Training children with artificial alphabet

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ABSTRACT The purpose of the paper was to confirm the use of analogy processes in the onset of reading acquisition and to delimit the special place of rime in these processes in French. In tasks where children were required to learn to recognise some pseudowords, then to recognise other pseudowords written with the same letters, an artificial alphabet was used in order to eliminate any role of the knowledge young children might have acquired about printed words. A first experiment contrasted artificial and standard alphabets in prereaders and compared prereaders and beginning readers with the artificial alphabet. The results suggested that prereaders used analogy while first graders deciphered. In prereaders the expected advantage of rime analogy over analogies on CV- units was only observed with the natural alphabet. A second and a third experiment used a concatenated artificial alphabet in which rime, CV- or C-C was coded by a single character to force the reader to encode correspondences on multi-phonemic units. These experiments failed to show any reliable effects of conditions and age when single characters encoded multi-phonemic units. It seems that encountering a script system where each phoneme did not correspond to at least one character disturbed children.

Key words: Analogy, French language, Learning to read.

Introduction

When reading new words or pseudowords, the reader uses knowledge about the way orthographically similar known words are pronounced. Various studies have demonstrated that adults (Peereman, 1991) and children (Goswami, Gombert, & Fraca de Barrera, 1998) often rely on analogies, based on "orthographic neighbourhoods", when trying to decipher new words (cf. Gombert, Bryant, & Warrick, 1997). However there is a controversy about when this phenomenon arises in the learning process. Two contrasting views can be distinguished.

A first view holds that the analogical processes would develop late in reading acquisition, after mastering of the grapheme-phoneme correspondences. Conversely, some researchers have assumed that reading by analogy occurs earlier and might help beginning readers to read new words.

Most of the developmental models that conceptualise reading acquisition as a sequence of stages agree with the first view. In a very influential model, Frith (1985) postulated a development in three successive stages: the

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logographic stage, the *alphabetic stage*, then the *orthographic stage*. In this framework, the use of analogies would not arise before the alphabetic stage. It would constitute a sophistication of the print-to-sound correspondences based on units larger than the graphemes and the phonemes.

Such an analysis does not fit well with some empirical data, which indicate an earlier development of analogy processes in reading. In fact, it is likely that the process of making analogies between letter strings can be regarded as part of beginning reading, and not merely as a special case of alphabetic processes. It has been hypothesised that, in order to read words never encountered before in print, beginning readers use their knowledge about the way similar orthographic patterns are pronounced in already known words. For instance, a child who can read the word *"light"* might read the words *"night"* or *"sight"* by using, on the one hand, the orthographic analogy between these words and, on the other hand, his/her own ability to recognise the *rime* [ait] in these three words. The same phenomenon would work for the word initial consonant clusters (the *onset*), but analogies based on other subsyllabic units would develop later.

Goswami (1986, 1988) asked children of six, seven and eight years old to read a set of words that were mostly too difficult for them. Then, she told them what one of these written words, such as *"peak"*, meant. It came out that telling the children how to read this word helped them to read other rhyming words with similar final spelling patterns such as *"beak"*, *"leak"* and *"weak"*, but had little effect on their ability to read other words, such as *"bean"* or *"bake"*, which did not share the same final spelling sequence and rhyming sound. Thus, if children are able, at the start of learning to read, to infer that two words which end with the same spelling sequence also share a rhyming sound, it is quite likely that their ability to group words by rhyme should help them to learn to read. In fact there is ample evidence for this connection. Children's early (preschool) sensitivity to rhyme and alliteration are extremely powerful predictors of their eventual success in learning to read. It is also the case that training in rhyme helps children learn to read (Bradley & Bryant, 1983).

Nevertheless, although this research strongly suggests a precocious role of analogy processes in learning to read, the specific importance of onset and rime analogies is not entirely clear. It remains possible that this phenomenon is peculiar to the English language where the pronunciation of vowels depends on the subsequent consonants, and where the spelling patterns corresponding to the rimes are often so complicated that it might be cognitively less costly to encode them as a block. Moreover, even in English, Goswami (1991) failed to reproduce the advantage for the rime in precocious analogies when children had to read words included in texts rather than isolated words.

The purpose of the present series of experiments was twofold. First, we wanted to confirm the use of analogy processes in the beginning of learning to read. Second, we investigated whether the rime unit has a specific status in these analogy processes for French. In addition, we were concerned with a major problem that is inherent in most studies on reading acquisition. Indeed, because it is generally impossible to control for the experience the children have with alphabetical material, it is difficult to completely disentangle what in the data are caused by the experimental factors or by knowledge of particular printed words. As a methodological solution to this problem, the present study used an artificial written language. This allowed examining the ease in coding graphophonological correspondences based on -VC, CV-, or graphemes units independently of the respective frequencies of these units in print. Moreover, the reader can be forced to encode correspondences based on multi-phonemic units by reducing the number of artificial characters to represent CVC syllables (e.g., the two characters * • to represent /far/).

General method

The experiments to follow involved two steps. First, children learned to associate CVC syllables pronounced by the experimenter, either to strings of letters (*natural* characters) or to strings of non-alphabetic characters (*artificial* characters). Then, after training, new strings were presented and the children were told to indicate which one of two alternative pronunciations was the right one (test items). The first dependent variable was the number of times the training syllables had to be presented to the child to reach a fixed criterion (two successive presentations without error). The second variable was the number of correct choices for the test items.

Experiment 1: Natural vs. artificial alphabets

Experiment 1 included three different conditions. In the "rime condition", correct responses to the test items should be contingent on the use of body-rime correspondences. In the "initial CV" condition, correspondences on initial CV- units should be applied whereas grapheme-phonemes correspondences were required in the "no analogy condition".

Experiment 1A compares natural and artificial written languages in prereaders. Experiment 1B compared prereaders and beginning readers using only artificial characters.

Method

Participants. The participants were 90 French-speaking children: Sixty kindergarteners (aged 5-3 to 6-1, mean: 5-9) who had not yet begun formal reading instruction; of them, 30 children were submitted to the natural alphabet condition and 30 children to the artificial alphabet condition. Thirty first graders (aged 6-1 to 7-0, mean: 6-4) who were submitted to the artificial alphabet condition.

Material. The items used in Experiment 1 are presented in Tables 1 to 3 for the natural alphabet, and in Tables 4 to 6 for the artificial alphabet. Three sets of nine CVC items were generated. For the rime condition, three onsets (f-; p-; t-) were orthogonally combined with three rimes (-ar; -ic; -ul) (cf. Table 1).

For the initial CV condition, three starts (fa-; pi-; tu-) were orthogonally combined with three codas (-r; -c; -l) (cf. Table 2).

For the no analogy condition, three sets of initial and final consonants (f-r; p-l; t-c) were orthogonally combined with three middle vowels (-a-; -i-; -u-) (cf. Table 3).

As shown in Tables 4, 5 and 6, items in artificial alphabet conditions were designed in the same way, but the "natural" alphabetic characters were replaced by artificial characters: ↓ = f, * = p, ♣ = t, + = r, ♥ = c, • = l, ❏ = a, ♦ = i, ♠ = u.

Each item was written on a white 9 by 12 cm card. In each condition, five items were used for

Table 1
Items used in the rime condition (natural alphabet)

	f-	p-	t-	Choice
-ar	**far (1)**	**par (2)**	tar (a)	**TAR? TIC?**
-ic	**fic (3)**	**pic (4)**	tic (b)	**TAR? TIC?**
-ul	ful (c)	pul (d)	**tul (5)**	
Choice	**FUL? PUL?**	**FUL? PUL?**		

Table 2
Items used in the initial CV condition (natural alphabet)

	fa-	pi-	tu-	Choice
-r	far (1)	pir (2)	tur (a)	TUR? TUC?
-c	fac (3)	pic (4)	tuc (b)	TUR? TUC?
-l	fal (c)	pil (d)	tul (5)	
Choice	FAL? PIL?	FAL? PIL?		

Table 3
Items used in the no analogy condition (natural alphabet)

	f-r	p-l	t-c	Choice
A	far (1)	pal (2)	tac (a)	TAC? TIC?
I	fir (3)	pil (4)	tic (b)	TAC? TIC?
U	fur (c)	pul (d)	tuc (5)	
Choice	FUR? PUL?	FUR? PUL?		

Table 4
Items used in the rime condition (artificial alphabet)

	↓-*[F]*	*-*[P]*	♣-*[T]*	Choice
-□+*[AR]*	↓□+*[FAR]* (1)	*□+*[PAR]* (2)	♣□+ (a)	TAR? TIC?
-♦♥*[IC]*	↓♦♥*[FIC]* (3)	*♦♥*[PIC]* (4)	♣♦♥ (b)	TAR? TIC?
-♠•*[UL]*	↓♠• (c)	*♠• (d)	♣♠•*[TUL]* (5)	
Choice	FUL? PUL?	FUL? PUL?		

training (items 1 to 5 in the tables), the four remaining items (a, b, c, d in the tables) were used for the test session.

Procedure. Kindergarten children were randomly assigned either to the natural alphabet condition or to the artificial alphabet condition. All first graders performed the artificial alphabet condition.

At the onset of the experimental session, each child was submitted to a standardised reading test ("L' Alouette": Lefavrais, 1967). Kindergarteners obtained a prereader level, and

Table 5
Items used in the initial CV condition (artificial alphabet)

	↓⊐-*[F]*	*♦-*[PI]*	♣♠-*[TU]*	Choice
-+*[R]*	↓⊐+*[FAR]* **(1)**	*♦+*[PIR]* **(2)**	♣♠+ (a)	**TUR? TUC?**
-♥*[IC]*	↓⊐♥*[FAC]* **(3)**	*♦♥*[PIC]* **(4)**	♣♠♥ (b)	**TUR? TUC?**
-●*[UL]*	↓⊐● (c)	*♦● (d)	♣♠●*[TUL]* **(5)**	
Choice	**FAL? PIL?**	**FAL? PIL?**		

Table 6
Items used in the no analogy condition (artificial alphabet)

	↓-+*[F-R]*	*-●*[P-L]*	♣-♥*[T-C]*	Choice
⊐*[A]*	↓⊐+*[FAR]* **(1)**	*⊐●*[PAL]* **(2)**	♣⊐♥ (a)	**TAC? TIC?**
♦*[I]*	↓♦+*[FIR]* **(3)**	*♦●*[PIL]* **(4)**	♣♦● (b)	**TAC? TIC?**
♠*[U]*	↓♠+ (c)	*♠● (d)	♣♠♥ *[TUC]* **(5)**	
Choice	**FUR? PUL?**	**FUR? PUL?**		

first graders reached a mean reading age of 6-6. In each group (Kindergarteners "natural" and "artificial", first graders), three subgroups of ten children were randomly constituted and assigned to one of the three experimental conditions (Rime, Initial CV, or No Analogy).

The procedure included a training phase followed by a test phase. Both phases were similar for each group and each condition.

Training phase. In the training phase, the child learned to match CVC syllables to 5 different items (items 1 to 5 in the tables). First, the examiner put all cards on the table, side by side, and pronounced for each one the associated syllable. For each card, the child was invited to try by her/himself to read the syllable. The cards were then removed and presented again, side by side, but this time, the child was asked to retrieve the correct pronunciation. Corrective feedback was provided in case of failure. Next, for each card presented in isolation, the child was invited to give the correct syllable. In case of errors, corrective feedback was provided and all cards were again put on the table side by side as previously. In contrast, if all responses were correct, all cards were presented a second time in isolation. If errors occurred, all the cards were put on the table again, side by side as previously. Training finished when the child was able to provide the correct syllable for two successive presentations of the cards in isolation. Hence, the criterion of success was two successive series without any error.

Test phase. During the test phase, four new items (items a, b, c, d, in Tables 1 to 6) were presented successively. For each one, two different pronunciations were proposed to the child. The task of the child was to choose the right one. To control the order of the items associated with each proposition, the items were presented twice with a different order. The order of the two pronunciations proposed for each item was counterbalanced across children. Neither explanation nor feedback was provided during the test phase.

Results

For the learning phase, the dependent variable was the number of presentations needed to reach the learning criterion. For the test phase, the dependent variable was the number of correct responses.

Two different analyses were conducted on the learning and test data. The first analysis compared "natural" and artificial alphabets in kindergarten children (Experiment 1A). The second analysis compared the two age groups in the artificial alphabet task (Experiment 1B).

Experiment 1A: Natural and artificial alphabets in kindergarteners. Figure 1 shows the mean number of presentations needed for learning the five items as a function of conditions and types of alphabet.

The data were analysed with a 2 (Alphabet: natural vs. artificial) x 3 (Condition: rime, CV-, non-analogy) ANOVA. The only significant effect was the interaction between alphabet and condition, $F(2, 54) = 4.18$, $p = .02$. As Figure 1 shows, there were less trials with the natural alphabet in the rime condition than in the two other conditions, this difference being marginally significant, $F(2, 27) = 2.62$, $p = .09$. In contrast, the three conditions did not differ significantly for the artificial alphabet ($F < 1$).

Thus, the expected effect of facilitation of learning in the rime condition was found only for natural language. It seems that the possibility to use rime analogy facilitated learning, provided that the alphabet is familiar to the child.

Figure 2 shows the mean numbers of correct choices (out of 8) in the test phase as a function of conditions and types of alphabet.

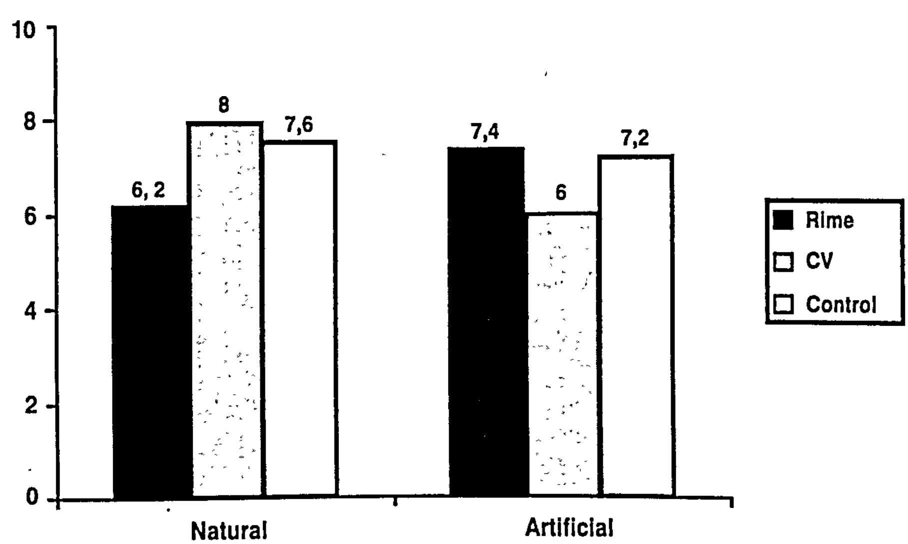

Figure 1
Number of presentations during training as a function of type of alphabet and condition in kindergarteners (Experiment 1A).

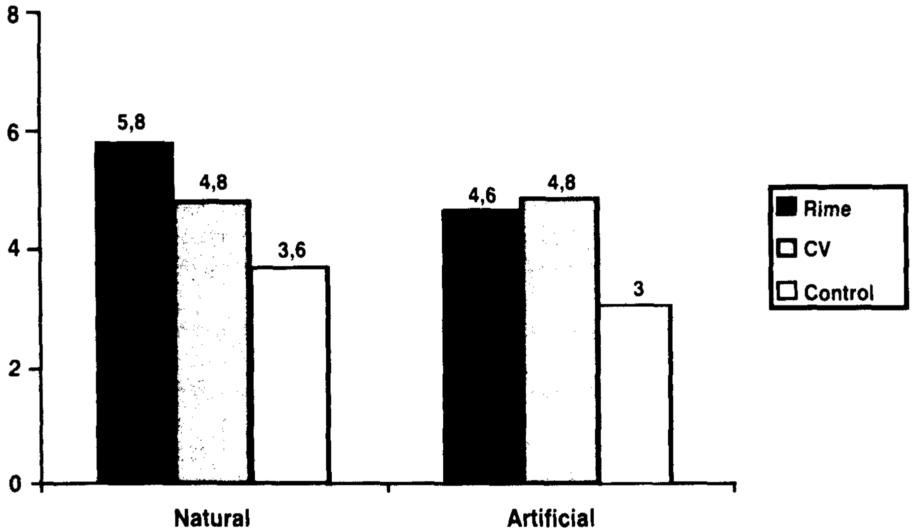

Figure 2
Mean number of correct choices (out of 8) as a function of condition and type of alphabet in kindergarteners (Experiment 1A).

Only the main effect of condition (rime, CV-, no analogy) was significant, $F(2, 54) = 9.37$, $p = .0003$. The main effect of alphabet was only marginally significant, $F(1, 54) = 2.87$, $p = .09$, and the Alphabet x Condition interaction did not reach significance ($F < 1$). Nevertheless, a *post hoc* analysis (Newman-Keuls test) indicated that in the artificial alphabet, both the rime condition and the CV condition differed significantly from the no analogy condition ($p = .04$ and $p = .03$, respectively). With the natural alphabet, only the rime condition was better than the no analogy condition ($p = .01$).

In the previous analysis, the chance level in the choice task was 4. The average performance was close to this level. In fact, the only score which significantly differed from chance level was the rime condition with the natural alphabet (bilateral limit of confidence of the mean, $p = .001$). Thus, in order to confirm the significance of the results, we performed additional analyses using more stringent criteria to qualify a choice as correct. In these analyses, the choice was considered as correct only if, for the same pair, both responses (order 1 and 2) were correct. Consequently, the chance level drops to 1. Figure 3 shows the mean numbers of correct choices (out of 4) in the test phase as a function of conditions and types of alphabet.

As it was the case in the previous analysis, only the factor Condition yielded a significant effect (Rime vs. CV, vs. Control), $F(2, 54) = 9.7$, $p = .0002$. Neither the main effect of alphabet, nor the Alphabet x Condition interaction reached significance. Here also, *post hoc* analyses (Newman-Keuls test) showed that while both rime condition and CV condition differed significantly from the no analogy condition in artificial alphabet (for both, $p = .04$), only the rime condition differed from the no analogy condition in natural alphabet ($p = .02$). Nevertheless, whatever the type of alphabet

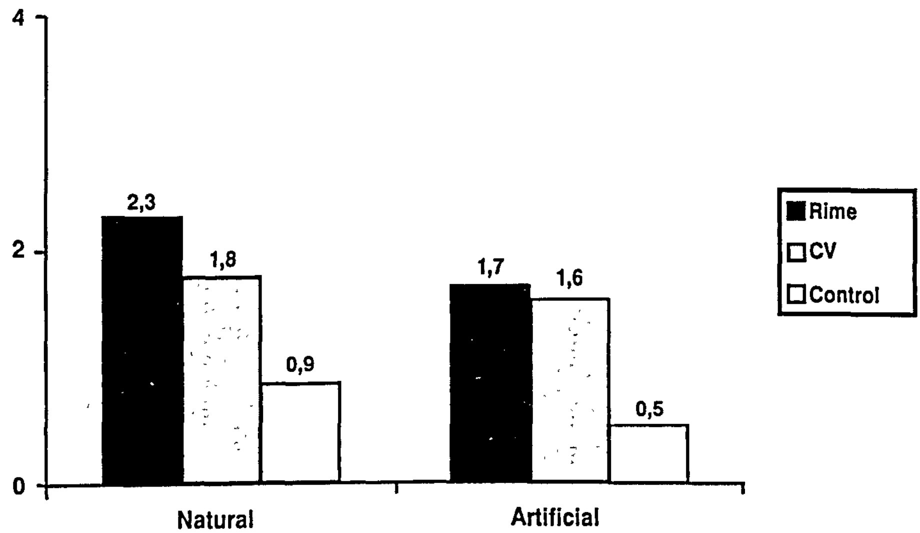

Figure 3
Mean numbers of correct choices (out of 4) as a function of condition and type of alphabet in kindergarteners (Experiment 1A).

(natural or artificial) only performance in the rime condition differed significantly from chance level (bilateral limit of confidence of the mean, p = .002 and p = .04, respectively).

Overall, the present results confirm that the possibility to use analogies during learning helped the children to determine, among two alternatives, the correct phonological coding of new strings of characters. However, except for the natural alphabet, there is no clear evidence that rime analogy provides an additional advantage in comparison to initial CV- analogy.

Experiment 1B: Kindergarteners vs. first graders in reading the artificial alphabet. Figure 4 shows the mean number of presentations needed for learning the five items as a function of condition and age.

The ANOVA included the factors Age (kindergarten, grade 1) and Condition (rime, CV-, no analogy). Only the effect of age was significant, $F(1, 54) = 18.1$, $p = .000$. The older children needed more item presentations than the younger for learning to recognise the five items.

Because first graders already know how to decipher natural alphabet, they might be incited to learn each item analytically and to establish correspondences between artificial characters and known letters. If such an analytical strategy is indeed adopted by the first graders, one should observe similar performance for all conditions (rime, CV-, no analogy) in the choice test.

Figure 5 shows the mean numbers of correct choices (out of 8) in the test phase as a function of condition and age.

The main effect of age was marginally significant, $F(1, 54) = 3.65$, $p = .06$. Neither the main effect of condition, nor the Age x Condition interaction reached significance. Nevertheless, *post hoc* analyses (Newman-Keuls test) showed that while both the rime condition and the CV-

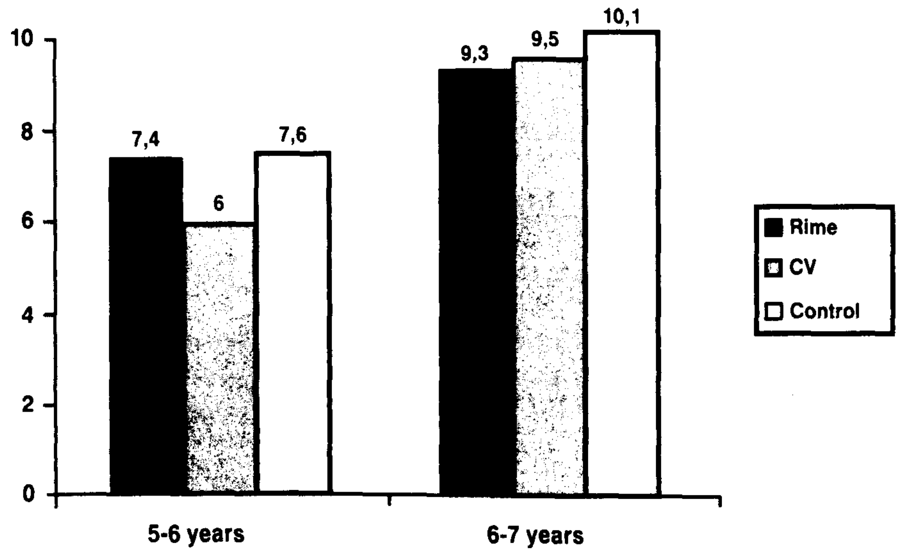

Figure 4
Number of presentations during training as a function of age and condition (Experiment 1B).

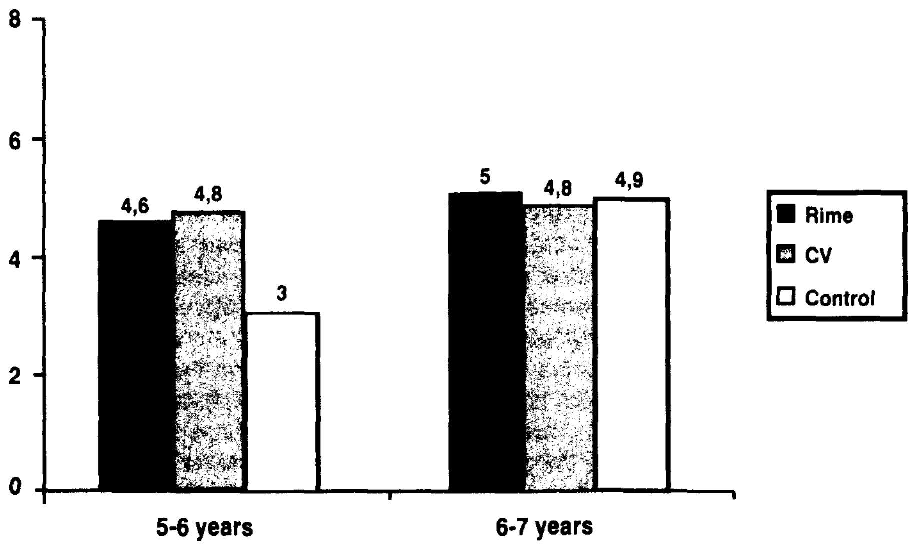

Figure 5
Mean number of correct choices (out of 8) as a function of condition and age in Experiment 1B.

condition differed significantly from the no analogy condition for kindergarteners (p = .04 and p = .03 respectively), there was no effect of condition for older children.

Here again, the chance level in the choice task was 4. The only score which significantly differed from chance level was the no analogy condition in older children (bilateral limit of confidence of the mean, p = .01). Thus, as performed previously, we carried out additional analyses in which the choice was considered as correct only if, for the same pair, both responses (order 1 and 2) were correct. Adopting this criterion drops the chance level to 1. Figure 6 shows the mean numbers of correct choices (out of 4) in the test phase as a function of condition and age.

The main effect of condition (rime, CV, no analogy) was significant, $F(2, 54) = 3.13, p = .05$, and the main effect of age was marginally significant, $F(1, 54) = 3.24, p = .07$. The Age x Condition interaction did not reach significance. *Post hoc* analyses (Newman-Keuls test) showed that, while younger children were better both in the Rime and the CV conditions rather than in the no analogy condition (p = .05 and p = .02, respectively), older children did not perform differently in the three conditions. Moreover, the only significant difference between younger and older children concerned the no analogy condition (p = .04). Last, while in younger children only the rime condition's score significantly differed from chance level (bilateral limit of confidence of the mean, p = .04), in older children it was the no analogy condition that differed (p = .02).

As expected from the data collected in the training phase, the younger children used analogy while the older deciphered. Interestingly, deciphering in beginning readers did not induce a higher level of performance than using analogies in prereaders.

In conclusion, although Experiment 1 is persuasive in establishing the use of analogies

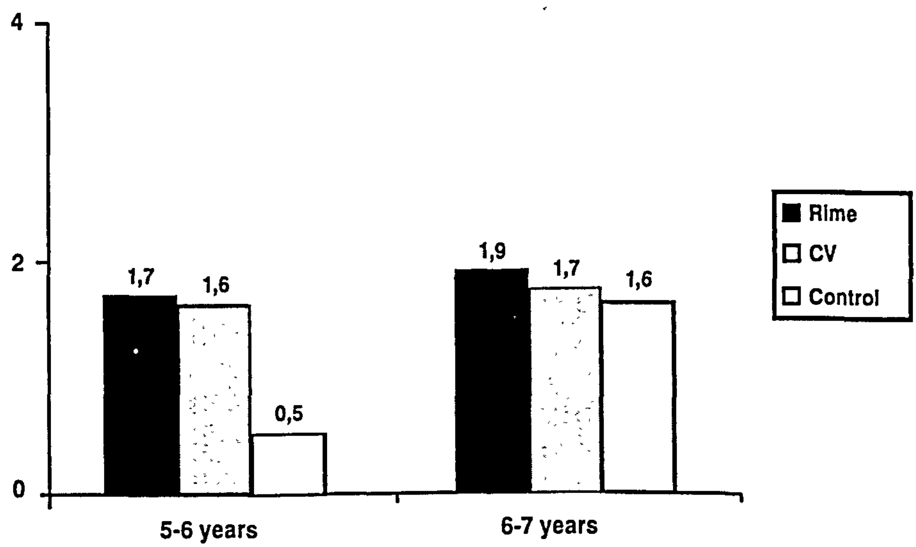

Figure 6
Mean number of correct choices (out of 4) as a function of condition and age in Experiment 1B.

right at the start of learning to read, it is unclear whether rime units have a special place in these analogy processes. In prereaders, natural alphabet led to a rime advantage, but both rime and CV- conditions were beneficial with the artificial alphabet. We shall return to this difference between alphabets in the final discussion.

Experiment 1 also revealed that first graders performed the task by relying on analytical processes based on character-to-phoneme correspondences. Hence, the ability to read by analogy in older children is obscured by the analytical strategy. The two next experiments were therefore designed to explore further the analogy processes when an analytical strategy was discouraged.

Experiment 2: Artificial alphabet with concatenated CV- and -VC units

Experiment 2A forced to parse the CVC syllables in two units by using a *concatenated* artificial alphabet that represented CVC by means of two artificial characters. Experiment 2A was similar to Experiment 1 except that each CVC syllable was represented with two artificial characters. Experiment 2B examined coding preferences by using a single set of items that allowed analogies on CV- or -VC.

Experiment 2A

Method

Participants. The participants were 60 French-speaking children: 30 kindergarteners (aged 5-2 to 6-0, mean: 5-8) who had not yet begun formal reading instruction and 30 first graders (aged 6-2 to 7-1, mean: 6-5).

Material. The items used in Experiment 2A are presented in Tables 7 to 9. Three sets of nine CVC items were created with an artificial alphabet. For the rime condition, three onsets (*- = f-; ♠- = p-; ⊐- = t-) were orthogonally combined with three rimes written with only one character each (-• = -ar; -+ = -ic, ♦ = -ul) (cf. Table 7).

For the initial CV condition, three starts written with only one character each (*- = fa-; ♠- = pi-; ⊐- = tu-) were orthogonally combined with three codas (-• = -r; -+ = -c, ♦ = -l) (cf. Table 8).

For the no analogy condition, three sets of initial and final consonants written with only one character each (*- = f-r; ♠- = f-c; ⊐- = f-l) were orthogonally combined with three median vowels (-• = -a-; -+ = -i-, ♦ = -u-) (cf. Table 9).

Each item was written on a white 9 by 12 cm card. In each condition, five items were used in the training phase (items 1 to 5 on the tables), the four remaining items (a, b, c, d on the tables) were used in the test phase.

Procedure. The procedure was the same as

Table 7
Items used in the rime condition of Experiment 2A

	*-[F]	♠-[P]	⊐-[T]	Choice
-•[AR]	*•[FAR] **(1)**	♠•[PAR] **(2)**	⊐• (a)	**TAR? TIC?**
-+[IC]	*+[FIC] **(3)**	♠+[PIC] **(4)**	⊐+ (b)	**TAR? TIC?**
-♦[UL]	*♦ (c)	♠♦ (d)	⊐♦ [TUL] **(5)**	
Choice	**FUL? PUL?**	**FUL? PUL?**		

Table 8
Items used in the initial CV condition of Experiment 2A

	*-[FA]		♠-[PI]		❑-[TU]		Choice	
-•[R]	*•[FAR]	(1)	♠•[PIR]	(2)	❑•	(a)	TUR?	TUC?
-+[C]	*+[FAC]	(3)	♠+[PIC]	(4)	❑+	(b)	TUR?	TUC?
-♦[L]	*♦	(c)	♠♦	(d)	❑♦ [TUL]	(5)		
Choice	FAL?	PIL?	FAL?	PIL?				

Table 9
Items used in the no analogy condition of Experiment 2A

	*-[F-R]		♠-[F-C]		❑-[F-L]		Choice	
-•[-A-]	*•[FAR]	(1)	♠•[FAC]	(2)	❑•	(a)	FAL?	FIL?
-+[-I-]	*+[FIR]	(3)	♠+[FIC]	(4)	❑+	(b)	FAL?	FIL?
-♦[-U-]	*♦	(c)	♠♦	(d)	❑♦ [FUL]	(5)		
Choice	FUR?	FUC?	FUR?	FUC?				

in Experiment 1. Each child was submitted to a standardised reading test ("L'Alouette": Lefavrais, 1967). In each group (kindergarteners and first graders), three subgroups of ten children were randomly constituted and assigned to one of the three experimental conditions (rime, initial CV, or no analogy). As in Experiment 1, Experiment 2 included a training phase followed by a test phase. The training and the test phase were identical to Experiment 1.

Results

As in Experiment 1, the two dependent variables were the number of presentations needed for reaching the learning criterion in the training phase and the number of correct responses in the test phase.

Figure 7 shows the mean numbers of presentations needed for learning the five items as a function of conditions and ages.

A 2 (Age: kindergarten, grade 1) x 3 (Condition: rime, initial CV, no analogy) ANOVA did not show any significant effect.

Figure 8 shows the mean numbers of correct choices (out of 8) in the test phase as a function of condition and age.

The data from the choice task were submitted to a 2 (Age: kindergarten, grade 1) x 3 (Condition: rime, initial CV, no analogy) ANOVA. As it was the case in the analysis of training performance, there was no significant effect.

Here also, the chance level in the choice task was 4. The only score which significantly differed from chance level was the CV condition in younger children (bilateral limit of confidence of the mean, $p = .05$). Thus, we conducted additional analyses in which the choice was considered as correct only if, for the same pair, both

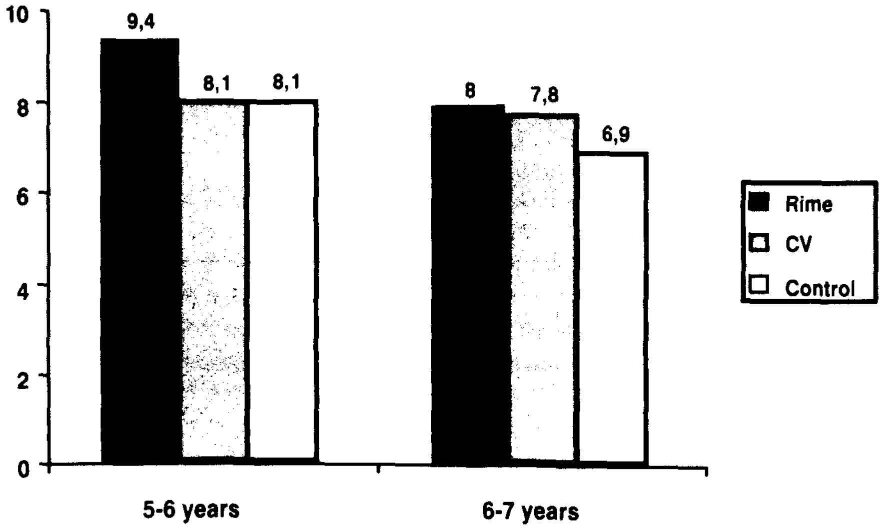

Figure 7
Number of presentations during training as a function of age and condition in Experiment 2A.

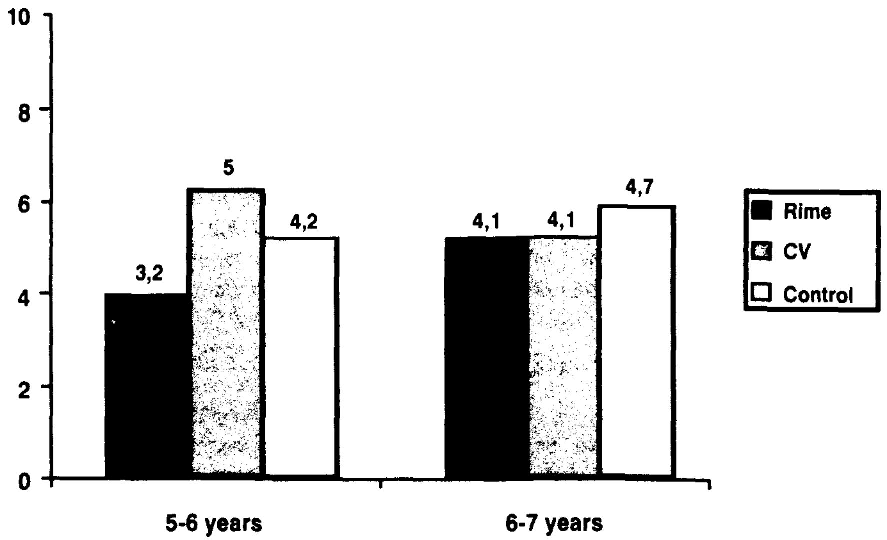

Figure 8
Mean number of correct choices (out of 8) as a function of condition and age in Experiment 2A.

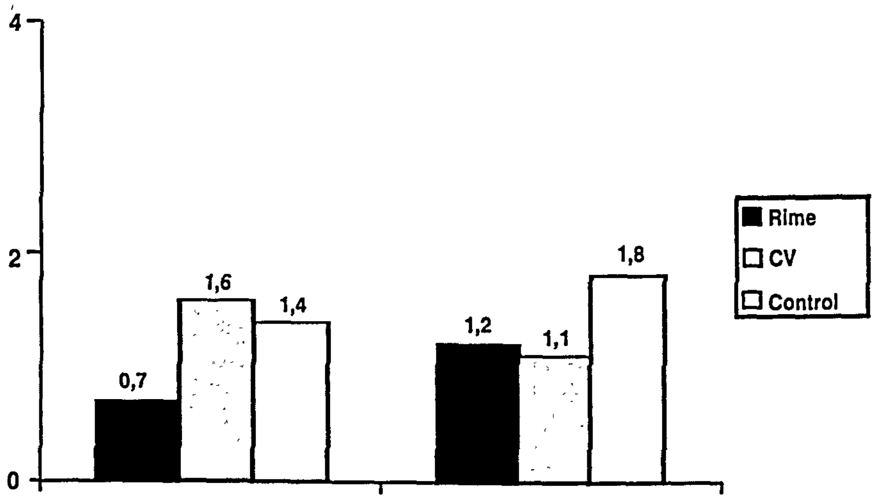

Figure 9
Mean number of correct choices (out of 4) as a function of condition and age in Experiment 2A.

responses (order 1 and 2) were correct. Figure 9 shows the mean number of correct choices (out of 4) in the test phase as a function of condition and age.

In accord with the previous analyses, there *was no significant effect. Only the no analogy* condition's score for older children was significantly different from chance (bilateral limit of confidence of the mean, *p* = .*04*). *This* unexpected finding deserves discussion. Indeed, there is no reason for beginning readers to perform better in the no analogy condition than in the rime or CV- conditions. If analogies were used, the performance for no analogy words would have been worse than performance in the rime and the CV- conditions. Conversely, there is *no a priori reason to expect differences across* conditions if the task is performed without making analogies.

A close look at the items indicated that, contrary to the rime and the CV- conditions, *half* of the stimuli in the no analogy condition could be answered simply by learning the characters associated with the vowels. In fact, in this condition, it was sufficient to know that • stood *for /a/* and + stood for */i/* to give the correct responses for □• and □+. Such a strategy was not possible for the pair *♦ (fur) and ♠♦ (fuc) *which included the same vowel /y/.* In the two other conditions the vowel was never represented by an isolated character. Therefore, to exclude responses based on this strategy, we computed the score of the no analogy condition considering only the responses to the pair *♦ (fur) and ♠♦ (fuc), and multiplying this score by 2. This procedure did not affect kindergarteners' *performance,* but the first graders performance in the no analogy condition was now similar to the two other conditions and did not differ anymore from chance level (cf. Figure 10).

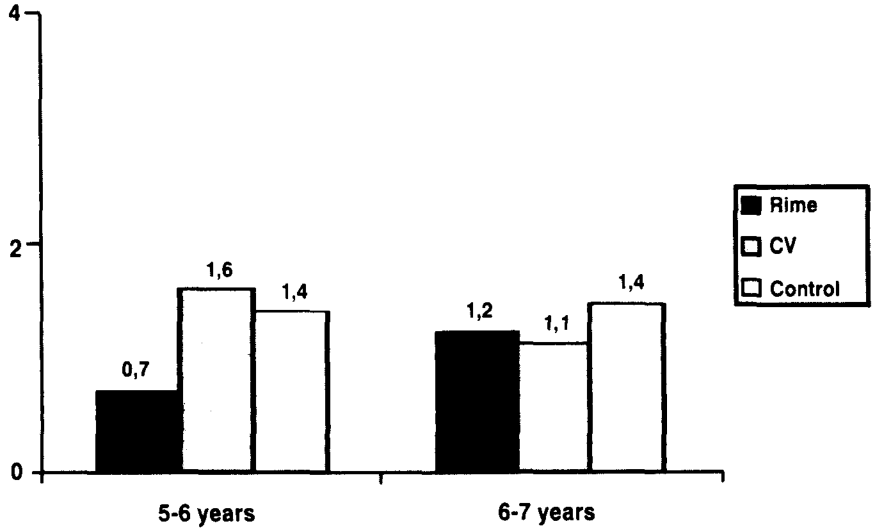

Figure 10
Mean number of correct choices (out of 4) as a function of condition and age (after correction) in Experiment 2A.

In conclusion, it seems that children were quite disturbed when the script system does not encode each phoneme by at least one letter. This might explain why there was definitely no effect of the conditions, and why the performance in the choice test never differed from chance level. What is interesting in comparison to Experiment 1, is that the disturbing effect caused by our concatenated writing system also occured with kindergarteners. Thus, we must conclude that the existence of graphemes (corresponding to phonemes) is a part of prereader-kindergarteners' knowledge (as shown by Gombert & Fayol, 1992).

Experiment 2B

As Experiment 2A, Experiment 2B investigated analogical processes in reading in kindergarteners and first graders. The main difference with Experiment 2A was that the same items were now used to examine rime analogy and CV-analogy. Indeed, as Experiment 2A suggested, children faced with our concatenated writing system probably developed specific analytical strategies to circumvent the difficulty of the task. Because the items used in the different conditions might have led to the use of different strategies, and thus weakened any analogical effect, we designed an additional experiment in which a single set of items could be coded using either rime or CV- analogies.

Method

Participants. The participants were 40 French-speaking children: 20 kindergarteners (aged 5-0 to 5-11, mean: 5-6) who had not yet begun formal reading instruction and 20 first graders (aged 6-1 to 7-1, mean: 6-6). Half of the younger children could not reach the criterion of success during the training phase. The analyses for the kindergarten group were thus based on the data of ten children only.

Material. The items used in Experiment 2B are presented in Table 10. Twelve monosyllabic items were created with an artificial alphabet. These items can be derived either by orthogonally combining three onsets (*- = f-; ♠- = p-; ❑- = t-) with four rimes written with only one character each (-• = -ar; -+ = -ac, -♦ = -al, -♣ = -ib), or by combining three starts written with only one character each (*- = fa-; ♠- = pa-; ❑- = ti-) with four codas (-• = -r; -+ = -c, ♦ = -l, -♣ = b). The way of pronouncing the test items (a, b, c, d and e) is congruent with only one of the two manners of building the items.

Procedure. The procedure was similar to Experiments 1 and 2A. Each child was submitted first to a standardised reading test ("L'Alouette": Lefavrais, 1967). Kindergarteners obtained a prereader level and first graders a mean reading age of 6-10. As in Experiment 1, Experiment 2 included a training phase followed by a test phase. The training and the test phase were identical to Experiment 1, except that this time 7 items were used for training and that 5 new items instead of 4 were presented twice in the test phase.

Results

The number of responses in the choice test that agreed either with onset/rime segmentation, or with CV-coda segmentation were computed as a function of age. The data were analysed by ANOVA. The effect of age was not significant. The older children gave exactly the same number of onset/rime responses than CV/C responses (mean = 5/10). The younger children did a little less onset/rime choice (4.3 vs. 5.7), but these scores were not significantly different from chance level.

Here also, the chance level in the task was 5. Thus, we performed additional analyses in which the choice was considered to correspond either to onset/rime or CV-coda analysis only when, for the same pair, both responses (order 1 and 2) were identical. Thus there were three types of responses: onset/rime choice, CV/C choice and inconsistent choice, and the chance level became 1.25 for onset/rime or CV/C responses and 2.5 for inconsistent responses. Figure 11 shows the mean numbers of each type of choice (out of 5) in the test phase as a function of ages.

Separate one way ANOVAs were conducted for each type of response. There was no significant effect. Nevertheless, while none of the type of response significantly differed from chance level in younger children, the number of inconsistent responses in older children was significantly inferior to the chance level (bilateral

Table 10
Items used in the no analogy condition of Experiment 2B

	-[F]*or*[FA]*	♠-*[P]*or*[PA]*	❑-*[T]*or*[TI]*	**Choice**	
-•*[R]*or*[AR]*	*•*[FAR]* (1)	♠•*[PAR]* (2)	❑• (a)	**TAR?**	**TIR?**
-+*[C]*or*[ac]*	*+*[FAC]* (3)	♠+*[PAC]* (4)	❑+ (b)	**TAC?**	**TIC?**
-♦*[L]*or*[AL]*	*♦ *[FAL]* (5)	♠♦ *[PAL]* (6)	❑♦ (c)	**TAL?**	**TIL?**
-♣*[B]*or*[IB]*	*♣ (d)	♠♣ (e)	❑♣ *[TIB]* (7)		
Choice	**FAB? FIB?**	**PAB? PIB?**			

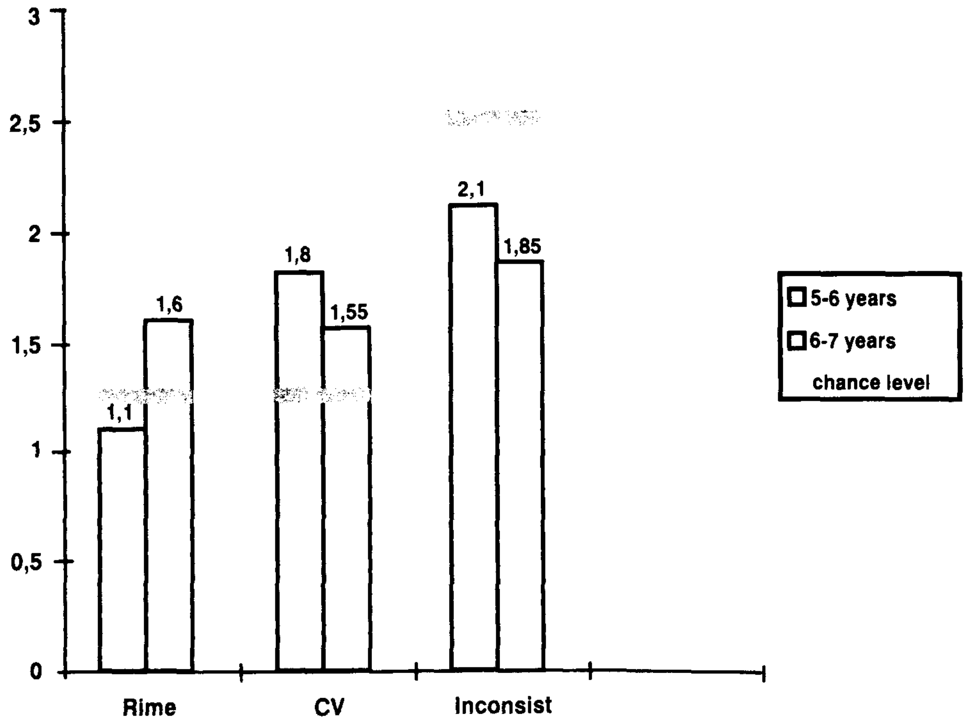

Figure 11
Type of response as a function of age.

limit of confidence of the mean, $p = .02$).

As the number of items to learn in the training phase was higher than in the experiments 1 and 2A, the mean number of presentations needed to reach the criterion were relatively large (5-6 y. = 10.7; 6-7 y. = 9). In younger children there was no relation between this number and the performance in the choice test. In older children such a relation occurred. There was a negative correlation between the number of CV/C strategies and the number of presentations (Pearson's $r = .45$, $p < .05$). In contrast, there was no such correlation for onset/rime or inconsistent responses. Thus it appears that, contrary to younger children, 6 to 7 year-old children often gave systematic responses.

The data of Experiment 2B converge with the findings of Experiment 2A in showing that beginning readers as well as prereaders are unable to acquire knowledge about print-to-sound correspondences when the artificial script system violates the simple alphabetical principle according to which there is at least one letter for each phoneme. The use of a concatenated script system seems to be responsible for the disappearance of any analogical processes in beginning readers and prereaders. The only effect was that the first graders, contrary to the kindergarteners, tried to respond in a systematic way. However, the response strategy was based neither on rime, nor on start.

Discussion

The purpose of the present series of experiments was to confirm the use of analogy processes in the onset of reading acquisition and to delimit the special place of rime in these processes in French. An artificial alphabet was used in order to eliminate any role of the knowledge young children might have acquired about printed words. Therefore, it was possible to examine the ease in learning print-to-sound correspondences based on -VC, CV-, or grapheme units, independently of their respective frequencies in the French orthography.

Experiment 1A contrasted artificial and natural alphabets in prereaders, and Experiment 1B compared prereaders and beginning readers with the artificial alphabet. Experiments 2A and 2B used a concatenated artificial alphabet in which rime, CV- or C-C were coded by a single character. The reason for using the concatenated artificial alphabet was to force the reader to encode correspondences on multi-phonemic units.

In Experiment 1A, prereaders' performance indicated that the easiness of using rime and initial CV- analogies was not identical for the artificial alphabet and for the natural alphabet. This was confirmed by the significant interaction between Alphabet and Condition in the training data. The two main findings were:

1) When the natural alphabet was used, the rime analogy facilitated the choice task and, overall, the learning during the training phase.

2) When the artificial alphabet was used, no facilitation appeared in the training phase, but analogies were clearly used in the choice task. The advantage caused by the analogies on rime was similar in size to the advantage caused by the analogies on CV- units.

Thus, the expected advantage of rime analogy was only observed with the natural alphabet. This result suggests that it is our deliberate choice to avoid the contribution of the knowledge the child has about French orthography that has annealed the advantage of rime analogy with the artificial alphabet. It is only when such knowledge can play a role that rime unit becomes predominant.

Our hypothesis is that, prior to learning to read, children already have some knowledge about letters' shapes and co-occurrence of letters in orthographic patterns. Recent analyses on lexical corpora indicate that there are more constraints in the combination of vowels and codas in rimes than in the combination of onsets and vowels in initial CV- units (as shown in English by Keissler & Treiman, 1997; and in French by Peereman & Content, 1997). This fact would be at the origin of the relative saliency of the rime unit. As the items written with the artificial alphabet included unfamiliar combinations of characters, such knowledge cannot help. In other words, the artificial alphabet experiment led to analogy processes that were not under the control of frequential aspects.

In this perspective, a research project should concern the implicit knowledge of orthographic arrangement in prereaders. For instance, would a preliterate child having to segment a CVC orthographic pattern in two pieces, prefer CV-C segmentation, or C-CV segmentation? Furthermore, are these segmentations sensitive to the frequency of onset-vowel and vowel-coda combinations independently from the single letter and phoneme frequencies? With an artificial alphabet, a way of examining the contribution of units' frequency would be to familiarise children (for example through copy tasks) with different orthographic arrangements and to assess the effect of such training in a task similar to Experiment 1.

Another finding was that first graders did not seem to rely on analogy processes in performing Experiment 1B. Both training and choice task performance suggest that the younger children used analogy while the older deciphered. We have attributed this absence of analogy effect to the fact that beginning readers would tackle the artificial alphabet by using an analytical strategy similar to the one learnt at school. Therefore, it would be interesting to see if analogy effects reappear later, as suggested by late analogy intervention conceptions (cf. Seymour & Evans, 1994).

Finally, contrary to our expectations, Experiments 2A and 2B failed to show any reliable effects of conditions and age when single characters encoded multiphonemic units. As a matter of fact, the children were mostly unable to perform the choice task. It seems that encountering a script system where each phoneme did not correspond to at least one character disturbed children. Interestingly, the detrimental effect of the concatenated script was already observed with kindergarteners. Two hypotheses can be proposed to account for the poor performance in Experiment 2.

A first proposal is that children at the age of 5-6 are already aware of the fact that the alphabetic writing system is based on the individual representation of single sounds. This hypothesis assumes at least some phonological awareness in prereaders. The sensitivity to the existence of three different sounds in our CVC syllables might have partially resulted from the use of CVC syllables that were contrasted on single phonemes during training. This is particularly true in Experiment 2B where items in the training phase contrasted on single consonants (e. g., /far/-/par/ for the onset, /far/-/fac/ for the coda). Note that the knowledge of the alphabetical principles could be minimal. For example, children might know that simple vowels such as /a/ or /i/ are represented by one character in French orthography. They could therefore try to find correspondences between one character of the string and the vowel of the CVC syllable. Such a strategy should be prejudicial to discover correspondences based on rime or initial CV units. However, as Experiment 2A suggested, beginning readers probably used this vowel strategy in the no analogy condition.

An additional proposal would be that analogy processes used by prereaders (as shown in Experiment 1) are based on the perception of some co-occurrences of letters (which thus constitute, for example, a rime). This hypothesis holds that it is not the saliency of units at the phonological level *per se*, but the frequency of some characters' combinations in print that determine the emergence of analogy effects in reading. By construction, the stimuli used in Experiment 2A and 2B never included identical groups of characters in the different CVC syllables, and consequently they precluded any role of analogy processes.

If the first hypothesis is correct, the analogy processes might re-emerge if we replicate Experiment 2, with a third character introduced in the middle position, but which would be visually degraded in such a way that its presence would be clear, but its identity not available. In contrast, the second hypothesis predicts that such a modification would be inefficient to restore the analogy effect.

References

Bradley, L., & Bryant, P. E. (1983). Categorizing sounds and learning to read: A causal connection. *Nature, 301*, 419-421.

Frith, U. (1985). Beneath the surface of developmental dyslexia. In K. E. Patterson, J. C. Marshall, & M. Coltheart (Eds.), *Surface dyslexia: Cognitive and neuropsychological studies of phonological reading* (pp. 301-330). Hillsdale, NJ: Erlbaum.

Gombert, J. E., Bryant, P., & Warrick, N. (1997). Children's use of analogy in learning to read and to spell. In C. Perfetti, M. Fayol, & L. Rieben (Eds.), *Learning to spell* (pp. 221-235). Hillsdale, NJ : Erlbaum.

Gombert, J. E., & Fayol, M. (1992). Writing in preliterate children. *Learning and Instruction, 2*, 23-41.

Goswami, U. C. (1986). Children's use of analogy in learning to read: A developmental study. *Journal of Experimental Child Psychology, 42*, 73-83.

Goswami, U. C. (1988). Orthographic analogies and reading development. *Quarterly Journal of Experimental Psychology, 40A*, 239-268.

Goswami, U. C. (1991). Learning about spelling sequences: The role of onset and rimes in analogies in reading. *Child Development, 62*, 1110-1123.

Goswami, U. C., Gombert, J. E., & Fraca de Barrera, L. (1998). Children's orthographic representations and linguistic transparency: Nonsense word reading in English, French and Spanish. *Applied Psycholinguistics, 19*, 19-52.

Kessler, B., & Treiman, R. (1997). Syllable structure and the distribution of phonemes in English syllables. *Journal of Memory and Language, 37*, 295-311.

Lefavrais, P. (1967). *L'Alouette, test d'analyse de la lecture et de la dyslexie* [Alouette, a test for analysing reading and dyslexia]. Paris : Les Éditions du Centre de Psychologie Appliqué.

Peereman, R. (1991). Phonological assembly in reading: Lexical contribution leads to violation of graphophonological rules. *Memory and Cognition, 19*, 568-578.

Peereman, R., & Content, A. (1997). Orthographic and phonological neighborhoods in naming: Not all neighbors are equally influencial in orthographic space. *Journal of Memory and Language, 37*, 382-421.

Seymour, P. H. K., & Evans, H. (1994). Levels of phonological awareness and learning to read. *Reading and Writing, 6*, 221-250.