

Acoustic Analysis of a Canadian French Speaker's Production of English Stress

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Lexical stress in English plays an important role in native speakers' perception and processing of speech. French learners of English have a fixed final-stress system, which differs from the free variable-stress system of English. This difference in stress systems between the two languages may result in interference from the native language stress system on the production of English stress by French learners of English. This paper reports a phonetic experiment that sets out to test the hypothesis of native language interference on stress production. One female native English speaker and one female French learner of English produced 50 initially-stressed, trisyllabic English words of French etymology (balanced for word frequency) twice in a carrier phrase 'I didn't say ____, but you said ____ yesterday.' In the carrier phrase, the first instance of the target word functions as new information and occurs on an intonational phrase boundary, and the second occurrence of the target word serves as old information and occurs in the intonational phrase medial position. The carrier phrase is designed this way in order to avoid the boundary effect of high tone that is often observed due to the French prosodic structure, and to investigate the effect of information structure of new and old information. A 2 (language) \times 3 (syllable position) repeated-measures ANOVA was conducted on the data for each parameter of stress: fundamental frequency, amplitude and duration. The results supported the hypothesis of native language interference for the French learner of English. Further analysis was performed for the target word in the prosodic structure and word frequency. Unlike the native English speaker who showed an effect of frequency and prosodic structure, neither had an effect on the overall results for French learners of English.

Keywords: Canadian French learners of English, English stress, prosodic transfer, L1 transfer on L2, acoustic correlates, Trisyllabic words of French etymology

1. Introduction

Lexical stress in English is an important component in speech perception and processing by native speakers. Since incorrect stress placement can con-

tribute to foreign accent, second-language learners of English need to be able to correctly produce stress to achieve native-like productions so that they can communicate more effectively in English (Derwing et al. 1998, Hahn 2004). Derwing et al. (1998) provide evidence that while learners who had received only segmental instruction improved their comprehensibility and accentedness when reading simple sentences, learners who had received instruction on prosodic features such as word stress and sentence stress showed significant improvement in comprehensibility and accentedness when they produced extemporaneous narratives as well as simple sentences. Hahn (2004) had a proficient Korean learner of English read three identical mini-lectures in English, each of which had the assignment of primary stress manipulated to a degree. Three groups of undergraduate students were asked to listen to the mini-lectures. Hahn (2004) reported that students who heard the lecture with the appropriate stress assignment understood the contents of the mini-lectures significantly more than either of the other two groups.

Learning an L2 (second language) stress system is influenced by L1 (first language) phonology. L1 speakers of Chinese and Japanese appear to memorize the position of stress for each individual word in English (Archibald 1997). Interference (or negative transfer) happens when there is a difference between a component of the native and the second language, which hinders the acquisition of that component in the second language (Rasier & Hiligsmann 2007). Polish, Hungarian, Spanish, and French learners of English, whose native languages have fixed stress systems, appear to be influenced or experience interference from their L1 phonological system (Archibald 1994, Pater 1997).

The present study adds to the existing literature on second language acquisition by reporting experimental results illustrating acoustic correlates that pertain to perceived foreign accent and intelligibility due to the influence of L1 on L2 stress production.

Generally speaking, French is a fixed-stress language, placing stress on the final non-schwa syllable of a word, whereas English is a free-stress language with stress occurring in various locations depending on the word (Doupoux & Peperkamp 2002, Guion 2003). In English, many exceptions aside, primary stress tends to be assigned to one of the final three syllables of a word, the precise syllable being determined by syllable weight and lexical category distinctions (Collie 2007: 3). To be more concrete, the most prominent syllable in non-derived nouns tends to be the penultimate syllable if it is heavy, and the antepenultimate syllable otherwise (Halle & Vergnaud 1987: 227-231). The most prominent syllable in non-derived verbs and adjectives tends to be the word-final syllable if it is heavy (i.e., if it contains a long vowel or a complex coda), and the penultimate syllable otherwise. Since the stress systems of French and English differ, the notion of negative transfer or interfer-

ence could be relevant to a second language study of English stress by native French speakers. For example, Doupoux et al. (1997) examined stress perception by native French participants and found that French speakers have difficulty perceiving stress contrasts in languages such as Spanish, which has contrastive stress. These researchers have described this inability to perceive stress contrasts as stress 'deafness.' Since they are unable to perceive stress, it is likely that native French speakers are unable to correctly produce lexical stress. Therefore, it is possible that the non-lexical, fixed-stress component of the French stress system interfere with the production of lexical stress in English, especially if the French learners of English are exposed to the English environment for a limited amount of time.

As mentioned in Rasier and Hiligsmann (2007), however, little research has been done on the interference effects of L1 on the acquisition of prosodic characteristics of L2. Furthermore, it is not evident what the outcome of research on the prosodic acquisition will be. Archibald (1994) reports errors of L2 English stress made by Polish speakers. The regular Polish stress pattern is penultimate (i.e., second to the last syllable of a word; Gussmann 2007). More often than not, the Polish participants put the stress on the initial syllable in trisyllabic nominal forms (e.g., *horizon*), and on the final syllable in trisyllabic verbal forms (e.g., *astonish*), rather than the appropriate penultimate syllable (p. 230). Archibald (1994) explained that the Polish learners of English treated all verbs as a single class, and the learners appeared to apply a process like 'if it's a verb, stress the final syllable' to verbs (p. 230). This rule may be derived from many verbs that bear stress on the final heavy syllable (e.g., *maintain*, *decide*). Therefore, it is not apparent whether learners of English will assign stress to words on the basis of the L1 stress pattern according to the appropriately acquired English stress pattern, or an incompletely learned interlanguage stress system. Waniek-Kimczak (2002) also suggested that L2 learners could be affected by the weight of a syllable and might end up acquiring an interlanguage grammar. In the study, Polish learners of English tended to stress the long vowels and diphthongs. Pater (1997) reported similar finding in French Canadian learners of English. Pater (1997) investigated the L2 acquisition of English word stress using contextualized nonsense words. French Canadian learners of English in their first week of a summer immersion program and native speakers of English completed a nonsense word production task. The stimuli included trisyllabic nonsense words containing a light or heavy penult of variable length. All the words were contextualized as nouns. The participants with a target-like grammar were expected to stress the penult when it was heavy and the antepenult when the penult was light. The native speakers' productions of trisyllabic words were more or less as expected. Similarly to the native speakers, the L2 learners consistently stressed the trisyllabic words with a light penult

word-initially. Yet, on the trisyllabic words with a heavy penult, they stressed either the penult or the antepenult. Pater interpreted these results as an indication that the L2 learners were in the process of learning that syllable weight influence stress placement in English. Tremblay and Owens (2010) investigates the acquisition of English word stress by Canadian French learners of English. They observed disyllabic and trisyllabic nonsense nouns produced by L2 learners and native English speakers. The nonsense nouns were designed by aligning the head of trochaic foot with heavy syllables. The participants with consistent stress patterns were grouped according to their prosodic grammar, and their productions were analyzed acoustically. The L2 learners who failed to align the head of the trochaic foot with the heavy syllable realized stress with higher pitch. On the other hand, the L2 learners who aligned the head of the trochaic foot with the heavy syllable realized non-initial stress by lengthening the syllable. The findings are interesting in that these findings suggest that L2 learners may attend to distinct acoustic cues to English stress. Unexpectedly, however, the native speakers produced higher pitch on the initial syllable irrespective of the position of stress of the putative nonsense words. Given the role of pitch in English stress, it may be the case that the unexpected high pitch on initial syllable is due to the use of non-sense words.

According to Guion et al. (2004), works such as Pater (1997) pose problems in that they assume that “metrical parameters and algorithms for stress placements are at work in native speakers, but do not provide empirical support for these assumptions (p. 208).” For example, Pater (1997) reported that some of the words with heavy penults (e.g., *kapistratson*, *katapestos*) “occasionally received antepenultimate stress, which is completely unexpected, as real words almost never display this pattern. (p. 245).” The learner behavior with respect to L2 stress placement needs to be explained by factors other than metrical parameter settings that still wait for empirical evidence, or empirical evidence is needed for metrical parameter approach. As an alternative to the metrical parameters approach to L2 phonology acquisition, Guion et al. (2004) tested the influence of syllable structure, lexical class, the stress placement of phonologically similar words in English nonsense words by native speakers of English, and early and late Spanish-English bilinguals.

The aim of the present study is to examine acoustic correlates that pertain to perceived foreign accentedness and intelligibility due to the influence of L1 on L2 stress production. In particular, by using English words of French etymology, we aim to illustrate the effects of transfer from the L1 stress system to that of L2 from a Canadian French speaker of English who moved to an English speaking region in Canada, specifically examining the effects of stressed syllable position within prosodic structure, and the effects of familiarity or frequency of the target word.

In Canadian French, the most prominent syllable is typically the last syllable in the word not containing a schwa (e.g., Walker 1984, Fagyal et al. 2006). However, stressing the last syllable in French is prone to being masked by other utterance-level prosodic phenomena. In addition to lexical stress, French is influenced by the intonational phenomena of accentual phrase (AP) and Intonational Phrase (IP) boundary tone (Fougeron & Smith 1999, S-A Jun & Fougeron 2002, Fagyal et al. 2006). As a consequence, “although French is often described as having stress on word-final syllables, in connected speech this is pre-empted by the accent on the final syllable of a group of words (sense group or accentual group)” (Fougeron & Smith 1999: 80), or by the boundary tone at the Intonational Phrase (Fagyal et al. 2006: 73).

In addition to the prosodic structure, the familiarity of words will influence the production of L2 stress patterns. The participants reported in Archibald (1994) vary in their exposure to L2 English learning from a few months to a number of years. It is quite uncertain whether the interlanguage phonological system is present for all learners, or it appears after certain amount of exposure to L2 English. Flege's (1995) Speech Learning Model (SLM) is based on the premise that the L1 shapes how the learner perceives the L2. The model also posits that the acquisition process begins with L1 perceptual categories, but states that these categories may change as a result of more L2 experience. Given this premise, more frequently used English words are more likely to induce appropriate stress assignment than less frequent English words.

Thus, the following experiment attempts to answer the question of whether there would be interference from the native language (French) stress system in the production of English stress. It is hypothesized that there will be interference from the native language given both the differences in the stress systems of French and English and the observed difficulties with stress in English by various French learners of English. Incorrect stress production in English words by French learners of English will provide evidence supporting this hypothesis; more specifically, the French learners of English would demonstrate L1 interference by placing stress on the final position of an English word (test stimuli) in accordance with their native fixed final-stress system.

We designed the stimuli using trisyllabic English words. Since the French stress system puts stress on the last syllable of a word, it would be interesting to look at where they would produce stress on an English word with non-final stress. Since English words have a tendency to be forestressed (stress on the initial syllable), we chose stimuli that have initial stress, as there would be a higher proportion of initially stressed real words (as opposed to non-words which are often used in experiments) in the English language (Sereno & Jongman 1995). We measured acoustic correlates of stress on each syllable

by extracting fundamental frequency, duration and amplitude (Serenó & Jongman 1995). To verify that these test words are actually initially stressed in English, we recruited a control participant who is a native English speaker. This control participant is of the same gender and of approximate age as the French learner of English in order to compare acoustic cues of stress such as fundamental frequency (which is in different ranges for males and females). Since real words were used, the effect of lexical frequency must also be examined to see if it has any effects on the results; thus, a balanced word list containing frequent and infrequent words was constructed to examine the effect of lexical frequency. As well, by using target English words with a French etymology, we attempted to encourage French learners of English to deliberate between using French or English stress patterns. Due to this criterion, it is important that the English control participant not have had significant formal training in French, which may result in the French (L2) stress production of that test word (with stress on the final syllable).

Finally, care was taken to minimize the influence of prosodic effects on acoustic realizations of target words. In English, there are effects of a word's position at an intonational phrase boundary on stress production; for example, duration increases and fundamental frequency decreases on the last syllable of a word at an intonational phrase boundary (Shattuck-Hufnagel & Turk 1996). On the other end, duration and fundamental frequency increase when the target words are placed in utterance-initial position, due to the so-called prosodic strengthening effect (Fougeron & Keating 1997). As a consequence, the location of target words within an utterance may be masked by prosodic structure. It is important, therefore, to consider the location of the target word within the carrier phrase to see if the location affects the overall results. The location of the target word within a carrier phrase is assessed for its effects on the results, since intonational contexts can play a role in stress production (Shattuck-Hufnagel & Turk 1996). The position within a carrier phrase along with all the previous considerations were each accounted for in the development of the experimental design that was used to test the hypothesis of L1 interference on stress production by French learners of English.

2. Method

2.1. Subjects

One female French learner of English (age = 24) and one female, native English speaker (age = 22) participated in the experiment. Participants were recruited from Victoria, BC through their response to poster advertisements.

The criterion for the participation in the experiment was an intermediate level of French learners of English who had dominant French usage in their daily activities, but who could communicate in English. No formal assessment of proficiency test was conducted. While it is the case that we need more participants (preferably across different proficiency levels (cf. Tremblay & Owens 2010)), in order to make any outcome of the experiment as representative of French learners of English, we chose to do an in-depth analysis of an individual speaker's behavior as a case study. Given the large enough number of tokens analyzed, the result in this experiment can be interpreted as an exemplar of the speaker's production of English words. The French participant's native language was French and she reported greater ease of communication in French than in English. She had arrived in an English-dominant community 12 months prior to her participation in the experiment. The native English participant had been brought up in a home environment where English was the only language spoken by both parents and was the only language used to communicate on a daily basis. She had no formal French language training or education.

2.2. Stimuli

A word list consisting of 100 words was developed to elicit lexical stress production of English words. The 50 target words contained 3 syllables and had primary stress on the first syllable of the word. We decided to use real words, unlike earlier studies that use nonsense words (cf. Pater 1997, Tremblay & Owens 2010). The reason is that non-sense words elicit some unexpected results from Native English speakers, which makes it hard to interpret the results of the learners of English. The words were also of French etymology and were balanced for word frequency (25 frequent words and 25 infrequent words). By taking word frequency into account, we attempted to control for practice or memory effects. The infrequent words were deemed as such by a definition of 'rare' from the Oxford English Dictionary, or because they were from a specific field or technical discipline, where their frequency would be limited. Six target words were removed from further analysis due to incorrect syllable or stress production by the English participant (i.e., *temperature*, *miserable*, *ralliance*, *remeal*, *pacifism*, *dolerite*); therefore, 44 target words were analyzed (23 frequent words and 21 infrequent words). The other 50 words were distracter words that helped prevent the participants from detecting the purpose of the experiment or the fact that the target words all had native stress on the first syllable. These words were three or more syllables in length but the primary stress was not on the first syllable of the word nor did the etymology of the word necessarily need to be French. Table 1 presents a few samples of the stimuli under the conditions of frequent words, infre-

quent words, and distracters. A complete list of all stimuli used in the experiment can be found in Appendix A.

Table 1. Example trisyllabic target words.

Frequent words	Infrequent words	Distracters
integer	sagathy	intangible
popular	salangane	integument
general	baladine	population
restaurant	balafon	generosity
conference	baluster	genomic

Each word was presented orthographically twice in the following carrier phrase: “I didn’t say ____, but you said ____ yesterday.” The first production of the target word was at an intonational boundary whereas the second production was in the medial position of the intonational phrase. The carrier phrase is designed this way in order to avoid the effect of high tone that would be observed by the default French intonational phrase of the Low High Low High (LHLH) tonal sequence. That is, if the French speaker produced the stress by means of high pitch on the ultimate syllable in the trisyllabic words, the higher pitch on the last syllable than the previous two syllables may be due to the influence of the intonational contour that may ends with high tone rather than due to the influence of word stress (Fagyal et al. 2006). The word list was presented to the participants in a randomized order of target words and distracter words via a Powerpoint presentation on a computer screen in the recording booth. There were 44 target words each with 2 productions, which resulted in 88 lexical target words for analysis.

2.3. Procedure

Participants were given a brief introduction to the study and were asked to read and sign the participant consent form. Each participant was informed about the presentation of the stimuli and adjusted for the correct microphone recording levels. The participants were given three practice examples using the experimental carrier phrase and were instructed to produce the sentences as naturally as possible without hesitation. They were told that if they had pronunciation difficulties, they should say the word to the best of their abilities without stopping to correct themselves. If they did hesitate, participants were asked to try the sentence again until their production was without pause or hesitation. Participants then continued on with the production of the experimental words (target and distracter words), in 3 blocks (Block 1:40 words; Block 2 and 3:30 words each) stopping after each block to

give participants a short 2 minute break. At the beginning of both blocks 2 and 3, the participants were given a practice carrier phrase to reacquaint themselves with the experimental procedure before continuing with the experiment.

After completing the experiment, the participants filled out a form giving their personal background information. The form contained questions about age, gender, age of arrival in an English speaking province, age that English was first learned, native language of their parents, language spoken in the home, years of formal English instruction, level of education completed, length of time spent in an English-dominant environment, knowledge of other languages, percentage of daily communication in English, and a self-reported English fluency level on a scale of 1 to 5. At the end of the experiment, the participants were debriefed on the purpose of the experiment and were thanked for their participation. The participants' productions were recorded using a condenser microphone in a sound-treated booth at the University of Victoria Phonetics lab. The program Audacity was used to record the productions directly into a computer workstation with a sampling rate of 44,100 Hz and a quantization rate of 16 bits. The target words were analyzed using Praat to determine the pitch, amplitude and duration of the stressed syllables.

2.4. Analysis

This experiment was designed to measure the stress production of a French learner of English compared to that of a native English speaker. The independent variables were language group (French or English), and stress placement (syllable 1, 2, 3). The dependent variables were three acoustic cues of stress: fundamental frequency, duration and amplitude of each syllable. The measurement domain of the acoustic cues was limited to the syllable nucleus within each syllable. In analyzing the target words, the acoustic stress cues of the three syllable positions of the target word were measured for the French participant and compared to those of the native English participant to determine which syllable the stress was placed on by the French learner of English. Further analysis was done to determine if the results were affected by word frequency or the position of the target words with respect to the prosodic structure.

3. Results

3.1. Overall Results

A 2 (language: French vs. English) \times 3 (syllable position: 1 vs. 2 vs. 3) repeated-measures ANOVA, with syllable position as the within-subjects variable, was conducted for the participants' data. In examining the results for each of the two language groups (French and English), three separate ANOVAs were additionally conducted for each of the two language groups across the three syllable positions (1st, 2nd, 3rd) for all three parameters of stress (fundamental frequency, duration and amplitude). Table 2 presents descriptive statistics for the means and standard deviation of each of the three acoustic properties.

Table 2. Descriptive statistics for mean values and standard deviations (SD) of fundamental frequency (Hz), duration (ms) and amplitude (dB) across syllable positions (1st, 2nd, 3rd) for French and English speakers.

		Syllable Position					
		French			English		
		1st	2nd	3rd	1st	2nd	3rd
F0 (Hz)	Mean	174.63	191.02	201.53	193.86	184.16	179.69
	SD	35.94	25.67	25.74	28.43	45.29	33.31
Duration (ms)	Mean	83.97	77.14	116.26	109.23	54.22	99.73
	SD	28.84	35.45	45.06	33.11	24.32	39.72
Amplitude (dB)	Mean	71.79	71.14	72.04	69.07	66.20	64.78
	SD	3.83	3.79	3.40	3.68	3.65	2.95

3.1.1. Fundamental Frequency (F0)

For fundamental frequency, there was neither a significant main effect for syllable position nor for language. The syllable position \times language interaction was found to be significant $F(2, 348) = 19.64, p < .001$ (partial $\eta^2 = .10$) indicating that the differences in F0 values for the three syllable positions were differently affected depending on whether the participant was French or English, as seen in Figure (1). For the English speaker, a difference in mean F0 values for syllable position was approaching significance $F(2, 174) = 3.67, p = .06$ (partial $\eta^2 = .04$), with the only significant difference of mean F0 values occurring between syllable 1 (193.86 Hz) and syllable 3 (179.69 Hz), whose mean F0 value was significantly less than that of syllable 1. For the French speaker, a significant difference in mean F0 values was found for syllable position $F(1, 174) = 23.85, p < .001$ (partial $\eta^2 = .22$), indicating the

mean F0 value for syllable 3 (201.53 Hz) was significantly greater than the values for both syllable 2 (191.02 Hz) and syllable 1 (174.63 Hz), with the mean F0 value for syllable 3 being significantly greater than that of syllable 2.

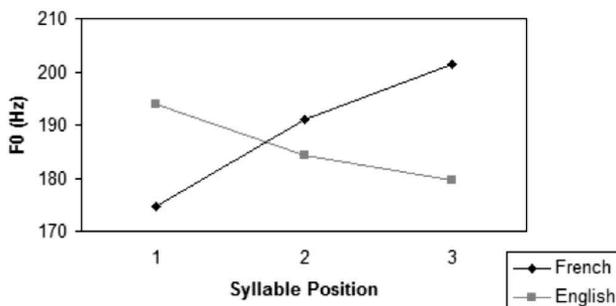


Figure 1. Mean F0 values across syllable position for French and English speakers.

3.1.2. Duration

For duration, a significant main effect was found for syllable position $F(2, 174) = 66.09, p < .001$ (partial $\eta^2 = .28$), but not for language. Pairwise comparisons revealed that mean duration values were significantly greater for syllable 3 (108.00 ms) than for syllable 1 (96.60 ms), both of which were significantly greater than the mean value of syllable 2 (65.68 ms). A significant interaction for syllable position \times language was found $F(2, 348) = 23.60, p < .001$ (partial $\eta^2 = .12$), which shows that differences in duration values for the 3 syllable positions were differently affected depending on the language of the participant, as shown in Figure (2). For the English speaker, a significant difference in mean duration values was found for syllable position $F(2, 174) = 74.44, p < .001$ (partial $\eta^2 = .46$), with mean duration values being significantly greater for syllable 1 (109.23 ms) than for syllable 2 (54.22 ms), which is significantly less than those for syllable 3 (99.73 ms). The difference between mean duration values for syllables 1 and 3 was not significant. For the French speaker, duration means showed a significant difference in values for syllable position $F(2, 174) = 25.09, p < .001$ (partial $\eta^2 = .22$), with mean duration values for syllable 3 (116.26 ms) being significantly greater than values for syllable 1 (83.97 ms) and syllable 2 (77.14 ms).

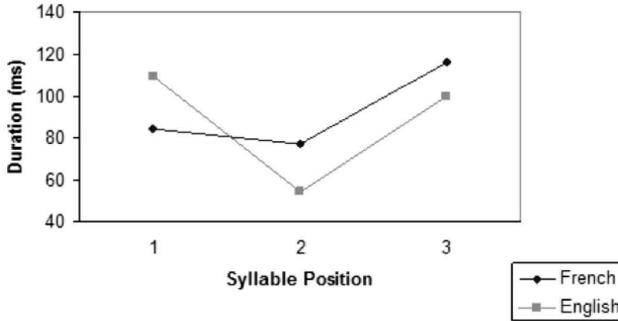


Figure 2. Mean duration values across syllable position for French and English speakers.

3.1.3. Amplitude

For amplitude, there was a significant main effect for syllable position $F(2, 174) = 52.72, p < .001$ (partial $\eta^2 = .23$) as well as for language $F(1, 174) = 108.95, p < .001$ (partial $\eta^2 = .39$). Pairwise comparisons of syllable position indicated that mean amplitude values of the 1st syllable were significantly greater than values for the 2nd syllable (68.67 dB) and the 3rd syllable (66.41 dB) whose values did not significantly differ. Pairwise comparisons of language showed that the mean amplitude values for the French speaker (71.66 dB) were significantly greater than the values for the English speaker (66.68 dB). This amplitude difference between the participants may be due to microphone placement or individual differences. A significant interaction of syllable position \times language was discovered $F(2, 348) = 56.09, p < .001$ (partial $\eta^2 = .24$), which indicates that the differences in amplitude values for the three syllable positions were affected differently depending on whether the speaker was French or English, as in Figure (3). With respect to amplitude in the English speaker, mean amplitude values were statistically different for syllable position $F(2, 174) = 105.85, p < .001$ (partial $\eta^2 = .55$), with mean values being significantly greater for syllable 1 (69.07 dB) than for either syllable 2 (66.20 dB) or syllable 3 (64.78 dB); the mean amplitude value of syllable 2 was also significantly greater than that of syllable 3. For the French speaker, amplitude also demonstrated a significant difference in mean values for syllable position $F(2, 174) = 4.55, p < .05$ (partial $\eta^2 = .05$), but the difference was only significant between mean amplitude values of syllable 2 (71.14 dB) and syllable 3 (72.04 dB) with syllable 3's mean amplitude value being greater than that of syllable 2. No significant difference was found between syllable 1 (71.79 dB) and syllable 3 (72.04 dB).

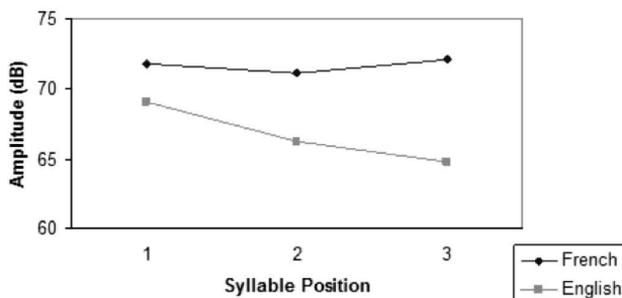


Figure 3. Mean amplitude values across syllable position for French and English speakers.

Thus, the results for the English participant demonstrated a significantly higher F0 and higher amplitude for syllable 1 compared to syllable 3 of the 44 English lexical items tested. Durational differences were not found to be significant between syllables 1 and 3. Overall, it appears that the English participant stressed syllable 1 more than any other syllable position as was predicted given that the lexical test items contained initial stress. On the other hand, the results for the French participant demonstrated a significantly higher F0 and longer duration for syllable 3 compared to syllable 1 of the 44 English lexical items tested. Amplitude was not found to be significantly different between syllables 1 and 3. Overall, it appears that the French participant stressed syllable 3 more than syllable 1 as predicted. It is interesting to note that while F0 is used commonly in both English and French speakers to cue lexical stress, duration and amplitude are used differently depending on the speaker. In addition to F0, the English speaker uses amplitude, whereas the French speaker uses duration in conveying stress.

3.2. Effects of Word Frequency

The overall results indicate that the French speaker did not seem to learn the L2 English stress pattern. Further analysis is needed to determine if the lexical frequency of target words influenced the production of stress by the French and English participants. For the English speaker, the results for word frequency showed a similar pattern to the overall stress production trend (significantly higher F0 and amplitude for the 1st syllable compared to the 3rd syllable) for the English participant with respect to infrequent words. Regarding frequent words, there was significantly longer duration and higher amplitude for the 1st syllable compared to the 3rd syllable.

On the other hand, the results for word frequency of the French speaker also showed a similar pattern to the overall stress production trend for the

French participant for both frequent and infrequent words (significantly higher F0 and longer duration for syllable 3 compared to syllable 1).

For fundamental frequency, there was a main effect of syllable position, $F(1, 172) = 23.62, p < .001$ (partial $\eta^2 = .22$), but there was no significant interaction between syllable position and word frequency for F0. There was also no significant main effect for word frequency. Both frequent and infrequent words showed a significant main effect for syllable position (frequent words: $F(2, 46) = 11.67, p < .01$, partial $\eta^2 = .21$; infrequent words: $F(2, 42) = 12.10, p < .01$, partial $\eta^2 = .23$), with mean values of F0 for syllable 3 (frequent words: 202.11 Hz; infrequent words: 200.90 Hz) being significantly greater than for both syllable 1 (frequent words: 176.15 Hz; infrequent words: 172.96 Hz) and syllable 2 (frequent words: 193.63 Hz; infrequent words: 188.16Hz), which was significantly greater than the values for syllable 1.

Duration demonstrated a main effect of syllable position $F(2, 172) = 26.09, p < .001$ (partial $\eta^2 = .23$) as well as a significant interaction between syllable position and word frequency $F(2, 172) = 5.65, p < .05$ (partial $\eta^2 = .062$). There was also a marginally significant main effect for word frequency $F(1, 172) = 3.95, p = .05$ (partial $\eta^2 = .044$), with further t-tests determining that there was a significant difference in the mean duration values for the 2nd syllable between frequent and infrequent words ($p < .001$). As in F0, frequent and infrequent words showed a significant main effect of syllable position (frequent words: $F(2, 46) = 22.17, p < .001$, partial $\eta^2 = .33$; infrequent words: $F(2, 42) = 11.00, p < .001$, partial $\eta^2 = .21$) with the mean duration value for syllable 3 (113.66 ms) being significantly higher than values for both syllable 1 (88.84 ms) and syllable 2 (63.66 ms). While the second syllable in frequent words was significantly shorter in duration than syllable 1, the difference between mean duration values for syllable 1 and 2 in infrequent words was not significant.

Amplitude showed a main effect of syllable position $F(2, 172) = 4.37, p < .05$ (partial $\eta^2 = .05$) but did not indicate a significant interaction between syllable position and word frequency. There was also no significant difference between infrequent and frequent words. Frequent words showed a significant main effect for syllable position $F(2, 46) = 4.11, p < .05$ (partial $\eta^2 = .084$), but pairwise comparisons revealed no significant difference for amplitude values between syllables 1 and 3 nor between syllables 1 and 2; the only significant difference was between syllables 2 and 3, with syllable 3 (72.17 dB) having a significantly greater mean amplitude value than syllable 2 (70.84 dB). Infrequent words, however, did not show a significant main effect of syllable position for the French participant.

The analysis of the French participant's results indicates that the stress production of the English target words was not differently affected by word

frequency. That is, no indication is found that frequent words are more likely to be correctly produced than infrequent words.

3.3. Influence of Prosodic Structure

Further analysis was also needed to determine if the position of the target words within the carrier phrase has an influence.

The results of the English participant showed a similar pattern to the overall stress production trend (significantly higher F0 and longer duration for the 1st syllable compared to the 3rd syllable) for the first occurrence of the target words in a carrier phrase. For the second occurrence of the target words, there was significantly longer duration and higher amplitude for the 1st syllable compared to the 3rd syllable, but no higher frequency. If the fact that the first target words are new information, and the second target words are old information is taken into account, it can be explained why there is no effect of F0 on the second occurrence of the target words in the carrier phrase.

The results for sentence production for the French participant showed a similar pattern to the overall stress trend of a significantly higher F0 and longer duration for the 3rd syllable compared to the 1st syllable for both occurrences of target words. For fundamental frequency, there was a main effect of syllable position, $F(2, 174) = 23.96$, $p < .001$ (partial $\eta^2 = .22$), but there was no significant interaction between syllable position and position of the target words for F0. There was also a significant main effect for the target word position in the carrier phrase $F(1, 174) = 34.63$, $p < .001$ (partial $\eta^2 = .29$) with the F0 values across each syllable position being significantly higher for the first occurrence than for the second occurrence ($p < .05$). The function of new and old information is likely to make this distinction. Both the first and second occurrences of the target words showed a significant main effect for syllable position (the first occurrence: $F(2, 43) = 22.30$, $p < .001$, partial $\eta^2 = .34$; the second occurrence: $F(2, 43) = 5.96$, $p < .05$, partial $\eta^2 = .12$), with mean values of F0 for syllable 3 (215.92 Hz and 182.44 Hz for the first and second occurrences, respectively) being significantly greater than syllable 2 (201.52 Hz and 187.13 Hz, respectively) which was significantly greater than for syllable 1 (182.44 Hz, and 162.81 Hz, respectively).

Duration demonstrated a main effect of syllable position $F(2, 174) = 25.20$, $p < .001$ (partial $\eta^2 = .23$) but there was not a significant interaction between syllable position and the position of target words in the carrier phrase. There was also a significant main effect for the position of the target words in the carrier phrase $F(1, 174) = 7.59$, $p < .01$ (partial $\eta^2 = .081$), with further t-tests determining that there was a significant difference in the mean

duration values for the 3rd syllable the first and second occurrence of the target word in a carrier phrase ($p < .05$). As in F0, both the first and second occurrences of the target words showed a significant main effect of syllable position (first occurrence: $F(2, 43) = 14.64$, $p < .001$, partial $\eta^2 = .25$; second occurrence: $F(2, 43) = 11.11$, $p < .01$, partial $\eta^2 = .21$) with the mean duration value for syllable 3 (126.61 ms for the first occurrence vs. 105.91 ms for the second occurrence) being significantly higher than values for both syllable 1 (84.59 ms vs. 83.35 ms) and syllable 2 (82.11 ms vs. 72.18 ms). There was no significant difference between mean duration values for syllable 1 and 2.

Amplitude showed a main effect of syllable position $F(2, 174) = 4.55$, $p < .05$ (partial $\eta^2 = .05$) but did not indicate a significant interaction between syllable position and the position of the target word in the carrier phrase. There was also no significant difference between the first and second occurrence of the target. The first occurrence showed a significant main effect for syllable position $F(1, 174) = 4.52$, $p < .05$ (partial $\eta^2 = .10$), but pairwise comparisons revealed no significant difference for amplitude values between syllables 1 and 3. The only significant differences were between syllables 1 and 2 and between 2 and 3, with syllable 3 (72.59 dB) having a significantly greater mean amplitude value than syllable 2 (71.10 dB) which had a significantly lower mean value than syllable 1 (72.48 dB). The second occurrence of the target words, however, did not show a significant main effect of syllable position for the French participant.

4. Discussion

The overall results for the English (control) participant ensured that the overall stress production pattern applied to these target words was one of initial stress, given that the initial syllable was stressed more than the final (3rd) syllable. This pattern was seen through significantly higher mean F0 and amplitude values for the 1st syllable compared to that of the 3rd syllable. Duration has also been found to be a salient cue for stress in English, but it didn't quite attain significance (it was only approaching significance) for the 1st syllable over the 3rd syllable. Overall, the English participant's results supported the predictions of stress production according to the English stress.

Overall, the findings from this study have supported the hypothesis that there was interference from the native language in the production of English lexical stress by a French learner of English. The evidence was seen in the tendency of this particular French learner of English to place stress on the last syllable of the English test words (in accordance with the stress pattern of French) as was noted by the higher values of fundamental frequency and

duration on the 3rd syllable compared to the 1st syllable of the word. Amplitude was not found to be a parameter that this French learner of English used in producing stress as there was no significant difference in the amplitude values of the 1st and 3rd syllable of the English target words over the two productions. This is not completely surprising as it has been noted that amplitude is not always the most salient cue for stress (Sereno & Jongman 1995).

With respect to further analyses done for word frequency and prosodic structure, there was agreement in the results between each of these factors and the overall results for the French participant: there was significantly higher fundamental frequency and longer duration values for the 3rd (final) syllable compared to the 1st (initial) syllable as was predicted by the hypothesis. Thus, neither word frequency nor sentence production seemed to impact the overall results for the French learner of English.

However, with respect to the position of target words in a carrier phrase, fundamental frequency values were significantly higher across all syllable positions for the first occurrence (at an intonational boundary with the function of new information) than for the second occurrence of the target word (at the medial position within an intonational phrase with the function of old information) for the French speaker. As well, the duration value for the 3rd syllable was significantly greater for the first occurrence than for the second occurrence. The higher F₀ and longer durations observed in the first occurrence of the target words can be explained by the fact that new information induces more prosodic prominence than old information does. From the examination of word frequency, the only significant difference in values between frequent and infrequent words was found to be in duration values for the second syllable; the duration value of the second syllable for frequent words was significantly shorter than that of the infrequent words. This is an interesting result, as this might be an indication that this French learner of English is reducing the duration of unstressed (2nd syllable) vowel of the English word, which is often another cue for stress (albeit that it was not a cue that was actually examined in this experiment). This could have implications for second language acquisition: vowel reduction may be a learnable phenomenon (as seen with frequent words that were likely to have been seen before by this French speaker). Word frequency, on a whole, did not seem to have much effect on the results, which is somewhat surprising, as one might expect that the abstraction of stress patterns across the lexicon might be less likely to be applied to infrequent words than to frequent words, if we assume that stress patterns may be learned on a word-by-word basis (Guion et al. 2003). Yet this does not appear to be the case for this French learner of English, given that the frequent and infrequent words show the same pattern of L1 interference.

5. Conclusion

Despite the fact this French learner of English has not demonstrated the ability to correctly produce English stress, a question still remains: can correct stress production be learned (or taught)? The answer to this question has implications for second language research and pedagogy. One question that might, if answered, begin to shed some light on this question is whether a more fluent French learner of English would show more similarities to the English pattern of lexical stress. If there was a greater similarity in the production of English stress by a more proficient French learner of English, this may be an indication that lexical stress production can be acquired by learners with a different stress system than English. If French learners of English were able to acquire the English stress patterns, this would help to diminish their foreign accent and increase their effectiveness of communication in a second language. It is also important to keep in mind that the stimuli were designed to be of French etymology to elicit a deliberation between stress patterns for the French learner of English, yet it may have been the case that this design actually encouraged the default usage of the native language (French) stress system because the target words (particularly infrequent words) may have seemed more like French words than English words. Thus, using words with a French origin may have biased the French participant to respond according to her French stress system. Further experimentation using English words with non-French etymology may clear up whether this factor may have inhibited correct stress production by French learners of English. Through the analysis of the acoustic cues, it has been found that different acoustic cues seem to be used to signal stress by the English speaker (F0 and amplitude), and the French learners of English (F0 and duration). It would be interesting not only to see whether advanced French learners of English will produce English stress correctly, but also to see whether the learners will utilize the same acoustic cues as English speakers do.

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Appendix A. A Complete List of Stimuli Word List.

Frequent words	Infrequent words	Distracter Words	
integer	sagathy	intangible	bacillar
popular	salangane	integument	barista
general	baladine	population	redundant
restaurant	balafon	generosity	capelocracy
conference	baluster	genomic	capacious
accident	barbotine	restoration	detective
antidote	barbastel	restriction	sagaciate
hospital	sanctify	confetti	salariat
politics	taberdar	confederacy	sanctimonius
battery	tabouret	ascension	sanctology
avalanche	ralliance*	ascertain	tabescent
privilege	radicant	antiviral	tabulation
anagram	rameal*	hosanna	rallentando
temperature*	arbitrage	politely	radicality
equinox	sacrilege	pollutant	ramiculose
element	rapier	batologist	ramentum
elephant	pacifism*	available	rapidity
eloquent	palatine	privateer	pacific
bachelor	peccable	analogy	palacious
baritone	quintolet	anagogical	palisade
ridicule	garrison	temporalis	pectineus
benefit	quiddany	equilibrity	garrulity
capable	dacryon	eliminate	quiescent
miserable*	fendillate	eieven	dactylic
detriment	dolerite*	elopement	fenestrule

* Target words removed from further analysis due to incorrect stress placement, incorrect syllabification or containing more than 4 syllables.