THE ACQUISITION OF RHYTHMIC PATTERNS IN ENGLISH AND FRENCH

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ABSTRACT

Although rhythm may provide a basic grid for the acquisition of language, experimental studies investigating its development are scarce. In this paper, we examine the rhythmic patterns produced by 4-year-old French and English children and their mothers. In utterances of minimally four syllables, vowel durations were measured, and a rhythm index was calculated which expresses the degree of variability between successive vowel durations. The results show

(1) that successive vowel durations produced by French mothers are more nearly equal than those produced by English mothers, and
(2) that the rhythmic patterns of English mothers and children differ, but those of French mothers and children do not.

Our findings are in accord with traditional descriptions of French and English as syllable- and stress-timed respectively, and show that 4-year-old French children appear to have acquired the syllable-timed rhythm of French, but 4-year-old English children have not acquired the stress-timed rhythm of English.

1. INTRODUCTION

In speech production, the acquisition of intonation has been studied sporadically, but the development of rhythm has received hardly any attention at all [4, 9, 10]. In the present paper, we offer a cross-linguistic study of the acquisition of rhythm in English and French. The comparison is motivated by well-documented prosodic differences between the languages; English is said to be more 'stress-timed', whereas French is described as more 'syllable-timed'. Experimental studies showing how such rhythmic differences develop, however, are few and far between. Exceptions are investigations by [4], and [9] which suggest that the rhythmic patterns of French have been acquired by age 1;5, but the rhythm of English has not been acquired by age 2. In the present study, we test whether English children have acquired the rhythm of English by age four, and we contrast our English data with comparable data from French.

2. THE EXPERIMENT

2.1 Method

A method for the investigation of rhythmic differences between languages and/or speakers has been suggested by Low and Grabe [6]. Low and Grabe measured vowel length in successive syllables in texts produced by Singapore English and British English speakers, and derived from their measurements a rhythm index for each variety of English. The index provided an acoustic verification of impressionistic comments in the literature about rhythmic differences between Singapore English and British English: Singapore English is said to be 'syllable-timed' (i.e. a rhythm characterised by syllables of roughly equal length) whereas British English has been described as stress-timed (i.e. intervals between stressed syllables are of roughly equal length). Low and Grabe's rhythm index provided a significantly smaller value for Singapore English, indicating a rhythmic structure approaching syllable-timing, than for British English, where the index suggested a rhythm approaching stress-timing.

In [7], a speaking rate normalisation component was added to Low and Grabe's formula, and the updated index was used in the present study. The rhythm index is calculated using the following formula:

$$\text{(1)}\quad \mathrm{PVI} = 100 \times \left[\sum_{k=1}^{m-1} \left| \frac{d_k - d_{k+1}}{\left(d_k + d_{k+1}\right)/2} \right| / (m-1) \right]$$

where m=number of vowels in utterance
d=duration of the kth vowel

The formula in (1) shows that the index is compiled by calculating the difference in duration between successive syllables in an intonation phrase, taking the absolute value of the difference and dividing it by the mean duration of the pair. In doing this, the values obtained are normalised across speakers independent of their individual speaking rates. The differences are then summed and divided by the number of differences. The output is multiplied by 100, because the normalisation produces fractional values.

2.1.1 Hypotheses

In the present study, we applied Low and Grabe's method to the investigation of rhythmic differences between French and British English; just like Singapore English, French is said to be syllable-timed, and therefore, the data from our French and English mothers should reflect rhythmic differences comparable to those which distinguish Singapore English and British.

With respect to the child data, we hypothesised the following: arguably, the syllable-timed rhythm of French is less complex than the stress-timed rhythm of English; for instance, there is no need to compress or lengthen different numbers of syllables between stresses in order to achieve an appropriate rhythmic pattern. Additionally, it appears that duration alone offers a reasonable acoustic correlate of rhythm in French. In English, duration is not sufficient, and intensity and pitch movement appear to make more important contributions to rhythmic patterns than in French.

A second factor contributing to the greater prosodic

complexity of rhythm in English is accent placement. In French, accent location is fixed and therefore predictable; every intonation phrase, and every rhythmic group (a prosodic constituent of French which is smaller than an intonation phrase) is delimited by an accent. In English, accent location is not predictable because the location of accents is determined by focus placement which is under the control of the speaker. As a result, the location of strong syllables in English is more difficult to predict than in French. Combined, the cross-linguistic differences in prosodic complexity lead us to expect that the rhythm of English should be more difficult to acquire than the rhythm of French.

2.1.1 Materials

In cross-linguistics studies, some level of comparability in the data is desirable. Direct comparability in adult speech is relatively easy to achieve; a group of adults can be asked to read the same text, and speakers from different languages can be asked to read comparable versions of a specific text. Comparable data from young children are more difficult to obtain (clearly, the reading option is not available). In the present study, we collected comparable data using an English and a French version of the same interactive board game, adapted from the 'Treasure Chest of Tales', a proprietary game from the Early Learning Centre.

The 'Treasure Chest of Tales' was a story-telling game in which players were asked to make up two fairy tales using a number of cards which suggested locations such as *a castle* and characters such as *the princess*. Mothers and children were asked to make up a sentence about each item on each card so that a fairy tale would be the outcome. Some cards contained text, and, obviously, these were dealt with by the mother. The recording could, for instance, start as follows:

Mother:	"Okay, let's begin. Go ahead and make a sentence with this."
Child:	"…"
Mother:	"What is it?"
Child:	"It's a princess."
Mother:	"And what is she doing?"
Child:	"She is sitting on a horse."
Mother:	"Right. Now you make a sentence: Once upon a time…"
Child:	"there was a little princess, and she was riding her horsey."

..etc…

Then the mother would take the next card, and she would turn the word on this card into a sentence.

2.1.2 Recordings

The English data were recorded in a sound-treated booth in the phonetics laboratory at the University of Oxford, and the French data were recorded in quiet rooms in the French subjects' homes in Proville, France. The data were recorded onto DAT tape, digitised and processed on a Silicon Graphics O2 workstation using the commercial software package xwaves™.

The speakers played the game twice, with two different sets of cards, chosen by the experimenters. All cards were presented in the same order to ensure some degree of comparability between the stories. Mothers and children were told that the first fairy tale was a scary story about a princess who met a dragon, and that in the second story, a king would be bewitched.

2.1.3 Subjects

In the present paper, we give data from three English and three French mother/child pairs. The children were 4;3 – 4;6 years old, and they had just reached the age at which they could be expected to play our board game with some degree of success (our recording sessions lead us to suspect that it may be impossible to obtain directly comparable production data from younger children). The English speakers were recruited from private nursery schools in the Oxford area, and the French speakers from Proville, a village in the north-western part of France (Nord-Pas-de-Calais). All of the English mothers held English University degrees and could be classified as 'middle class' or 'upper middle class'. All French mothers appeared to be 'middle-class', except for one ('upper working class'), and most were academically trained. The children were recorded with their mothers rather than with the experimenter because of (a) a need for monolingual reference data from an equal number of adults and children, and (b) the fact that previous research has established that the input language from caregivers has an influence on the development of speech in children. This means that realisations from mother/child pairs should be optimally comparable.

2.1.4 Measurements

From the recorded data, we selected for each speaker 15 intonation phrases which contained minimally 4 syllables. Utterances of minimally 4 syllables are required to compile the rhythm index because the final syllable of each intonation phrase was excluded from the calculation. In English and French, intonation phrase-final syllables are lengthened, an effect which functions as an intonation phrase boundary cue [1, 2]. As we do not know to what extent phrase-final lengthening is realised our 4-year-old English and French speakers, we excluded the durations of IP-final syllables to avoid a potentially uncontrollable confound in our results. Instead, we report on the durations of final and medial syllables in the two languages and the two age groups separately (see section 2 below).The 15 intonation phrases chosen from each speaker had been produced fluently, without any obvious hesitations, or filled pauses (for intonation phrase boundary definitions, see e.g. [5], or [3]).

As an acoustic correlate of rhythm, we measured vowel duration in successive syllables using wide-band spectrograms generated in xwaves™. The segmentation of the spectrogram was carried out according to criteria suggested by [8].

2. Results

The rhythm index data, as well as the raw syllable duration measurements were subjected to a number of separate Analyses of Variance. In what follows, we report on the analyses of the rhythm index data first.

2.1 Rhythm index

The analysis of the rhythm index data was carried out in two stages. Firstly, we carried out an Analysis of Variance (ANOVA) with the independent variables Language (English, French) and Age (child, mother) and the dependent variable 'Rhythm index'. The purpose of this analysis was to establish

(a) whether our data reflected significant cross-linguistic differences, and (b) whether the data from mothers and children differed. The analysis revealed highly significant main effects for Language ($F[1,176]=70.5$, $p<0.001$) and Age ($F[1,176]=7.3$, $p<0.01$) and a significant interaction between Language and Age ($F[1,176]=4.1$, $p<0.05$). Figure 1 below illustrates the results for Language, and Figure 2 gives the results for Age.

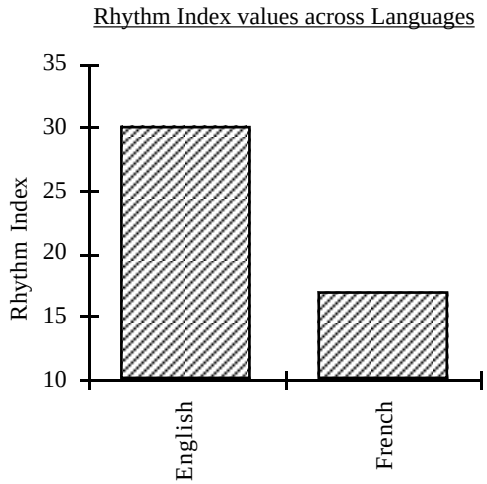

Figure 1. Results for the variable Language.

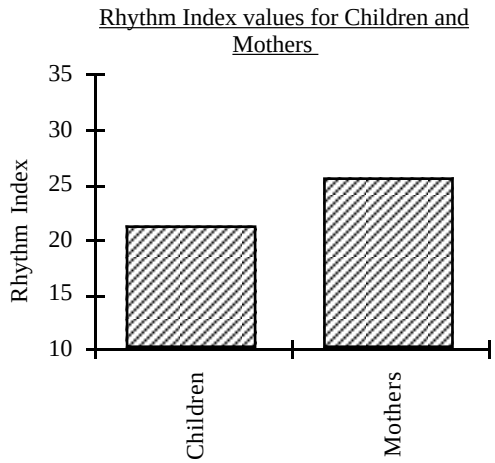

Figure 2. Results for the variable Age.

Figure 1 shows that the rhythm index values for English were significantly higher than those for French. In the English data, there was more variability in successive vowel durations. This finding was expected; if French is characterised appropriately as a syllable-timed language, then data from French should exhibit less variability between successive vowels than data from English, a language whose rhythmic pattern tends towards stress-timing

Figure 2 shows the results for Age. English and French children exhibit less variability between successive vowels than their mothers. This finding can be interpreted to suggest that 4-year-olds produce more regular timing patterns than adults, whether the language they acquire tends towards syllable-timing or towards stress timing.

Then the data were processed separately for each language. Independent variables were Pair (of speakers) (1,2), and Age (child, mother); the dependent variable was 'Rhythm index'. In the English data, main effects emerged for Pair ($F[2,84]=5.7$, $p<0.01$) and Age ($F[1,176]=8.6$, $p<0.01$). The interaction was not significant. The French data were different, only Pair ($F[2,84]=3.8$, $p<0.05$ was marginally significant; Age was not, and neither was the interaction. The data are illustrated in Figure 3 below, which shows rhythm index values within English on the left, and within French on the right. Figure 3 shows that the data from English and French mother-child pairs were different. No difference was found in duration patterns produced by French children and adults, but the patterns produced by English children and adults differ significantly. The data suggest that French children have acquired the rhythm of French by age 4 (at least as far as duration is concerned), but English children have not acquired the rhythm of English.

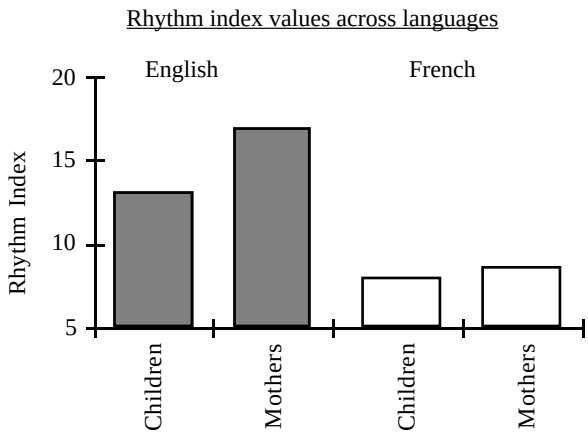

Figure 3. Results for English (left) and French (right).

The results for Pair are given in Table 1 below. The table shows that the significant effect of Pair in English is due to the higher variability in the data from pair 1; in French, the data from pair 2 are more variable than those from the other pair. But note that even in French pair 2, the variability is lower than in the data from any English pair.

	Pair 1	Pair 2	Pair 3
English	18.16	13.37	13.76
French	7.41	10.06	7.67

Table 1. Rhythm index values for Pair in English and French.

2.2 Raw syllable durations

The second set of statistical analyses involved the raw syllable durations. Descriptive statistics showed that the syllable durations produced by 4-year-olds English children were 1.42 times longer than those produced by English mothers, and those by French children were 1.55 times longer than those produced by their mothers. We tested whether this difference was significant. Figure 4 illustrate the data.

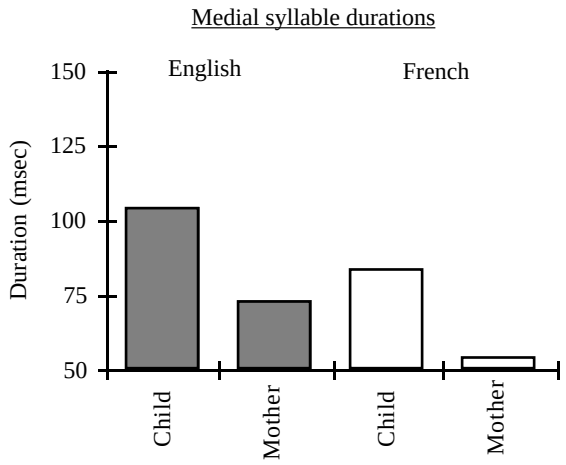

Figure 4. Medial syllable durations in English (left) and French (right).

Secondly, the syllable duration data suggested a cross-linguistic difference in the application of phrase-final lengthening. English mothers produced final syllables which were 2.1 times longer than medial syllables, and English children lengthened by factor 1.8. In French, the data from children and mothers did not appear to differ; children lengthened their final syllables by factor 2.2, and the mothers lengthened by factor 2.1. Figure 5 illustrates the data.

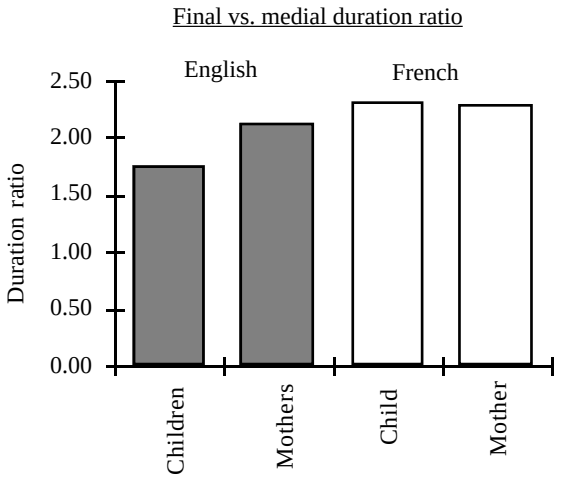

Figure 5. Final vs medial syllable duration ratio in English (left) and French (right).

The data were subjected to several Analyses of Variance. The first involved the independent variables Language and Age and the dependent variable 'IP-medial syllable duration'. Language and Age were significant (Language: $F[1,176]=31.8$, $p<0.001$; Age: $F[1,176=78.7$, $p<0.001)$); overall, syllable durations were longer in English than in French, and longer in children than in mothers. This finding suggests that 4-year-olds may speak with a slower articulation rate than their mothers in both English and French. The cross-linguistic difference might reflect the presence of stressed and accented syllables in IP-internal position in English. Alternatively, it may be an artefact of a cross-linguistic difference in articulation rate in our data.

The second ANOVA involved the duration ratio between IP-final and IP-medial syllables in the two languages and the two age groups (mean duration ratio from English mothers: 2.1, English children: 1.8; French mothers: 2.1, French children: 2.2). The analysis involved the independent variables Language and Age, and the dependent variable 'duration ratio'. No significant results emerged from the analysis; in other words, neither the cross-linguistic difference, nor the age difference, not the interaction were significant.

3. SUMMARY AND CONCLUSION

We hypothesised that English children would acquire the rhythm of English later than French children would acquire the rhythm of French. Our findings support this hypothesis. By age 4, as far as duration is concerned, the rhythmic patterns produced by French children do not differ significantly from those produced by their mothers. The rhythmic patterns produced by English mothers and children, on the other hand, differ significantly. We account for our findings in terms of the greater complexity of rhythmic structure in English as compared to French

Clearly, more research is required. Our data provide a snapshot of rhythmic development in two prosodically diverse languages at age 4; complementary data from children older and younger than 4 are needed, as well as comparable data from other languages. In future work, we intend to collect such data and carry our a number of studies investigating the development of the rhythmic 'grid' and its acoustic properties at different stages of development.

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