Kramer tests with a 0.05 significance level revealed the following results regarding syllable structure. Participants had more initial stress on Types 2 and 4 than Types 5 and 3 and on Type 1 than Type 3.

For the noun or verb frame condition, the effects of lexical class $[F1(1, 15)=5.34, p<.05; F2(1, 120)=26.14, p<.0001]$ and syllable structure $[F1(4, 60)=13.24; F2(4, 120)=32.78, both p<.0001]$ were significant, but there was no significant effect of intervocalic phonotactics (p>.1 for both F1 & F2). No two-way or three-way interaction among the factors was significant, indicating their independent influences on stress position. Post hoc tests revealed the following results: Noun frames had more first-syllable stress than verb frames. Participants had more initial stress on Types 2, 4, and 1 than Types 5 and 3 and on Type 5 than Type 3.

4.2. Perception task

Figure 4 shows the proportions of initial stress preference for Japanese participants.

![Figure 4: Proportion of first-syllable preference for perception tasks by Japanese speakers.](image)

It can be seen from the results of Type 1 used as a standard type that Japanese learners also preferred main stress on the first syllable in two-syllable nonwords.

The arcsine-transformed values of these proportions were submitted to an ANOVA with three factors of lexical class (noun or verb), syllable structure (5 types), and phonotactic legality of intervocalic consonants (3 classes). The effects of lexical class $[F1(1, 15)=7.10, p<.05; F2(1, 120)=26.61, p<.0001]$ and syllable structure $[F1(4, 60)=5.66, p<.001; F2(4, 120)=5.11, p<.001]$ were significant. The effect of intervocalic phonotactics was not significant (p>.5 for both F1 & F2), indicating no reliable influence of intervocalic phonotactics on Japanese participants for perception tasks as well. No two-way or three-way interaction among the three factors was significant, indicating their separate influences on stress placement. Post hoc tests revealed the following results: Noun frames showed more initial stress preference than verb frames. Participants preferred more first-syllable stress on Type 4 than Types 5 and 3 and on Type 2 than Type 3.
5. Discussion
Syllable structure affected both native speakers and Japanese learners of English in the production and the perception tasks. Long vowels and onset clusters in the first syllable tended to attract more first-syllable stress and long vowels and coda clusters in the second syllable induced more second-syllable stress, although long vowels seem to have a greater impact than consonant clusters. The effects of syllable structure were not as clear in the perception task as in the production task, probably because people have to combine various factors to produce words while they use a broader context (i.e., rhythmic structure of sentences) to decide naturalness at sentence levels.

Phonotactic legality of intervocalic consonants influenced English speakers alone such that Class 3 (clusters which are legal only word-finally, e.g., bomp) had more second-syllable stress than Class 1 (clusters which are illegal both word-initially and word-finally, e.g., bopken) in the production task and Class 3 had more second-syllable stress than Class 1 and Class 2 (clusters which are legal only word-finally, e.g., bomgen) in the perception task. Japanese speakers were not affected by intervocalic phonotactics, thus suggesting its weaker effect on stress placement than vowel length and the number of consonants.

Lexical class had an impact on stress assignment by both two groups. People tended to place or prefer initial stress more often for nouns than for verbs. They are sensitive to the statistical distribution of noun-verb stress differences in the English lexicon. One notable exception was the case of the perception task by English speakers. In this case nouns and verbs exhibited almost the same rate of initial stress preference. It can be assumed that American participants focused on rhythmic structure of the whole sentences where nouns and verbs were preceded by unstressed syllables (“a” and “to”), which induced native speakers to prefer first-syllable stress on both nouns and verbs.

The production and the perception tasks had different effects on the preference of stress position. Both English and Japanese speakers favored more first-syllable stress in the perception task than in the production task for both noun and verb frames (t-tests, p<.001, for both groups). It appears that participants relied on the trochaic stress pattern of the nonwords caused by preceding unstressed syllables in order to judge the naturalness of the whole sentence.

Another important question is why Japanese learners of English were influenced by syllable structure and lexical class, as were native speakers of English. A possible explanation may be that (a) both English and Japanese have word-level accent, not at a phrase level such as in Korean, (b) the position of accent in both languages is not fixed, unlike Spanish with predominant penultimate stress, and (c) Japanese has a phonemic vowel-length distinction in words, although these have different systems in which accent is realized phonetically. Moreover, a search of the Japanese database (Amano & Kondo [9]) showed that among Japanese two-mora words with high familiarity ratings (more than 6 in the range of 1 to 7), nouns have more first-mora accent than verbs (56.4% vs. 44.4%), indicating noun-verbs have asymmetry in Japanese, too. It may be that Japanese learners of English are able to learn how to move stress according to syllable structure in English words and to learn the noun-verb stress asymmetry in English based on their tacit knowledge about word-accent lexical differences in Japanese.

6. Acknowledgment
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7. References

8. Appendix
Nonwords used in Experiments

<table>
<thead>
<tr>
<th>Syllable structure</th>
<th>Phonotactic legality of intervocalic consonants</th>
</tr>
</thead>
<tbody>
<tr>
<td>Illegal ini. &amp; fin.</td>
<td>Legal finally</td>
</tr>
<tr>
<td>Type 1 (standard)</td>
<td>bopken datlop pebmis fazbek signat</td>
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Type 2 (long vowel in the 1st syllable)

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<td>Legal finally</td>
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<tr>
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<tr>
<td>Type 2 (long vowel in the 2nd syllable)</td>
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Type 4 (two consonants in the onset of the 1st syllable)

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Type 5 (two consonants in the coda of the 2nd syllable)

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