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Effect of word frequency in producing English unstressed vowels by Korean learners of English

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Lee, Goun. 2018. Effect of word frequency in producing English unstressed vowels by Korean learners of English. *Studies in Phonetics, Phonology and Morphology* 24.2. 193-208. The current study aimed to investigate whether Korean L2 learners of English can acquire vowel reduction cues to stress as their English proficiency increases, and whether lexical frequency influences on the acquisition of vowel reduction. Fifteen Korean learners and 15 English speakers produced 13 English disyllabic stress minimal pairs (e.g., OBject – obJECT), adopted from Lai (2008). F1 and F2 values of the first syllables were measured and compared according to the stress patterns (first syllable stressed vs. second syllable stressed). The results showed that English proficiency cannot predict vowel reduction to stress for Korean L2 learners. However, word frequency showed a significant effect on the production of unstressed syllables from English native speakers as well as Korean learners of English, suggesting that high frequency words undergo more reduction than low frequency words. Taken together, these findings demonstrated that the difficulty in producing vowel reduction might be due to the difficulty in learning articulatory gestures, rather than to the dissimilarity of phonological features between L1 and L2. **(Sungkyunkwan University, Lecturer)**

Keywords: English lexical stress, Vowel reduction, Word frequency

1. Introduction

Previous studies in the field of L2 acquisition investigated whether L2 learners can acquire a new L2 phonological feature (i.e., lexical stress) that does not exist in their L1 phonological system. To date, two models have explained the learnability of lexical stress by L2 learners. First, the Stress Parameter Model (SPM: Dupoux et al. 1997, Dupoux and Peperkamp 2002, Peperkamp and Dupoux 2002) suggested that typological similarity between L1 and L2 only determines whether L2 learners can acquire lexical stress or not. For example, Dupoux et al. (1997, 2001) tested whether the processing of lexical stress varied based on the phonological feature of the native language (Spanish listeners vs. French listeners). While Spanish is categorized as a stress-timed language in which the primary stress falls on the final, penultimate, or antepenultimate syllables, French does not carry lexical stress. Based on these cross-linguistic differences, Dupoux et al. (1997, 2001) tested how these two groups of the listeners perceive different stress patterns. The result showed that, in an ABX discrimination task or in a sequence recalling task, French listeners systematically showed a higher error rate than Spanish listeners. Based on these results, Dupoux et al. (1997, 2001) claimed that the inability of processing lexical stress is based on the phonological pattern in their native language.

On the other hand, other papers have also suggested some evidence that L2 learners can learn a new phonological feature in a non-native-like way with cues used in their native language. A series of these studies supporting the Cue-Weighting Model provides evidence that the use cues in L2 is dependent on the significance of the cues in L1 (e.g., Ingvalson et al. 2011, Zhang and Francis 2010). For example, Iverson et al. (2003) have shown that Japanese learners of English rely on a secondary cue (F2) in distinguishing between English /r/ and /l/, whereas native speakers mainly use F3 differences (Iverson et al. 2003). Qin et al. (2017) have also shown that, regardless Taiwanese Chinese does not have lexical stress, Taiwanese Chinese could process English stress by using F0 cue. Similar results have been also found from Zhang and Francis (2010) from Mandarin Chinese learners' perception of stress such that Mandarin Chinese speakers use F0 cues more heavily than English native speakers in perceiving English lexical stress, when F0 cues and segmental cues are manipulated. Thus, these studies seem to suggest that L2 learners might be able to acquire L2 phonetic/phonological feature, albeit non-native-like, by using the phonetic cues available in their L1.

With regard to the Korean L2 learners of English, these two models suggest different predictions in terms of the acquisition of English lexical stress. As Korean does not employ lexical stress (Jun 1995, Lee 2015), SPM would predict that Korean L2 learners would not be able to acquire lexical stress at all. However, considering that the cues used in implementing lexical stress (i.e., duration, F0, and intensity) are also used in higher-level prosody, the Cue Weighting Model predicts that Korean L2 learners would be able to use these prosodic cues for lexical stress, but not in a native-like level. Contrary to what SPM predicts, previous studies (Lee et al. 2006, Han et al. 2011, Lin et al. 2013, Lee 2015) have found that, Korean learners of English can produce and perceive English lexical stress although their performance was not native-like level.

For example, Lee et al. (2006) have examined the productions of two age groups divided by age of acquisition (early: Age of Arrival (AOA) > 6 years vs. late bilinguals: AOA: < 15 years) from two L2 groups (Korean vs. Japanese). Their hypothesis was that Japanese learners would be able to use F0 and duration cue to implement stress regardless of the age of acquisition, since Japanese is a pitch-accented language which F0 pattern is used to distinguish lexical meaning of the word. Since Japanese also has vowel length contrasts, it was also predicted that both age groups in Japanese would be able to use the duration correlates. On the other hand, since Korean does not have vowel length contrasts but uses F0 to express accentual Phrase boundary (Jun 1996), it was hypothesized that Korean late bilinguals would not be able to use duration but be able to use F0 cues. Their results showed that Japanese learners of English were able to use both duration and F0 cues in a native-like way regardless of the age of acquisition. Both age groups of Korean learners of English were able to use F0 cues in a native-like way in implementing lexical stress. Thus, their results seem to indicate that the cues existing in L1 facilitates acquiring L2 phonological features.

Similar results have also been found from Shin and Lee (2016). They examined whether the use of F0 and duration correlates by Korean learners of English to implement English stress are affected by the context availability. Although their results did not find any significant effect from context on implementing stress, they found that the use of F0 cues by Korean learners are similar to native speakers. Therefore, these results also suggest that phonetic feature of the native language for the L2 learners is the crucial factor to acquire L2 lexical stress.

With respect to the acquisition of vowel reduction, however, neither of these two models predicts whether Korean learners would acquire vowel reduction. In English, in addition to the suprasegmental cues like F0, duration, and intensity, segmental differences between stressed and unstressed syllables also implement lexical stress patterns (Cutler and van Donselaar 2001, Cutler 1986). Previous studies have also found that English native speakers weight segmental cue more heavily than suprasegmental cues in perceiving lexical stress (Lee 2015, Zhang and Francis 2010). Regarding that segmental cue is an important indicator to stress in English, L2 learners might have difficulties when such cues do not exist in their native language. Since Korean does not have vowel reduction nor lexical stress, both SPM and Cue Weighting Model would predict that Korean learners of English would not be able to acquire vowel reduction at all. Regarding this, previous studies have found contradicting results in terms of production and perception of lexical stress by Korean learners. With respect to the production, Lee et al. (2006) found that late Korean/Japanese bilinguals have failed to produce unstressed syllables with reduced vowel quality. However, a previous study about perception experiment suggests that, although Korean learners failed to acquire production of reduced vowel quality, they can still perceive and use suprasegmental cue to stress (Lee 2015). For example, Lee (2015) manipulated F1 and F2 values of the stressed vowels and created 5 continua from stressed to unstressed syllable of ‘object’. She also orthogonally manipulated suprasegmental cues (intensity, duration, F0) in addition to the vowel quality in order to investigate which acoustic cues the Korean learners use in processing lexical stress as compared to the native listeners of English. The results found that Korean learners weight vowel reduction cue the most saliently, similarly to what native speakers do. These results thus suggest that Korean learners can use suprasegmental cue in perceiving English lexical stress.

Therefore, there seems to exist unparallel development between production and perception of vowel reduction by English L2 learners. If the learners store each word with different category, then, the inability of producing English unstressed vowel might be due to the fact that certain words with low frequency have not been stored in learners’ mental lexicon.

The effect of word frequency on the production and perception of language change has been suggested by exemplar theory (Goldinger 1996, Johnson 1997). Exemplar theory (Goldinger 1996, Johnson 1997) supposes that that listeners store variant details of speech segments in their episodic memory, while constructing phonemic categories of sounds based on the similar tokens collected from large clouds of exemplars. As language is used by the speakers, changes in the phonetic representation may take place while producing certain words more frequently (Bybee 2001). Thus, the phonetic representation of a frequently used word will gradually accrue more exemplars that are reduced, and these exemplars will become more likely to be chosen for production, where they may undergo further reduction (Bybee 2001, Johnson 1997, Pierrehumbert 2000, 2001).

Although not directly investigated, the effect of word frequency on acquisition of lexical stress has been found from Lin et al. (2013). Lin et al. (2013) tested Korean learners of English and Chinese learners of English by using a lexical decision task in which the stimuli were word-to-nonword pairs varied by stress positions (e.g., ‘human’ /ˈhjumən/ vs. nonword /hjuˈmæn/). The results found that neither groups of learners benefited from vowel reduction cue in judging the lexical stress. However, with respect to the word frequency, Korean learners were less accurately rejected high-frequency non-word counterpart (e.g., nonword from ‘human’ /hjuˈmæn/) than low-frequency non-word counterpart (e.g., nonword from ‘potion’ /pəʊˈʃn/). If word frequency affects acquisition of new cue, we could also find the similar effect on the production. Based on these findings, the present study aims to see whether Korean L2 learners can produce unstressed syllables with reduced vowel quality as English native speakers do, and whether word frequency affect the use of vowel reduction cue in implementing English stress.

2. Methods

2.1 Participants

Fifteen native speakers of American English (7 females, mean age = 26.4 years old (sd = 6.5)) and 15 Korean learners of English (8 males, mean age = 25.8 years old (sd = 5.8)) participated for this study. The range of age of acquisition (AOA) and length of residency (LOR) for Korean subjects were 8 to 12, and zero to 3 years, respectively. All of the Korean speakers were identified themselves as native speakers of Seoul dialect, with no hearing or speaking disorders.

2.2 Stimuli

All subjects read 13 English disyllabic stress pairs from Lai (2008). In order to prompt the intended stress pattern, the target word was first read in a context sentence such as “It is mean to insult people”. Then the same words were recorded in a carrier sentence such as "Please say insult again" in order to exclude a listing effect. Both speaker groups read the target sentences with two repetitions and only the second repetition was analyzed. Since many of the participants did not know how to produce the word *rebel*, the word pair *rebel* was not included in the analysis. Thus, a total of 720 tokens (12 words x 2 stress patterns x 30 speakers) were analyzed for this study.

2.3 Procedure

For Korean speakers, the stimuli were recorded in a quiet room located in one of the universities in Seoul, and the American native speakers were recorded in an anechoic chamber in University of Kansas. A Marantz Digital Recorder (PMD 671), a SHURE microphone (for Korean speakers) or an Electro-Voice N/D 767 cardioid microphone (for English speakers) were used for the recording apparatus. The sampling rate of recording was 22,050 Hz, and these recordings were automatically labeled and manually realigned by using Praat (version 5.3.52, Boersma and Weenink 2018). The vowel interval is determined from the onset point of the periodic glottal cycles to the offset point on the waveform. F1 and F2 values of the total vowel interval were measured. Statistical analysis was conducted in R (version 3.2.4-revised). After the recordings, Korean subjects took Michigan test (Upshur et al. 1972) in order to measure their English proficiency. The Michigan test is a standardized English proficiency test which assesses L2 English learners' comprehension ability on their listening skills and grammar. The subjects first heard 45 sentences auditorily and then had to click one possible answer presented on the screen among three options. The average score of Korean learners' Michigan test was 34.7/45 (sd = 7.5).

2.4 Data analysis

First, frequency information entered based on the Brown Corpus (Francis and Kucera 1964); then converted into a categorical variable (Low: 1-24; Mid : 41-69; High: 93-182). See Table 1 for the frequency information of the experimental words.

Table 1. Frequency information of the experimental words.

Words	First syllable stressed	First syllable unstressed	Words	First syllable stressed	First syllable unstressed
import	19	21	subject	182	12
insult	14	10	conflict	56	5
permit	5	43	contract	42	15
present	55	99	object	104	24
desert	41	19	progress	65	17
record	93	52	project	69	22

For the statistical analysis, we conducted Repeated measures ANOVAs with F1 or F2 as dependent variables and Stress (first vs. second), Height (High, Mid, Low; for F1)/or Frontness (Front, Central, Back; for F2) as within-subject independent variables and Group (Korean vs. English) as a between-subject variable. When there is a three-way interaction, we stratified the data by each speaker group and examined the two-way interactions for each group. For the analysis of the Korean speakers, we also added Proficiency (1-45) as a factor in order to examine whether proficiency can predict the production of vowel reduction on the unstressed syllables.

In order to examine the effect of word frequency on vowel reduction, we stratified data by each speaker group and conducted a separate repeated measures ANOVAs with Stress, Height/or Frontness, and Frequency (High, Mid, Low) as independent variables. In order to examine the word frequency effect, we stratified the data and ran two repeated measures of ANOVAs for each speaker group since four-way interactions can increase the Type I error (Cohen 2008). In this analysis, F1 and F2 are used as dependent variables, and Stress (first vs. second), Frequency (High vs. Mid vs. Low), and Height (High, Mid, Low; for F1)/or Frontness (Front, Central, Back; for F2) were used as independent variables. All analyses were carried out in R version 3.4.2 (R Development Team 2017) using the ez package (version 1.1-10) (Lawrence 2011).

3. Results

3.1 Results of the vowel reduction

In terms of the F1 values, we found a statistically significant main effects of Stress [$F(1, 28) = 42.52$, $p < .001$] and Height [$F(2, 56) = 16.53$, $p < .001$]. We also found a significant two-way interaction between Stress and Height [$F(2, 56) = 7.24$, $p < .001$] as well as a statistically significant three-way interaction among Stress, Group, and Height [$F(2, 56) = 8.31$, $p < .001$]. In order to further examine this three-way interaction, we stratified the data by each speaker group and conducted Repeated measures of ANOVAs. For English speakers, we found significant main effects of Stress [$F(1, 14) = 27.60$, $p < .001$] and Height [$F(2, 28) = 6.47$, $p < .001$] as well as a significant two-way interaction between Stress and Height [$F(2, 28) = 23.84$, $p < .001$], indicating that English native speakers reduced vowel quality to implement stress. For Korean speakers, however, although we found main effects of Stress [$F(1, 14) = 14.93$, $p < .001$] and Height [$F(2, 28) = 10.71$, $p < .001$], there was no significant two way interaction between these two factors ($p = .65$). When we added Proficiency as an independent variable, no interaction among these factors was found at $p > .05$, either. Thus, the insignificant interactions found from Korean speakers indicate that Korean speakers' F1 values are not centralized when the syllables of the target words are unstressed, and also the proficiency failed to predict the vowel reduction.

With respect to F2 values, there was a statistically significant main effects of Language [F(1, 28) = 5.70, p < .001], Stress [F(1, 28) = 10.01, p = .001], and Vowel Frontness [F(2, 56) = 110.93, p < .001]. Two-way interactions between Language and Frontness [F(2, 56) = 17.52, p < .001] and Stress and Frontness [F(2, 56) = 13.78, p < .001] were also found. We also found a significant three-way interaction among Stress, Group, and Frontness [F(2, 56) = 8.62, p < .001], indicating that the two group showed different degree of centralization of F2 values as a function of stress patterns. In order to further examine this interaction effect, we stratified the data by each speaker group and conducted Repeated measures of ANOVAs. For English speakers, we found significant main effects of Stress [F(1, 14) = 13.37, p < .001] and Frontness [F(2, 28) = 24.30, p < .001] as well as a significant two-way interaction between Stress and Frontness [F(2, 28) = 21.95, p < .001]. For Korean speakers, however, we only found a main effect of Frontness [F(2, 28) = 101.69, p < .001]. When we added Proficiency as a factor, no two-way or three-way interactions were found, either (p > .05). Thus, these results again indicate that while native speakers' F2 productions were centralized when the first syllable of the target words were unstressed, Korean speakers failed to do so. Also, the proficiency could not predict the vowel reduction of the unstressed syllables. Table 2 represents mean F1 and F2 values of the target words as a function of stress patterns produced by two speaker groups.

Table 1. Mean F1 and F2 values of the target words as a function of stress patterns produced by two speaker groups.

		F1	F2
English speakers	Stressed	688 (188)	1,624 (346)
	Unstressed	477 (246)	1,739 (319)
Korean speakers	Stressed	580 (196)	1,599 (477)
	Unstressed	521 (159)	1,633 (488)

3.2 Effect of word frequency on vowel reduction

In these analyses, we ran Repeated measures of ANOVAs for each speaker group, in order to decrease the likelihood of having Type I error (Cohen 2008). For English native speakers, the analysis on the F1 values showed main effects of Stress [F(1, 14) = 36.76, p < .001], Vowel Height [F(2, 28) = 7.0, p < .001], and Frequency [F(2, 28) = 13.36, p < .001]. We also found a significant two-way interaction between Stress and

Height ([$F(2, 28) = 5.24$, $p < .001$]. For F2 analysis on the native speakers' productions, the model found main effects of Stress [$F(1, 14) = 22.37$, $p < .001$], Frontness [$F(2, 28) = 29.97$, $p < .001$], and Frequency [$F(2, 28) = 54.84$, $p < .001$]. We also found significant two-way interactions between Stress and Frontness [$F(2, 28) = 14.34$, $p < .001$], Stress and Frequency [$F(2, 28) = 4.00$, $p = .003$], and Frontness and Frequency [$F(1, 14) = 7.18$, $p = .002$]. These results indicate that the higher frequency words are more centralized than lower frequency words in terms of the frontness, and also higher frequency words are more reduced when they are unstressed than lower frequency words.

With respect to Korean speakers, the analysis on the F1 values showed main effects of Stress [$F(1, 14) = 12.12$, $p = .004$] and Height [$F(2, 28) = 11.16$, $p < .001$]. We also found a significant interaction between Height and Frequency [$F(1, 14) = 6.07$, $p = .003$]. This result only indicates that higher frequency words are more centralized than lower frequency words in terms of the vowel height. With respect to the F2 values of Korean speakers' productions, we found main effect of Frontness [$F(2, 28) = 138.4$, $p < .001$] and Frequency [$F(2, 28) = 7.70$, $p = .002$]. We also found significant two-way interactions between Stress and Frontness [$F(2, 28) = 6.88$, $p < .004$] and Frontness and Frequency [$F(1, 14) = 8.88$, $p = .001$]. These results also indicate that, similarly to native speakers of English, Korean speakers' productions on vowel frontness is affected by frequency levels, and also their degree of vowel reduction as a function of stress pattern is affected by word frequency.

Figure 1 illustrates vowel space of the stressed- (left column) and unstressed- (right column) of the first syllables produced by English speakers (top row) and Korean speakers (bottom row). Each shape on the plot indicates different vowels, and lexical frequency are indicated by different colors (Green = high frequency, Black = mid frequency, Red = low frequency).

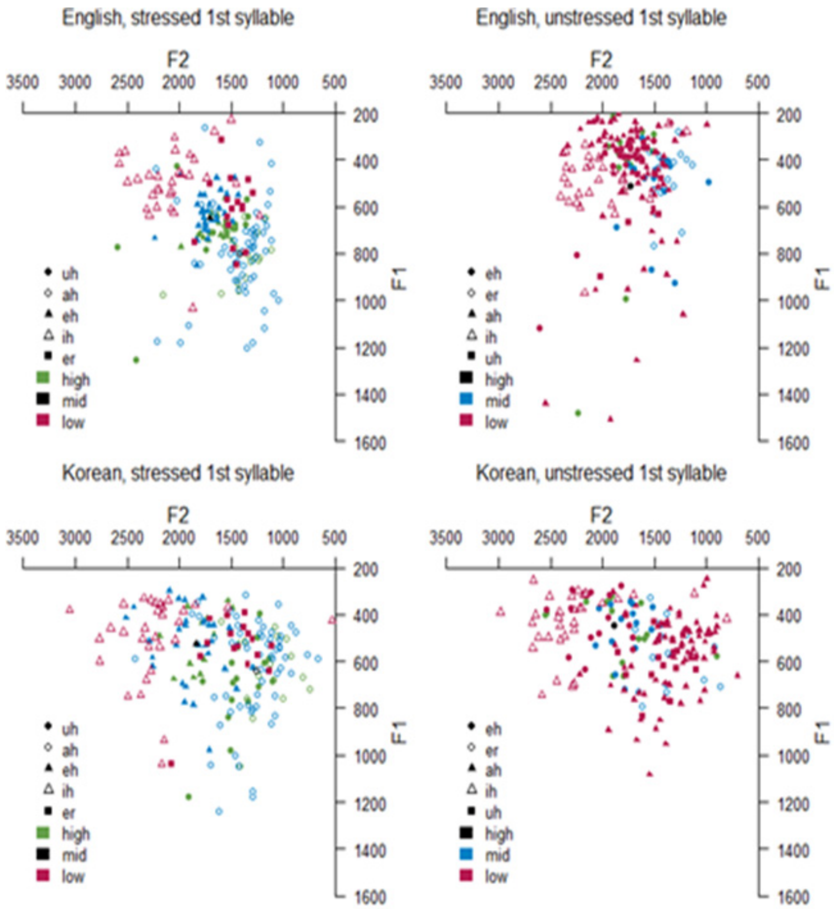

Figure 1. Vowel space of the stressed- (left column) and unstressed- (right column) of the first syllables produced by English speakers (top row) and Korean speakers (bottom row).

4. Conclusion

The current study investigated whether Korean L2 learners of English can acquire L2 lexical stress in their production. Specifically, we examined whether Korean learners of English can produce unstressed vowels with reduced vowel quality as their proficiency increases. We also examined whether the lexical frequency influences on vowel reduction. The results have demonstrated two main findings. First, Korean L2 learners failed to show the reduction of vowel quality on unstressed syllables, as suggested by insignificant interaction between Stress and Height on F1 and Stress and Frontness on F2 values. While native English speakers produced unstressed vowels with centralized vowel space, Korean speakers in general showed more expanded vowel space (See Figure 1) regardless of the stress patterns. Also, we did not find a significant interaction with Proficiency, indicating that L2 proficiency did not predict vowel reduction. This seems to be in line with what SPM suggests, such that the phonological feature in the L1 determines the learnability of L2 feature. However, based on the pervious study indicating that word frequency might have an impact on the acquisition of vowel reduction to stress (Lin et al. 2013), we have further examined whether lexical frequency predicts the degree of vowel reduction on the unstressed syllables.

In examining the effect of word frequency, the current study demonstrated that higher frequency words are more centralized than lower frequency words when unstressed, as suggested by significant interaction between Stress and Frequency, and Frontness and Frequency on F2 values by both speaker groups. This indicates that frequency affects the production of vowel reduction not only for native English speakers, but Korean learners of English. This result can be explained by exemplar theory (Goldinger 1996, Johnson 1997), supposing that phonetic representation collected from large clouds of exemplars can be varied by the frequency of word usage (Bybee 2001). While producing certain words more frequency, speakers might choose the phonetic representation that has more thicker clouds of exemplars. Exemplar theory thus can explain that high frequency word will be acquired more easily than low frequency words since the clouds of exemplars of high frequency words are thicker than low frequency words. As shown from the frequency and stress interaction, the higher frequency words have greater centralization of vowel quality than lower frequency words. Thus, it could be the case that learners need more exemplars of each word in order to fully acquire vowel reduction cues in stress. Therefore, opposing to SPM, the current study contributed to find that L2 learners whose native language does not employ lexical stress can still acquire L2 phonological feature (lexical stress), albeit non-native-like.

Then, why did we observe an asymmetry between production and perception in acquiring vowel reduction cue to stress in previous literature? Recall that Lee (2015) found that Korean learners of English dominantly weighted vowel reduction cue in perceiving stress pattern than any other suprasegmental cues. However, Lee et al. (2006) showed that late Korean bilinguals of English failed to acquire vowel reduction in their production. If the difficulty to acquire lexical stress in the production resulted from articulatory difficulty, not because of the perceptual deafness of L2 learners, then we might be able to explain why previous studies have shown inconsistent results between production and perception. According to the Speech Learning Model (SLM, Flege 1995), the acquisition of L2 sounds are dependent on how similar an L2 sound is to that of L1 phonetic category. In this model, it is presupposed that accurate perception needs to be preceded in order to achieve accurate production of L2 categories. In other words, L2 learners will be able to produce L2 sounds accurately if and only if they can perceive these L2 sounds accurately. However, this does not mean that accurate perception can guarantee the accurate production, since learners might fail to produce the target sounds in a native-like-way due to the mismatching of the timing in their articulatory gestures. If this is the case, we can explain why previous studies have shown that Korean learners were able to perceive vowel reduction cues in detecting stress patterns (Lee 2015), while they were not able to reduce the vowel quality in their production (Lee et al. 2016). The results of the current study that frequency effect on vowel reduction seems to support this explanation, since learners seems to be able to reduce greater degree of vowel quality as their exemplars accrue. As a future study, investigating whether the word frequency also affects the perception of vowel reduction, and what the relationship between the production and perception of vowel reduction cue to stress will be able to shed a light the learnability of L2 lexical stress.

Appendix A. Stimulus list of contextually-related sentences adopted from Lai (2008)

1. conflict
    There is a conflict between them. (8 syllables)
    This does not conflict with her plan. (8 syllables)
2. contract
    The new contract is much better. (8 syllables)
    Steel will contract when it is cooled. (8 syllables)
3. desert
    This desert is very hot. (8 syllables)
    It is bad to desert pets. (8 syllables)
4. digest

Reader's Digest is popular. (8 syllables)
It is hard to digest this book. (8 syllables)

5. import
   Bananas are an import for Japan. (10 syllables)
   We import apples from America. (10 syllables)
6. insult
   That is the worst insult I know. (8 syllables)
   It is mean to insult people. (8 syllables)
7. object
   The object of this game is to win. (9 syllables)
   I object this proposal strongly. (9 syllables)
8. permit
   I got my learner's permit this year. (9 syllables)
   I will not permit you to go there. (9 syllables)
9. present
   Jack gave me a present for Christmas. (9 syllables)
   We will present our project today. (9 syllables)
10. progress
   I am making progress on my book. (9 syllables)
   Children learn as they progress in school. (9 syllables)
11. project
   Mary started her project yesterday. (10 syllables)
   He likes to project photos on big screens. (10 syllables)
12. rebel
   He is a rebel in his own country. (10 syllables)
   It is unwise to rebel against him. (10 syllables)
13. record
   It is a record of your grades. (8 syllables)
   We record ten native speakers. (8 syllables)
14. subject
   It is an easy subject for him to learn. (11 syllables)
   It makes no sense to subject yourself to this. (11 syllables)

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