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DURATIONAL PROPERTIES OF SYLLABLES AS POTENTIAL EVIDENCE FOR RHYTHMIC PATTERN IN L2 ACQUISITION

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RECENTLY, MUCH TIME AND EFFORT has been devoted to understanding the phenomenon of foreign accent in adult L2 acquisition. As a result, it is now possible for researchers to predict assimilation patterns of new phonemic contrasts (Flege 1995, Best 1995). However, experimental studies on the nature of a possible prosodic accent are still too few and far between. This is somewhat paradoxical, since the effect of non-native prosody is considered by many to be of crucial importance for accurate production of individual phones, for the expression of emotions and for proper parsing and processing of the speech signal by listeners. This study presents the results of two experiments which examined the rhythmic temporal pattern of French as produced by native speakers of English learning French.

1. THE PROBLEM. Rhythm is central to the prosodic structure of speech. The work of Pike (1945) and Abercrombie (1967) has led to the traditional distinction between *stress-timed* and *syllable-timed*. Languages that belong to the former category exhibit equal temporal distance between stresses and languages that belong to the latter category exhibit equal temporal distance between syllables. A third category was later proposed for Japanese and Tamil, which exhibit moraic rhythm. The most important consequence of stress-timed languages like English, according to this proposal, is the necessity to either compress or lengthen syllables in order to make stress groups approximately equal in duration. By definition, syllable-timed languages, like French, exhibit constant syllable duration (except for group-final syllables, see Wenk & Wioland 1982). Measurement studies have failed to provide empirical evidence of strict acoustical isochrony (Dauer 1983, Roach 1982, Wenk & Wioland 1982 among others), and most authors now consider these labels as tendencies rather than categories. These studies also led to the proposal that the two opposing rhythmic types be replaced by a continuum with prototypical stress-timed and syllable-timed languages located at opposing ends. Other languages would be located on this continuum according to their approximate resemblance to either type (Dauer 1987). Despite the interest of such a proposal, the role played by temporal patterns in a language and their importance in locating a specific language on this continuum is still unclear.

2. GOAL OF THE CURRENT EXPERIMENT. The primary goal of the current research is to investigate the use of duration as a primary property of the syllable and its ability to account for rhythmic properties of languages. More specifically, I expect to shed

French sentences	English sentences
Luc a mangé et s'est endormi.	Luke has been gone and has not been seen.
Luc qui a mangé s'est endormi.	Luke who has been gone has not been seen.
Luc qui aurait mangé se serait endormi.	Luke who would have been gone would have been seen.
Pierre qui a peint travaille beaucoup.	Claire who has painted travels a lot.
Pierre qui nous a peint travaille beaucoup.	Claire who should have painted travels a lot.
Pierre qui nous a bien peint travaille beaucoup.	Claire who should have been painting works a lot.
Claude n'a pas vu Marie à la fenêtre.	Jim has not seen Mary at the window.
Claude n'aurait pas vu Marie à la fenêtre.	Jim would not have seen Mary at the window.
Claude ne l'aurait pas vu à la fenêtre.	Jimmy would not have seen Mary at the window.

Table 1. Sample of English and French corpora.

some light on the phenomenon of L2 acquisition of the temporal rhythmic structure of French by native speakers of English. A secondary goal of this research is to gather empirical evidence related to the acquisition of suprasegmental features of a language. The acquisition of new phonemic segmental contrasts is fairly well documented, but experiments investigating the acquisition of suprasegmental features are still infrequent. In this paper, I report on two experiments which examined the rhythmic temporal pattern of French as produced by native speakers of English learning French.

3. METHODOLOGY. This study involved twelve participants. Among these were six learners of French and six native speakers of French who were recruited from the student and staff populations at the University of Alberta. The learners of French were divided into two subgroups according to their oral proficiency and their overall experience in French¹. Less experienced learners (EL1) had between 7 and 13 years of exposure to formal instruction in high school or university. More experienced learners had in general spent extensive immersion periods in French-speaking environments either in Montreal, Canada, or in Paris, France. All native speakers of English but one were native speakers of Canadian English. Native speakers of French were subdivided into two smaller groups, based on their dialect: 3 native speakers of Canadian French (CF), 3 native speakers of European French (EF)². Both groups were considered representative of their respective dialect.

Speech samples consisted of recalled single-sentence utterances. During the recording session, participants were presented with a single sentence on a computer screen. They were instructed to read the sentence and then to repeat it while facing a blank page. Due to the relatively high number of sentences to be uttered, no distractors were used. The second utterance of every sentence was used for measurements. All speakers read the same list of sentences presented in a different random order.

The stimuli were single sentences in French which included one relative clause varying in length. Given that French has a group-final primary stress, it was expected that this clause would have only one primary stress mark and, hence, would constitute a single rhythmic group³. Six sentence groups were conceived involving words with different syllable structures (see Table 1 for a sample list of the analyzed sentences). A similar corpus was formed in English with sentences that have a similar number of syllables, similar syntactic structure, and, in some cases, comparable syllable structures.

Syllable durations were measured within the embedded clause of each sentence. Measures were taken from the onset of the first segment—the nucleus or the first C in onset position—to the beginning of the next syllable at the zero-crossing point. The very rare hesitations and silent pauses were removed from the measurements. The segmentation process of the French corpus into syllables was done according to the principles proposed by Delattre (1940). Most syllables in the French corpus had a CV or CVC structure. The syllabification of the English corpus was also relatively straightforward because of the nature of the corpus. Intervocalic consonants were assigned to a syllable following the maximal onset principle. Most syllable structures in the English corpus were also CV or CVC.

4. EXPERIMENT 1.

4.1 VARIABILITY INDEX. The goal of this first experiment was to determine if English learners of French exhibit more syllabic durational variability in a production task than native speakers of French. In order to measure this variability, the index used by Deterding (2001) was chosen. This index measures variations in syllable duration compared to an average syllable duration. All syllables within the relative clause were measured. Following Deterding, it was decided not to include the final syllable of this clause in the measurements. The motivation for this decision is that measuring group-final syllables, which usually bear primary stress in French, would introduce an important amount of variation in the calculations if produced differently across groups of participants. Among all 30 sentences recorded for each participant, only the last three sentences of each sentence group had the three syllables minimally required for the computation of the index (total of 18 sentences for each participant). Normalized durations were used in the computation in order to neutralize variations in tempo. The formula in (1) shows the computation of the VarIndex:

$$(1) \quad VarIndex = \left(\sum_{k=1}^{n-2} |d_{k-1} - d_k| \right) / (n-1)$$

d_k = normalized duration (duration of a syllable divided by average duration of all measured durations of a phrase) of the k th syllable,
and

n = number of syllables

Speaker Groups	VarIndex French Corpus	Standard Deviation
English	0.3601	0.1995
EL1	0.4056*	0.2486
EL2	0.4298*	0.2399
CF	0.3508	0.2042
EF	0.2866*	0.1547

Table 2. *VarIndex for all speaker groups. (*EL1 and EL2 are statistically significant when paired with EF.)*

According to this VarIndex, perfect syllable isochrony would allow for no durational variability, hence leading to a VarIndex of 0. The greater the variability in syllable duration, the greater the index. Digitization (20 kHz) and measurements were done using Computer Speech Laboratory by Kay Elemetrics Corporation model 4300.

Earlier studies have considered English and French as prototypical examples of stress-timed and syllable-timed languages. Therefore, it is expected that syllabic durational variability as measured with the VarIndex will be greater in English than in French. Previous research in L2 acquisition has found evidence which suggests that L2 learners gradually acquire the rhythmic properties of an L2 (Wenk 1986). Hence, English learners of French are expected to exhibit more variability in syllabic duration in French than native speakers of French. Moreover, the amount of inter-syllabic variability should decrease as English speakers become more proficient in French. Finally, one more hypothesis can be made based on the differences reported between CF and EF (Armstrong 1999, Paradis & Deshaies 1990, Ouellet & Tardif 1996 among others): CF speakers will exhibit more inter-syllabic variability than EF speakers.

4.2. RESULTS. The VarIndexes for all groups of speakers are given in Table 2 and Figure 1. The results partially validate the first hypothesis, as native speakers of English produced a greater VarIndex than native speakers of European French (EF). However, the index displayed by native speakers of English in their mother tongue, 0.3601, is noticeably lower than the ones reported by Deterding (2001). In his study, indexes of 0.448 and 0.543 were reported for British and Singaporean speakers respectively, with standard deviations of 0.164 and 0.172. This discrepancy between the results of the present research and Deterding's are attributed mainly to the different experimental tasks. It has been claimed that read speech in French (which resembles the recall speech used in the current experiment) is characterized by a tendency to regularize inter-syllabic intervals, whereas spontaneous speech favors the production of breath groups of equal length (Vaissière 1991). In addition, the unusually low number of syllables with complex onsets or codas in our corpus of English (most syllables are CV or CVC) may have contributed to lower inter-syllabic variability. Contrary to the first hypothesis, however, durational variability displayed by CF speakers is noticeably greater than the index displayed by EF

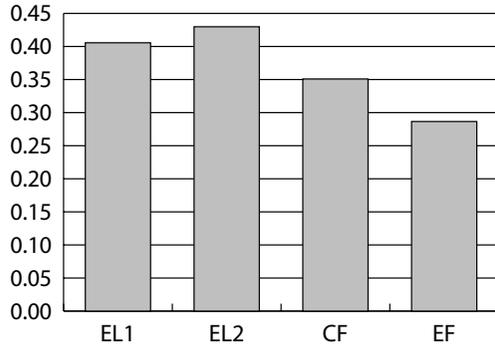


Figure 1. *VarIndex* for all speaker groups: Intermediate English learners of French (EL1), Advanced English learners of French (EL2), native speakers of Canadian French (CF), and native speakers of European French (EF).

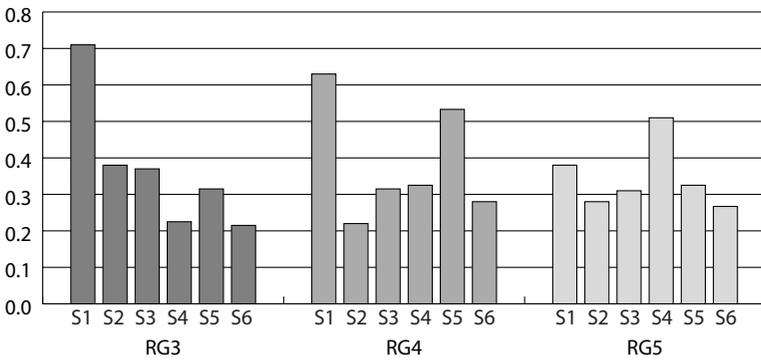


Figure 2. *VarIndex* for each sentence within each rhythmic group.

speakers, and similar to the one of English speakers. There is no immediate explanation for this surprising result. It is possible that the index used in this study did not capture the more subtle differences between the three groups of speakers, or that Canadian French is becoming a quantity-sensitive language (Armstrong 1999), thereby resembling to English more than to European French. This hypothesis will have to be investigated more in depth in further research.

The second hypothesis for this experiment is confirmed. In general, English L2 learners of French produced greater *VarIndex* and standard deviations in the target language than native speakers of French. Results from a two-way ANOVA revealed a significant Speaker Group effect ($p < .05$). A Post-hoc (Tukey's HSD) analysis indicated that EL1 and EL2 are significantly different when paired with EF but not when paired with CF. The third hypothesis, which assigned significantly lower indexes to more advanced learners of French, was not confirmed by the post-hoc analysis. This unexpected result suggests that L2 learners of French did not make significant progress after several years of exposure to French. It appears that despite their greater

experience, the EL2 speakers have not acquired a native-like temporal rhythmic structure in French.

A closer look at the results of the ANOVA revealed a second interesting effect. The analysis characterizes the main effect of Sentences nested within Rhythmic Group as significant ($p < .05$). This result indicates that some sentences were produced across all groups of speakers with a significantly greater index than other sentences. Among these sentences, RG3S1, RG4S1, and RG5S1 may have a higher index because they include a short vowel immediately followed by a syllable with a long French nasal vowel (*Luc a mangé*). Similarly, the presence of a complex onset like /br/ or /bj/ when preceded by a syllable which has no onset nor coda, found in RG4S5 (*Rome qui a brûlé serait détruite*) and RG5S4 (*Paul avait bien aimé la chasse*), generated a high VarIndex.

These results suggest that duration provides consistent information regarding the temporal structure associated with French rhythm. It is still undetermined if the absence of significant difference between both groups of learners should be attributed to the limits of the index or to the possibility that EL2 speakers may display fossilization. The results also strongly suggest that specific phonemic factors must be considered in an account of syllable variability.

5. EXPERIMENT 2: LANGUAGE-SPECIFIC PHONEMIC PROPERTIES. The previous experiment rested on the assumption that all speakers, including L2 learners of French, followed similar rules for segmenting the signal into syllables. Previous research (Beaudoin 1996) has shown that English learners of French, especially in the earlier stages of acquisition, exhibit mixed syllable structures. A proper account of L2 rhythm must consider this important variable. The goal of this second experiment is to confirm the tendencies identified in experiment 1 when syllable structure is not considered.

Measurements for this experiment are similar to the one proposed by Ramus, Nespor & Mehler (1999), who proposed a simple measure of the duration of vocalic and consonantal intervals and their respective standard deviations. These intervals consist of the unaltered total duration of the segments in a given sentence. In their paper, the authors argued that this basic phonetic account of the temporal structure of a sentence reflects the phonemic properties of a language, such as syllable structure and vowel reduction, for instance. They further explain, following a proposal made for the first time by Dasher and Bolinger (1982), that these language-specific phonemic properties are responsible for the perception of different distinct rhythmic classes.

The following experiment attempts to show that language-specific phonemic properties are responsible for different rhythmic temporal structures. English and French differ in a number of phonemic properties, among which the most noticeable are the syllable structures (greater use of CVC in English, CV in French), the existence of vowel reduction in English, and the presence of lexical stress in English (Dauer 1983). These phonemic properties should be reflected in the phonetic structure of the utterances, which will be measured in the vocalic and consonantal intervals.

The specific hypotheses for this experiment are: a) L2 learners of French will produce a greater percentage of vocalic intervals in English than in French; b) L2 learners

of French will produce smaller vocalic intervals in French than native speakers; c) standard deviations for consonants and vowels will be greater for learners of French than for native speakers of French; and d) more proficient learners will exhibit intervals closer to native speakers'.

5.1. METHODOLOGICAL CONSIDERATIONS. The data used for this analysis were taken from the same corpus used in the first experiment. Measurements were taken only on the last sentence of each sentence group, however. Contrary to the first experiment, the entire sentence was used for the analysis. Once more, the last syllable of the sentence had to be excluded from the calculations mainly because it was on many occasions almost inaudible and impossible to measure with accuracy.

Following Ramus, Nespore and Mehler (1999), vocalic intervals of the recalled sentences are defined as all vowels located in between two consonants, and consonantal intervals are formed by all consonants located between two vowels. The sentences were segmented as in (2).

- (2) *Rome qui aurait brûlé serait détruite.*
/r-ɔ-mk-i-ɔ-r-ε-br-y-l-e-s-ə-r-ε-d-e-(tr-ɥi-t)/

In these examples, intervals are separated by “-” and the omitted sentence-final syllable is in parentheses. The authors provided three variables in their study:

1. Percentage of vocalic intervals in the entire sentence (%V), computed by dividing the sum of all vocalic intervals by the total duration of the sentence and multiplying it by 100;
2. Standard deviations of vocalic intervals within each sentence (ΔV), and
3. Standard deviations of consonantal intervals within each sentence (ΔC).

The sum of all consonantal and vocalic intervals should be identical to the duration of the entire sentence.

5.2. RESULTS. Table 3 and Figure 3 (overleaf) present the results across all groups of speakers. As predicted by the first hypothesis, English speakers exhibit noticeably greater %V in English than in French, thereby supporting the first hypothesis. The ratios in this second experiment are in general greater than the ones reported by Ramus et al., who found proportions of vocalic intervals for English and French of 40.1% and 43.6% respectively. These discrepancies are, once again, attributed to the constitution of the English corpus, which is not considered similar to free speech. As mentioned before, there is an insufficient amount of complex onsets and codas compared to CVs and CVCs, and this would give a higher vowel interval percentage.

The analysis of the French corpus produced by all groups of speakers partially confirmed the experimental hypotheses. Contrary to the second hypothesis, the proportions of vocalic intervals produced by EL1 is noticeably greater than those of EL2

	# of V Intervals	# of C Intervals	%V	ΔC	ΔV
EL1	94	93	57.81	0.064	0.069*
EL2	93	93	53.09	0.057	0.047
CF	95	95	53.83	0.058	0.045
EF	99	98	54.98	0.058	0.038*
total:	381	379	—	—	—
English	225	231	47.21	0.057	0.046

Table 3. Number of consonantal and vocalic intervals measured, vocalic intervals and standard deviations across all speaker groups. (*Significant difference as determined by a Tukey (HSD) post-hoc analysis.)

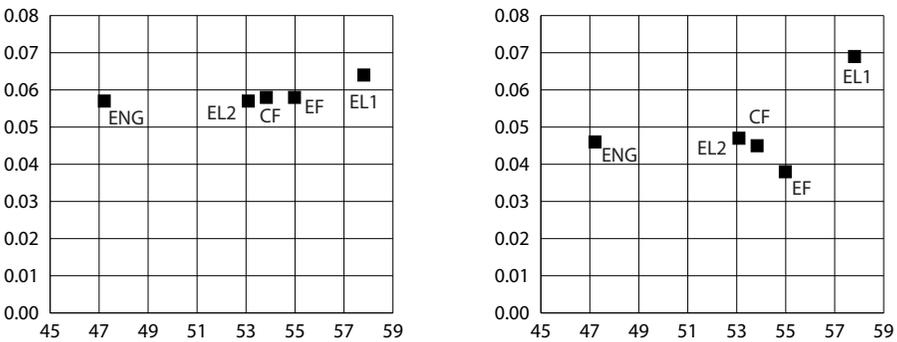


Figure 3. Distribution of speaker groups over the %V, ΔC (left) and (right) ΔV planes.

and both groups of native speakers of French. Unfortunately, the two-way ANOVA did not reveal any significant difference between these ratios. Standard deviations for consonants (ΔC) and vowels (ΔV), however, did confirm the experimental hypothesis, as greater values were displayed by both groups of learners of French (EL1, EL2). Contrary to the results reported by Ramus et al., and as predicted by hypotheses (c) and (d), the standard deviation of vocalic intervals (ΔV) proved useful in discriminating between speaker groups. Speakers who belong to EL1 exhibited the greatest standard deviation (0.069), EF displayed the smallest deviations (0.038) and EL2 and CF presented intermediate variations (0.047, 0.045). This difference between EL1 and EF was declared significant, in a one-way ANOVA ($p < .05$). The standard deviations associated with consonantal intervals were not significant in this study.

6. DISCUSSION. This study examined the hypothesis that duration as a fundamental property of the syllable provides an account of English and French rhythm. It differs from previous studies, since it compares data about adult L2 learners and native speakers of French. The first experiment used a variability index to determine

if variations in syllabic duration are consistent with previous accounts of English and French rhythm. Moreover, it was predicted that English L2 learners of French would display more syllabic variability in French than native speakers. The confirmation of these hypotheses strongly suggests that duration as a fundamental property of the syllable must be part of a proper account of rhythm. Even though these results are in agreement with the controversial notion of isochrony, the analysis also suggests that a more detailed investigation is required in order to explain the effects related to the quality of the segments and syllable structure.

An attempt was made with the second experiment to examine more accurately the effect of phonemic properties of both languages and their role in the account of rhythm. The tendency for learners and native speakers of French to produce identical relative clauses with different syllabic temporal properties measured in the first experiment was confirmed. These different acoustic properties displayed by learners of French strongly suggest that, at least in the early stages of acquisition, learners have not fully acquired the phonological properties of the target language. In the acquisition of French by native speakers of English, the phonetic characteristics of vowels seem to be more challenging than consonants. These experiments raise many interesting questions regarding the nature of linguistic rhythm and its acquisition. For instance, what exactly are the language-specific phonemic properties which contribute to the perception of rhythm? Which of the phonemic properties are acquired during the acquisition of an L2? Are some languages more difficult to acquire by L2 learners than others because of the complexity or nature of their rhythmic properties, and if so, why?

The results obtained in the study presented here certainly highlight the importance of duration as a fundamental property of French rhythm. However, more empirical evidence from cross-linguistic studies is needed to confirm the importance of phonemic properties of vowels in L2 acquisition as observed in this research. To confirm this will require a larger sampling of the population and a broader sampling of languages and speech material. Regardless, the results of this study does not support the strong position which attributes the perception of rhythmic differences between languages solely to isochrony. Instead, the results presented here suggest that the phenomenon of rhythm would be better understood if analyses of languages' segmental properties and phonetic aspects are included.

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- ¹ This initial classification has been confirmed by a perceptual experiment. In this experiment, native speakers of French subjectively classified these learners into two distinct categories. The intraclass correlation (Shrout 1995) between all listeners was high at 0.895.
 - ² The term 'European French' refers to speakers who speak a variety of French with no traces of regional accent perceived by the main experimenter.
 - ³ A *rhythmic group*—or *groupe accentuel*—in French is a series of unstressed syllables followed by and including one syllable bearing primary stress (Lacheret-Dujour & Beaugendre 1999:45).

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