

Reiterant speech as a test of non-native speakers' mastery of the timing of French

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The reiterant speech of ten native speakers of French was analyzed to develop baseline measures for syllable and consonant/vowel timing for a series of two-, three-, four-, and five-syllable French words spoken in isolation. Ten native speakers of English, who learned French as a second language, produced reiterant versions of both the French words and a comparable set of English words. The native speakers of English were divided into two groups on the basis of their second language experience. The first group consisted of four university-level teachers, who were relatively experienced learners of French, and the second group of six less experienced learners of French. The French reiterant imitations of the two groups of native speakers of English were compared to the native French speakers' productions. The timing patterns of the experienced group of non-native speakers did not differ significantly from those of the native French speakers, whereas there was a significant difference between these two groups and the group of six less experienced second-language learners. Deviations from the French baseline measures produced by the less experienced group are discussed in terms of the influence of the timing patterns of English and the literature on a sensitive period for second language acquisition.

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INTRODUCTION

Although considerable research shows that native language phonetic habits influence second language productions, even for experienced second-language speakers (see Flege, 1986, for an extensive review), little work has been done on the influence of first language timing patterns on second language rhythmic patterns. One such study (Wenk, 1985) found an influence of native French rhythmic patterns on the timing of English as a second language. However, the effect of English timing patterns on the acquisition of French has not been directly tested.

The use of reiterant speech to test for such influence presents several advantages. In reiterant speech studies, subjects are asked to substitute a single syllable, often /ma/, for each of the original syllables in a word or sentence. Acoustic and perceptual analyses of reiterant speech have shown that it preserves the prosodic characteristics of the original utterance (Larkey, 1983; Liberman and Streeter, 1978; Nakatani *et al.*, 1981; Oller, 1973). Furthermore, because measurements of segment and syllable durations are easy with reiterant speech and are generally unconfounded by segmental variation, many studies have used such duration measurements in English for analyzing rhythm (e.g., Nakatani *et al.*, 1981), for studying the perceptual effects of timing variations (Larkey, 1983; Nakatani and Schaffer, 1978), and especially for determining how durations vary as a function of utterance position and stress (e.g., Oller, 1973). Reiterant speech duration measurements have also been made on Swedish (e.g., Lindblom and Rapp, 1973), and comparisons of the rhythmic features of a group of languages have been made on the basis of reiterant speech (Vatikiotis-Bateson,

1986; Hoequist, 1983). However, very little work has been done with reiterant speech on the rhythmic features of French, aside from that done by Vatikiotis-Bateson (1986), where reiterant speech was used to determine universal and language-specific effects on articulator timing in native speakers from a group of languages. The use of reiterant speech as a means of testing a non-native speaker's mastery of the timing patterns of a foreign language has not been previously attempted. In learning a second language, speakers need to learn new timing patterns for individual segments, often as a function of context (Mack, 1982), as well as new rhythmic patterns. Reiterant speech is particularly well suited to testing the acquisition of new rhythmic patterns independently from the effects of timing for non-native segments.

The speech rhythm of French and that of English are quite distinct. French has been traditionally classified as a "syllable-timed" language (e.g., Pike, 1945), with syllables essentially equal in length. This characterization of French rhythm has been criticized (e.g., Wenk and Wioland, 1982; Dauer, 1983; Fletcher, 1991) for failing to recognize the important final-syllable lengthening that is characteristic of French rhythmic groups, which may be either the individual "sense groups" of a French sentence or individual French words spoken in isolation. Thus nonfinal syllables within unemphatic French rhythmic groups are, except for effects of phonetic variation, essentially equal in length, whereas final syllables show considerable lengthening. English, on the other hand, has been traditionally classified as a "stress-timed" language (e.g., Pike, 1945). Because of variable word stress, a typical English sentence presents a series of stressed syllables that alternate with unstressed syllables. A

Table I shows the mean length of each of the word types and the ratio of the mean length of the consonant to that of the vowel in each syllable. The overall mean C/V ratio was 0.9 for nonfinal syllables and the C/V ratio was 0.6 for final syllables. In addition, Table I presents the ratios of the mean syllable length to the word as a whole.

F. Discussion

The results of this experiment showed fairly good agreement with the published data on French, especially with respect to French syllable duration ratios. The segment measurements will be considered first and then the syllable measurements.

The duration measurements for French nonfinal /m/ and /a/ and for final /m/ tended to be roughly 20 ms longer than the durations found for the same segments by other researchers (Smith, 1977; Di Cristo, 1980; O'Shaughnessy, 1984). This discrepancy is most likely due to the fact that the subjects in the present experiment spoke at a slower rate in producing reiterant speech than the subjects in the other studies, who read French texts. The measurement for utterance-final /a/ was roughly 10 ms longer than that of O'Shaughnessy (1984). The smaller discrepancy in final position is probably due to the conservative segmentation criterion adopted in the present study. Thus given the segment values of the present study, the nasal consonant /m/ accounted for 47% of the duration of nonfinal syllables, whereas for final syllables, it accounted for 38%.

In general, nonfinal syllables were remarkably close in duration (see Fig. 1). The present data did not show an initial syllable shortening as compared to medial syllables, which disagrees with Crompton's (1980) finding of decreased length for initial syllables. In fact, another researcher (Vaissière, 1983) has found growing evidence in French of a tendency to stress word initial syllables, and presumably to lengthen them. Indeed, one of the subjects showed a regular lengthening of initial syllables. Crompton (1980) also found evidence for prenuclear lengthening, or lengthening of a syllable just prior to a nuclear stress. An analogous penultimate syllable lengthening has been de-

TABLE I. Mean word lengths (in ms) and C/V and CV/length ratios in reiterant speech productions of French words by native speakers of French.

	Word length in syllables			
	Two	Three	Four	Five
Mean word length	448	612	776	1028
Ratios				
C1/V1	0.9	0.9	0.8	0.9
C2/V2	0.6	0.8	0.9	1.0
C3/V3		0.6	0.9	1.0
C4/V4			0.7	0.9
C5/V5				0.7
Ratios				
CV1/L	0.4	0.3	0.2	0.2
CV2/L	0.6	0.3	0.2	0.2
CV3/L		0.4	0.2	0.2
CV4/L			0.4	0.2
CV5/L				0.3

scribed by Smith (1977) as characteristic of Parisian French (although only one of Crompton's four subjects was from Paris, while the other three came from Brittany). The present pooled data show no overall effect of penultimate syllable lengthening, although data from two of the speakers do show such an effect.

The ratio of final syllable to nonfinal syllable length in the present data was 1.6, which agrees exactly with Parmenter and Blanc's measure of 1.6 (1933), with Benguerel's (1971) measure of 1.6, and with Allen's (1983) finding of an overall ratio of 1.6 when he compared the median lengths of final to penultimate vowels in French children's productions of French words. It does not match Delattre's (1966) measure of 1.8, perhaps because of differences in the criteria used for measuring final syllable lengths.

In summary, our French timing data based on reiterant speech productions of French words spoken in isolation showed generally consistent syllable durations for nonfinal syllables and a ratio of final/nonfinal syllables of 1.6. Individual subjects showed some slight lengthening of initial or penultimate syllables, but no consistent evidence for any shortening effects. Insofar as intrasyllabic timing is concerned, in nonfinal syllables, the nasal accounted for 47% of the duration, and in final syllables, it accounted for 38%. How well then do non-native speakers of French match these characteristic duration patterns when they produce reiterant speech versions of French words?

II. EXPERIMENT II

A. Subjects

Ten subjects, five male and five female, participated in the study. All of the subjects except for one have advanced graduate degrees. All are native speakers of English, currently living in the Boston area, who have studied standard French. Four of the subjects (two men and two women, including the author) teach French at the university level. One subject learned French from his French wife, whom he met after graduate school. The other subjects all had some formal training in French; seven subjects began the study of French in high school and the remaining two in junior high school. The four teachers of French and the other subjects, with the exception of the subject who learned French at home, averaged over 2 years of high school French. The four French teachers, however, studied French for four years in college, as compared to an average of slightly over 1-1/2 years in college for the others. The four French teachers also completed postgraduate training in French and had traveled more extensively in French-speaking countries than had the other subjects.

B. Test materials

The same French deck of 3×5 cards used in the previous experiment was used in this second study. An additional deck consisting of the English cognates of the French words was also used. The 30 English words consisted of two, three, four, or five syllables. There were ten possible stress patterns represented. For words of two syllables, both initial and final primary stress patterns occurred (*sacred* and *de-*

gree.) For words of three syllables, initial, medial and final primary stress patterns occurred (*compliment, instructive, and engineer*). For words of four syllables, three of the four possible primary stress patterns occurred (*commentary, economy, and exposition*). For words of five syllables, two possible patterns occurred (*electricity and communication*). There were three different words representing each of the syllable and stress types.³ Although in general most of the cognates had the same number of syllables in the two languages, there were three items for which the syllable count differed. (See the Appendix for a complete list of the stimuli used).

C. Procedure

Subjects first filled out a short questionnaire about their years of experience with French and were then recorded in a quiet room, onto a Teac tape recorder (model X-7MKII) using a Realistic dynamic microphone (model 33-984A). The rest of the procedure was the same as in the previous experiment, except that subjects read and produced reiterant versions for the words of the English deck first.

D. Equipment and measurement methods

All 30 French and 30 English words and their reiterant versions were low-pass filtered at 4.9 kHz, digitized at 10 kHz, and stored on disk on Haskins Laboratories' Vax 11/780. The same criteria used in the previous experiment were used here to determine the consonant and vowel boundaries and the end of the reiterant speech utterance.

A random sample of 14 reiterant productions of English words containing 102 separate measurements were measured a second time. The absolute duration measurements were within 4 ms of the original measures on the average overall, and within 9 ms on the average for the 14 final vowel measurements.

The errors from both sets of reiterant productions will be discussed first. The data from experiment II will then be presented as a set of baseline measures for consonant, vowel, and syllable timing for English words of various lengths and stress patterns based on the productions of the most consistent reiterant speakers. Third, the English speakers' reiterant versions of the French words will be examined for patterns of intra- and intersyllabic timing. Finally, the durations of the productions of the French native speakers will be statistically compared to those of the non-native speakers, broken into two groups, the relatively experienced teachers of French and the other, less experienced group of French learners.

As with the French subjects, measures of the American subjects' duration measurement variability in producing word types were used as an indication of their ability to neutralize inherent segmental length differences. Each reduplicative version of a particular word of a given length and stress pattern was considered a token of that word-length/stress-pattern type. The standard deviations for comparable measurements, e.g., first syllable length, were calculated across tokens for each subject for each of the ten word-length/stress-pattern types and averaged. Separate values were calculated for each of the ten word-length/stress-pat-

tern types because it is generally more difficult to produce good reiterant productions for longer utterances and because variable word stress in English affects the duration of syllables in comparable positions. Finally, an overall mean (measure A) and a standard deviation (measure B) of each subject's mean standard deviations for the ten word-length/stress-pattern types were calculated. For the English words, the group mean on measure A was 18 ms with a group mean on measure B of 17 ms. When the subjects were rank ordered on these two measures, two subjects, one male and one female, showed the highest scores on both measures (for measure A, their mean was 26 ms, with a mean of 24 ms for measure B). The remaining eight subjects showed a group mean of 17 ms on measure A and 15 ms on measure B. In constructing the baseline measures for timing for the English words, only the data from the eight most consistent subjects were included.

E. Results

The American subjects made relatively few errors in their reiterant versions of the English words. The 12 errors across the eight most consistent subjects gave an error rate of 5%, with most errors due to a subject's producing an incorrect number of syllables for one of the longer words or to a subject's clearly stressing the wrong syllable in the reiterant production. There were only two missing tokens (0.8%). The American subjects made many more errors in their reiterant versions of the French words. There were 29 such errors (12%) across the eight subjects. Twenty-four of those errors (83% of the total), were words ending in "ion" or containing the vowel sequence "ié" as in "société," which the French count as a single syllable, but which many of the Americans counted as two. There was only one missing token (0.4%).

Figure 2 presents the averaged durational measurements of the eight American speakers for each of the ten word types as a function of the consonants (/m/) and vowels (/a/). For initial stressed syllables,⁴ /m/ averaged 56 ms and /a/ 92 ms, for medial stressed syllables, /m/ averaged 79 ms and /a/ 108 ms, for final stressed syllables, /m/ averaged 82 ms and /a/ 255 ms. For unstressed syllables, /m/ averaged 45 ms and /a/ 70 ms in initial syllables, /m/ was 65 ms and /a/ was 76 ms in medial syllables, and /m/ was 79 ms and /a/ was 155 ms in final syllables. The mean duration of syllables bearing primary stress⁵ were 160 ms in initial position, 190 ms medially, and 336 ms finally. Syllables with secondary stress averaged 137 ms initially and 168 medially. Syllables that were not stressed averaged 113 ms initially, 138 ms medially, and 233 ms finally.

Table II shows the overall mean length for each word type, the consonant/vowel ratios for each syllable and the ratios of each of the individual syllables to the length of the word.

Figure 3 shows the mean durational measurements for the reiterant versions of the syllables of each of the four French word-length types, as produced by the native speakers of English, in terms of consonants (/m/) and vowels (/a/). The mean duration of /m/ in nonfinal syllables was 73 ms, of /m/ in final syllables was 95 ms, of /a/ in nonfinal

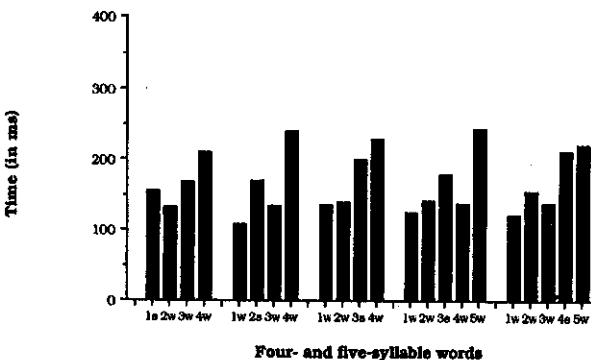
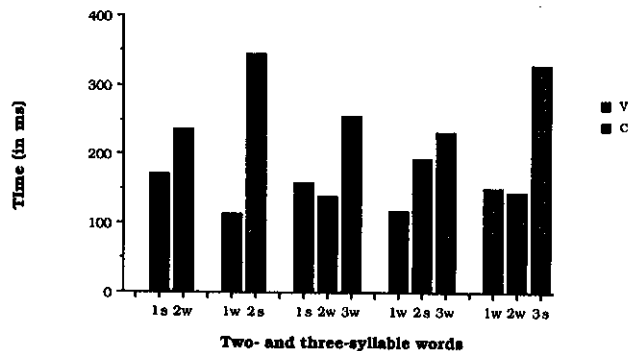


FIG. 2. Consonant and vowel durations, as a function of word length, syllable position, and stress, for reiterant imitations of English words spoken in isolation by native speakers of English. (Numbers indicate syllable position, S indicates stressed syllables, and W indicates unstressed syllables or those bearing secondary stress).

syllables was 85 ms, and of /a/ in final syllables was 235 ms. Nonfinal syllables thus averaged 157 ms, whereas final syllables averaged 330 ms. The difference in syllable length averaged over 170 ms and produced a final/nonfinal ratio of 2.1.

The results of a two-way analysis of variance comparing

the subjects' mean nonfinal and final syllable lengths for the four word-length types showed a highly significant effect of syllable position [$F(1,9) = 182.22, p < 0.0000$], but no word-length type and no word-length type by syllable position interaction. Separate analyses comparing subjects' mean nonfinal syllable lengths for each of the four word-length types were also not significant.⁶

Table III shows the mean length of each of the word-length types and the ratio of the mean length of the consonant to that of the vowel in each syllable. The overall mean C/V ratio was 0.9 for nonfinal syllables, which was comparable to that of the French subjects, but the overall mean C/V ratio was 0.45 for final syllables, which was different from that of the French subjects.

In order to test how well the American subjects conformed to the French baseline measures for timing for nonfinal and final syllables in their reiterant productions of French words, their timing measures were subjected to an analysis of variance with one between group factor with three levels (native French versus teachers of French versus English speakers) and two within group factors (syllable position [nonfinal versus final] and segment duration [consonant versus vowel length]).

Although there was no significant main effect of group, there was a significant effect of syllable position [$F(1,17) = 417.87, p < 0.0000$] and of segment duration [$F(1,17) = 121.42, p < 0.0000$], and both of these effects interacted significantly with the group factor [$F(2,17) = 15.41, p < 0.0003$], in the case of syllable position, and [$F(2,17) = 8.28, p < 0.0032$], in the case of consonant versus vowel length. There was also a significant two-way interaction of syllable position and segment duration [$F(1,17) = 145.20, p < 0.0000$] that also interacted significantly with the group factor [$F(2,17) = 10.88, p < 0.001$]. Figure 4 shows the pattern of results for the three groups.

An exploration of the group interactions with syllable

TABLE II. Mean word lengths (in ms) and C/V and CV/length ratios in reiterant speech productions of English words by native speakers of English. Tokens of types: 1 = counter; 2 = control; 3 = compliment; 4 = conclusion; 5 = engineer; 6 = commentary; 7 = economy; 8 = exposition; 9 = elasticity; 10 = communication.

	Word length in syllables									
	Two		Three		Four		Five		Ten	
Stress type	1	2	3	4	5	6	7	8	9	10
Mean word length	408	457	552	543	624	663	651	703	826	862
Ratios										
C1/V1	0.5	0.6	0.6	0.6	0.7	0.7	0.6	0.6	0.6	0.7
C2/V2	0.5	0.3	0.9	0.7	0.9	0.8	0.8	0.9	0.8	0.9
C3/V3			0.5	0.6	0.4	0.9	0.8	0.7	0.8	0.8
C4/V4						0.8	0.5	0.5	0.8	0.7
C5/V5									0.6	0.5
Ratios										
CV1/L	0.4	0.2	0.3	0.2	0.2	0.2	0.2	0.2	0.1	0.1
CV2/L	0.6	0.8	0.3	0.4	0.2	0.2	0.3	0.2	0.2	0.2
CV3/L			0.5	0.4	0.5	0.3	0.2	0.3	0.2	0.2
CV4/L						0.3	0.4	0.3	0.2	0.2
CV5/L									0.3	0.3

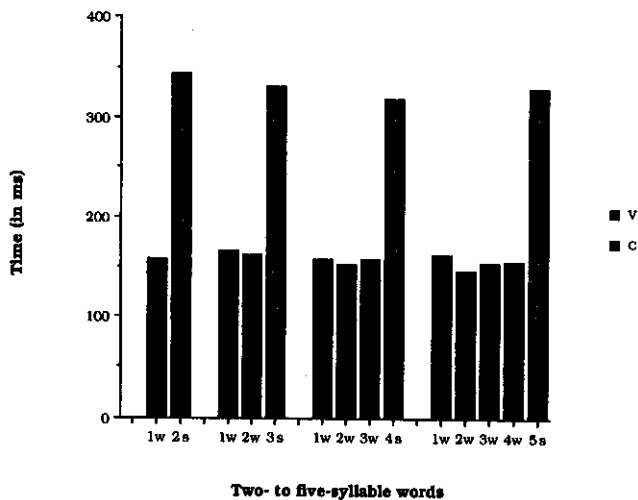


FIG. 3. Consonant and vowel durations, as a function of word length, syllable position, and stress, for reiterant French words spoken in isolation by non-native speakers. (Numbers indicate syllable position, S indicates stressed syllables, and W indicates unstressed syllables.)

position and consonant versus vowel revealed that the source of the interactions was the differences in final syllable length among the three groups, in particular due to differences in the vowel length, as can be seen in Fig. 4. A separate analysis of variance conducted on final syllable vowel length was significant [$F(2,17) = 7.65, p < 0.0044$]. Post hoc (Newman-Keuls) tests revealed that in terms of final vowel length, the productions of the native speakers of French and the French teachers did not differ from one another but the productions of both groups differed from those of the other native English speakers ($p < 0.05$).

F. Discussion

The American subjects' productions of the English segment and syllable durations will first be discussed, followed by an examination of the ways in which their reiterant productions of the French words deviate from the French base-

TABLE III. Mean word lengths (in ms) and C/V and CV/length ratios in reiterant speech productions of French words by native speakers of English.

	Word length in syllables			
	Two	Three	Four	Five
Mean word length	501	656	786	944
Ratios				
C1/V1	0.7	0.8	1.0	1.0
C2/V2	0.4	0.9	1.0	0.9
C3/V3		0.4	0.8	1.0
C4/V4			0.5	0.9
C5/V5				0.5
Ratios				
CV1/L	0.3	0.2	0.2	0.2
CV2/L	0.7	0.3	0.2	0.2
CV3/L		0.5	0.2	0.2
CV4/L			0.4	0.2
CV5/L				0.2

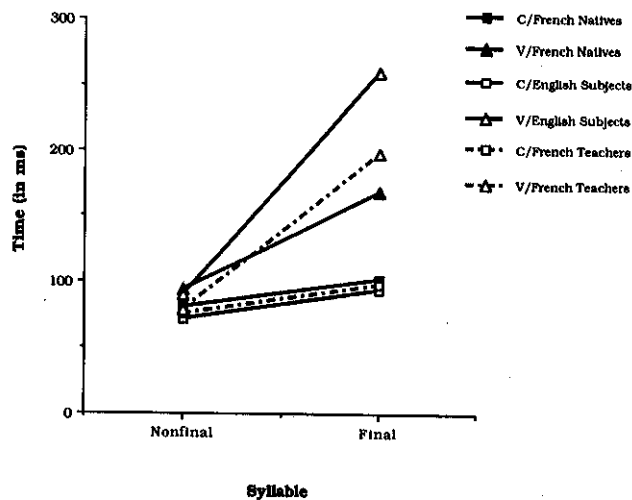


FIG. 4. Mean consonant and vowel length for final and nonfinal syllables for French native speakers, experienced learners of French (French Teachers), and relatively inexperienced learners of French (English Subjects).

line measures. Finally, the possible effects of English timing patterns on the French productions will be considered.

In the English reiterant speech, the nasal murmur accounted for 38% of the syllable in stressed initial syllables, 42% in stressed medial syllables and 24% in stressed final syllables. For unstressed syllables the percentages were 39% initially, 45% medially, and 34% finally. These percentages clearly differ from those found in French in experiment I, which suggests that the intrasyllabic timing is not the same in the two languages.

There was also clearly an effect of utterance-final lengthening carried largely by the vowel in the English data. For stressed syllables, lengthening for final vowels was roughly 150 ms and for unstressed syllables it was roughly 75 ms. These durational lengthenings are comparable to those found by Oller (1973).⁷

Insofar as the syllable measurements are concerned, the present data showed clear effects both of stress and of utterance-final lengthening. There also appeared to be increments due to secondary stress, although Nakatani *et al.* found only marginal increases in length for such syllables and only for some speakers. The ratio of final/nonfinal syllables was 1.7, which is greater than the 1.5 found by Delattre (1966), but which may be due to the unusually short initial syllables found in this study. Indeed, if initial syllables are eliminated from consideration, the ratio becomes 1.6, which is closer to Delattre's measure. The ratio of accented to unaccented syllables was 1.43 in initial syllables, 1.38 in medial syllables, and 1.44 in final syllables. These ratios, which do not include the somewhat problematic syllables that bear secondary stress, correspond fairly well to Hoequist's measure of 1.45, although they are lower than the measure given by Delattre (1966) of 1.7. Hoequist's (1983) suggestion that Delattre's higher ratio is due to the inclusion in the unstressed group of very short /ə/ syllables, which are generally not found in reiterant speech, seems quite reasonable.

As can be seen in Fig. 4, for the reiterant versions of the French words, there was little difference in the consonant

and vowel lengths in nonfinal syllables for the three groups. Thus the percentage represented by the nasal in nonfinal syllables was 47% for the native speakers of French, 49% for the American teachers of French, and 44% for the less experienced French speakers. There was also little difference in the mean length of /m/ in final syllables for the three groups of subjects. The striking difference in the reiterant productions of the three groups occurs in the length of utterance-final /a/ which was 171 ms for the French natives, 199 ms for the French teachers, and 260 ms for the less experienced group. Thus the nasal consonant accounts for 38% of the final syllable for French natives, 33% for French teachers, and only 26% for the less experienced group. Intrasyllabic timing appears to be more nativelike in nonfinal than in final syllables. The ratio of final to nonfinal syllables was 1.6 for the French natives, 1.9 for the French teachers, and 2.2 for the others. Although the reiterant productions of the American teachers of French were not significantly different from those of the French natives, in almost all cases, the teachers' productions, while close to those of the French natives, fall between that group and the other group of native speakers of English.

Surprisingly, the Americans had a durational pattern in their reiterant versions of English words that turned out to be very close to the French timing pattern. Thus the average duration of the first syllable in two syllable words with stress on the first syllable (see Fig. 2) was 173 ms while the final syllable was 236 ms on the average, which is comparable to the French natives' average length of 176 ms for nonfinal syllables and average length of 274 ms for final syllables. Yet many of the Americans who were less experienced in French seemed to match the durational pattern of the final syllable of French words uttered in isolation (353 ms) by patterning it after the duration of their own stressed syllables in final position (336 ms) whereas the teachers of French achieved a closer match to the French baseline measure (296 ms).

Insofar as the nonfinal syllables are concerned, all the Americans showed that they can generally produce syllables of quite equal length (see Fig. 3), and there was no indication in their reiterant versions of French of the systematic initial syllable shortening that was found with the same subjects in the English reiterant productions, although some individual subjects continued to show such a pattern.

Thus the American teachers of French produced reiterant timing patterns that, while not identical to those of the native French speakers, did not differ significantly from them. On the other hand, the American teachers of French and the French natives both produced final vowel timing patterns that were significantly different from those of the other Americans.

G. General discussion

There is a growing body of acoustic-phonetic literature that suggests that the non-native productions of late second language learners are influenced, sometimes in subtle ways, by their native language speech patterns (see Flege, 1986, for a review). Most of the research has focused on the analysis of the phonetic characteristics of bilingual speech. Thus the

influence of native language phonetic habits has been demonstrated for voice onset time (VOT) in stop consonants for English/French bilinguals (Flege and Hillenbrand, 1984) and for Arabic/English bilinguals (Flege and Port, 1981), because bilinguals show a range of VOT values when speaking their second language that are intermediate between the values produced by monolingual native speakers of the two languages. Native language influences have also been shown for English vowel durations that depend on the voicing of the final consonant, because French/English bilinguals showed vowel durations, when speaking English, that were closer to those of French monolinguals (which vary less with respect to the voicing of a syllable-final consonant) than to those of English-speaking monolinguals (Mack, 1982).

A similar effect of the rhythmic pattern of the native language on the acquisition of the rhythmic patterns of English by native speakers of French has been found by Wenk (1985) who has described his subjects as passing through a transitional "interlanguage" phase, characterized by features of both language systems. Intermediate-level speakers of French who were learning English apparently mastered post-tonic reduced vowels (as in *matter*) before pre-tonic reduced vowels (as in *Japan*), when their productions of such words was judged by native speakers of English. In the present study, native speakers of English who have studied French appear to master the relatively equal durations of nonfinal syllables in French before they master the appropriate French final syllable length, because both groups of American subjects produced essentially equal nonfinal reiterant syllables in French, but only the more experienced group of American subjects, the teachers of French, also produced French-like final syllables. Flege (e.g., Flege, 1981; Flege and Hillenbrand, 1984; Flege 1987) has hypothesized that second language learners may acquire more rapid, accurate pronunciation of a sound that is totally foreign to their native repertoire, because they are unable to assimilate it to one of their native phonemes. Equally timed nonfinal syllables are not typical of English words, whereas final-syllable stress does occur. Perhaps native speakers of English who learn French are more successful in producing essentially equal nonfinal syllables in their reiterant versions of French than in producing the correct final-syllable lengthening, because the former pattern is more foreign to their native repertoire.

Many have argued that language learners who begin their study of a second language relatively late fail to master fully the phonetic details of that second language because of biological limitations imposed by a critical or sensitive period for speech acquisition (Lenneberg, 1967; Oyama, 1979; Scovel, 1988; Long, 1990). The notion of a critical period for language acquisition is a strong one and describes a period that is genetically determined, clearly delimited, and not susceptible to the influence of the environment. The notion of a sensitive period for language acquisition, on the other hand, while still a maturational effect, is subject to greater variability, including a less clearly delimited time frame. Although for some researchers in the field, the onset of adolescence (roughly 12 years of age) was seen as the point after which second language learners were likely to speak their non-na-

tive language with a notable foreign accent (see Flege, 1988), others have argued for acquisition of a foreign accent to age 6, at least for some individuals (see Long, 1990, for a review). Indeed, Long (1990) has written:

Thus, while somewhat weaker than the claim for a critical period for first language learning, the claim for a sensitive period for second language acquisition is still a strong and interesting one. The maturational processes underlying it are held to be universal. Hence, learners who begin a second language after its supposed closure (which will here be claimed to be as early as age 6 for phonology in many individuals and around 15 for morphology and syntax), and who nevertheless attain native-like ability in those areas, will falsify the hypothesis (p. 253).

However, all of the native speakers of English in the present study were late learners of French (beginning in junior high school at the earliest), yet the more experienced group of learners (American teachers of French) produced timing patterns that were not significantly different from those of the native French speakers.

Two possible explanations for this pattern of results can be suggested. Either the acquisition of second-language rhythm patterns is exempt from the sensitive period constraint or factors such as length of exposure, training, language aptitude, or motivation may play an important role. Whereas there has been little empirical investigation of the first hypothesis, the role of experience and training has been supported by a number of studies. For example, Wenk (1985) found that his advanced French students of English, unlike those at the intermediate level, had mastered the vowel reduction patterns associated with English word stress. Similarly, Flege and Eefting (1987) found that Dutch speakers of English who majored in the subject were judged to have significantly better pronunciation scores than Dutch students of English who studied to become engineers, although both groups' productions were judged to be signifi-

cantly different from those of native English speakers. As in the present study, however, experience may have been confounded with aptitude. The English majors, like the university-level teachers of French in the present study, were more experienced second-language learners, but they also probably had greater aptitude for second-language learning. In fact, aptitude rather than experience may be the source of the performance of the group of French teachers. However, in either case, if good reasons for exempting the acquisition of second-language rhythm patterns from the sensitive period constraint are not found, then these results call into question the notion of a sensitive period as currently formulated.

Future research needs to compare directly second-language segmental and rhythmic learning, to see if rhythmic patterns are easier to acquire, and to determine the relative contribution of rhythmic and phonetic factors to the detection of non-native pronunciation.

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APPENDIX

	French words	English words (stress pattern)
Two syllables	comptoir	counter (SW)
	sacré	sacred (SW)
	progrès	progress (SW)
	contrôle	control (WS)
	surprise	surprise (WS)
	degré	degree (WS)
Three syllables	compliment	compliment (SWW)
	instrument	instrument (SWW)
	solitude	solitude (SWW)
	ingénieur	engineer (WWS)
	indiscret	indiscrete (WWS)
	japonais	japanese (WWS)
	conclusion	conclusion (WSW)
	instructif	instructive (WSW)

	solution	solution (WSW)
	commentaire	
	légendaire	
	société	
Four syllables		commentary (SWWW)
		legendary (SWWW)
	télévision	television (SWWW)
		society (WSWW)
	économie	economy (WSWW)
	publicité	publicity (WSWW)
	exposition	exposition (WWSW)
	population	population (WWSW)
	satisfaction	satisfaction (WWSW)
Five syllables	automatiquement	automatically (WWSWW)
	élasticité	elasticity (WWSWW)
	électricité	electricity (WWSWW)
	possibilité	possibility (WWSWW)
	communication	communication (WWWSW)
	civilisation	civilization (WWWSW)

(S = primary stress, W = secondary stress or no stress)

¹ All ratios reported in the paper are to 1.

² Results of these analyses of variance were essentially the same, even when all ten original subjects were included. The only significant effect was that of syllable position [$F(1,9) = 121.16, p < 0.0000$]. None of the other effects were significant.

³ In the case of five-syllable words, there were actually four words representing one of the five-syllable word types and two words representing the other.

⁴ For comparability with Oller (1973) secondary stress syllables were grouped with unstressed syllables.

⁵ The syllables were here divided into those with primary, secondary, and no stress for comparability with Nakatani *et al.* (1981). The two initial syllables of the second set of five syllable words had complementary stress patterns (one of the words had a secondary stress where the other had no stress and vice versa), so the averaged durations of those syllables were excluded from these calculations.

⁶ The results of this analysis and all subsequent analyses include all of the original subjects from both groups. Similar analyses including only the subjects who produced the most consistent reiterant speech produced essentially the same results.

⁷ However, the present data exhibit a consistent effect of initial syllable shortening (see Fig. 2), which disagrees with findings by Oller (1973), Klatt (1976) and Nakatani *et al.* (1981). The most likely explanation for this discrepancy is that the reiterant productions in this study were produced as citation forms, rather than in a sentence frame. The present study used citation forms in order to reduce the number of syllables that subjects needed to remember for the reiterant production of individual words (but cf. Nakatani *et al.*, 1981 for a different method). It may be the case that the sentence frame gives extra prominence to the word to be imitated and that such prominence results in the pattern of word-initial syllable length found in the other studies.

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