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L. Sprenger-Charolles, L. S. Siegel, P. Bonnet. Reading and spelling acquisition in French: the role of phonological mediation and orthographic factors.. *Journal of Experimental Child Psychology*, 1998, 68 (2), pp.134-65. 10.1006/jecp.1997.2422 . hal-00733544v1

**HAL Id: hal-00733544**

**<https://hal.science/hal-00733544v1>**

Submitted on 19 Sep 2012 (v1), last revised 24 Sep 2012 (v2)

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JECP 1998, 68, 134-160

Reading and spelling acquisition in French: The role of phonological mediation and  
orthographic factors

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**septembre 97**

Running Head: Reading and Spelling in French

## Abstract

The objective of this research was to study the development of reading and spelling in French. The two main hypotheses were that 1. phonological mediation is the primary process in the acquisition of these skills and that 2. the use of phonological mediation may allow the construction of the orthographic lexicon. In January and June, first graders ( $n = 57$ ) were required to read and spell items designed to assess the variables of regularity, graphemic complexity, frequency, lexicality and analogy. The findings of the January session partially corroborated the first hypothesis as a regularity effect, but no frequency effect and no word superiority, were found both in reading and spelling. The main contradictory finding was the presence, in early reading only, of a facilitative effect of analogy. The changes in the frequency and the lexicality effects between the two sessions in reading and in spelling indicated that the children were able to rapidly construct an orthographic lexicon. However, this procedure did not entirely replace phonological mediation since a regularity effect and regularization errors were observed and increased between sessions. The second hypothesis was supported as relationships were found to exist between early phonological skills and subsequent orthographic skills. Finally, we observed that French children were using graphemes (not only letters), in the early stage of reading, and, to a lesser extent, in the early stage of spelling. The findings are discussed in the context of developmental models of reading and spelling.

The aim of this study was to examine reading and spelling acquisition in French. Because of the characteristics of developmental growth in reading and spelling and of French orthography, we assumed that French children would rely mainly on phonological processing in the beginning of reading and spelling acquisition and that phonological processing allows for the establishment of the orthographic lexicon (see Share, 1995). In order to test these hypotheses we designed a longitudinal study. We assessed effects attributed to phonological processing, i.e. regularity (regular versus irregular words) and graphemic complexity (processing of single versus complex graphemes). In addition, we assessed effects assumed to be a manifestation of orthographic processing such as frequency (high frequency versus low frequency words), lexicality (words versus pseudowords) and analogy (analog versus non analog pseudowords).

Our hypotheses are derived from stage developmental models (Frith, 1986; Harris & Coltheart, 1986; Morton, 1989). A key feature of these models is that they postulate that procedures occur in successive stages. The phonological stage precedes the orthographic stage and both stages are preceded by a logographic stage. These stage models have been challenged in three ways. First, Seymour (1990, 1994) assumes that the logographic and the phonological procedures coexist in the beginning of both reading and spelling acquisition. Second, Goswami and Bryant (1990) deny the central assumption of the stage models, namely, that children in the phonological stage first use small units like letters and only later employ larger units like morphemes or analogies based on word rimes. In contrast, Goswami and Bryant (1990) proposed that the use of analogies based on word rimes occurs first, being mediated by the early awareness of rhymes and alliterations. A third challenge comes from the fact that most of the developmental studies were done with English which has a very deep writing system, that is the relationship between graphemes and phonemes are complex and somewhat unpredictable. It is, thus, important to determine how and to what extent the orthographic characteristics of different alphabetic written languages influence the course of literacy acquisition.

In the studies of English, some of the predictions of the stage models have been corroborated. For example, the transition from a mainly phonological stage to a mainly

orthographic stage in reading is illustrated in the work of Backman, Bruck, Hebert and Seidenberg (1984), Seidenberg, Waters, Barnes and Tanenhaus (1984), and Waters, Seidenberg and Bruck (1984). These studies, that have compared the performance of older and younger readers, have shown that, in younger children, there are fewer correct responses and longer latencies for irregular words, as compared to high or low frequency regular words. However, for older children, as for mature readers, the differences between regular and irregular words are found only for low frequency words. Therefore, if a regularity effect indicates the use of the phonological route, the data from younger readers have shown a strong use of phonological processing. Alternatively, if a frequency effect indicates the use of the direct route, results obtained by older children have shown that they were able to read using an orthographic procedure.

The same developmental trend has been observed in studies dealing with spelling. Foorman, Novy, Francis and Liberman (1991) and Foorman, Jenkins and Francis (1993) for example, have shown the facilitative effects of regularity in beginning readers and spellers. Moreover, correlational analyses have shown strong relationships to exist between reading and spelling at the beginning of acquisition (e.g., Juel, 1988; Juel, Griffith & Gough, 1986; Stage & Wagner, 1992).

Concerning logographic strategies, in the "classic" stage models, it was argued (see for instance, Morton, 1989) that logographic processing ceases to function when the phonological procedure emerges. In contrast, Seymour (1990, 1994; Seymour & Evans, 1991) assumes that logographic and phonological procedures can coexist. In support of his hypothesis, Seymour cites data which showed that children, before knowing how to read, were able to recognize certain words, in particular, the first name of the children that they knew. They were able to read them quite rapidly without any overt "sounding out". Later, when children began to read, they continued to read names this way, although at the same time other items showed evidence of phonological mediation, e.g. overt sounding out, long latencies, and regularization errors. However, a number of other English studies have cast doubt on the importance (Ehri & Wilce,

1985; Masonheimer, Drum & Ehri, 1984; Rack, Hulme, Snowling & Wightman 1994) or even the existence (Gough, 1993; Siegel, 1985; Stuart & Coltheart, 1988) of a logographic stage. Moreover, in the "Split word study", Gough (1993) observed that children did not read their first words in a totally different way than in later decoding as they were able to use selective graphemic associations. Similarly, Stuart and Coltheart (1988) have shown that children who have good phonological awareness before reading acquisition, rely on partial phonological cues in early reading. The results obtained by Ehri and Wilce (1985) and Rack et al. (1994) have also demonstrated that a letter-sound association training improves performance of young children better than a visual pair-associate task.

Goswami and Bryant's position (1990) fundamentally questions the developmental dynamics postulated in the "classic" stage models. In their model, analogies based on word rimes are considered to be used first and phonological procedure based on grapheme-phoneme correspondences (GPC) or phoneme-grapheme correspondences (PGC) only later. The paradigms used by Goswami to test the hypothesis of an early use of analogy were all of the same type. The children were taught to read or spell monosyllabic words and later were given words and pseudowords which were -- or were not -- analogs to the words previously learned that they had to read or spell. For the analog items, the analogy was based either on rime (VC), on onset (C, CC) or on vocalic peak (V).

The main hypothesis derived from this model was that if children use rime analogies, they might be able to accurately read or spell more analog items than non analog items, especially when items share the same rime. This hypothesis has been corroborated for both reading and spelling in the work of Goswami (see Goswami 1986, 1988a and 1988b). For example, Goswami (1988a) has shown that children aged 6 to 7 years, whether readers or not, used analogies for reading and that these were mostly rime analogies (see Goswami, 1988b, for similar results in spelling). Another study (Goswami, 1993) demonstrated that both younger and older children used rime analogies to read vowels in a CVC sequence and that only the older children benefited from priming with phonemic units (in this case, with the vowel). These results,

consistent with the hypothesis of the early use of analogy are problematic since, in the studies of Goswami, the children were always trained to read or to spell by analogy, which may have led to a priming effect.

In other studies, results were found that were inconsistent with the idea of the early use of rime analogies. Those studies used monosyllabic ambiguous words -- or pseudowords -- which could be read either by GPC or by rime analogies. Coltheart and Leahy (1992) used this paradigm with children at the middle and at the end of grade one and with children at the end of grades 2-3 (see also Laxon, Coltheart & Keating, 1988; Laxon, Masterson & Coltheart, 1991; Treiman, Goswami & Bruck, 1990). In those studies, it was observed that pronunciation based on rime analogy increased with the level of schooling. Moreover, Ehri and Robbins (1992) have shown with pre-readers or beginning readers that analogies were used in kindergarten and grade one only by children able to decode and not by non decoders. On the other hand, Bruck and Treiman (1992) observed that first graders who were explicitly taught to use rime analogies required fewer training trials to read new words than children who were taught to use CV or vowels analogies. Nevertheless, in the generalization test, both the rime and the CV groups performed more poorly than the vowel group. These results suggest that, although first graders can be trained to use rime analogies in reading, this training has only a short term effect. More recently, in two experiments investigating 7-year-old children's use of analogy in spelling, Nation and Hulme (1996) failed to show any preference for rime analogies as compared to CV or vowel analogies. These data did not support Goswami and Bryant's model (1990) since they suggested that beginning readers and spellers did not rely to a larger extent on rime analogies than on GPC<sup>1</sup>.

The results of all these different studies have shown some contradictory evidence particularly with respect to the possible coexistence of logographic and phonological procedures at the beginning of reading and spelling acquisition in English (see Seymour, 1990, 1994; Seymour & Evans, 1991 versus Ehri & Wilce, 1985; Gough, 1993; Masonheimer et al., 1984; Rack et al., 1994; Stuart & Coltheart, 1988). The same is true for rime analogies in reading and

in spelling acquisition (see Goswami & Bryant, 1990, Goswami 1986, 1988a, 1988b, 1993 versus Bruck & Treiman, 1992; Coltheart & Leahy, 1992; Ehri & Robbins, 1992; Nation & Hulme, 1996). Furthermore, the studies of children learning to read and spell in languages whose orthography is more transparent than the English have not shown the same trends.

With German speaking children, Wimmer and Hummer (1990) have observed that phonological mediation appears to be operating even in the very beginning of reading. When performances of German-speaking children were directly compared to those of English-speaking children (Wimmer & Goswami, 1994), it was observed that the younger German children (7 years old) made fewer pseudoword errors than the older English children (9 years old). Moreover, the youngest English children's errors were mainly word substitutions and non responses while the youngest German children produced mainly neologisms. Finally, high correlations between word and pseudoword reading times were found in the youngest German group but not in the youngest English group. These results suggested that, from the very beginning of learning to read, German children used a phonological procedure, and not logographic strategies.

In a study with French children, Sprenger-Charolles and Bonnet (1996) reached the same conclusion. Twice in kindergarten, children were presented a series of word to picture matching tasks. Metaphonological skills and letter knowledge were also assessed. Besides the fact that kindergartners "read" the environment (the picture) rather than the word itself, logographic strategies were not observed in this study. Moreover, the children who had better letter knowledge and metaphonological skills used prereading strategies that relied on partial phonological cues. It seems difficult to assert that the other children relied only on visual strategies since they were sensitive to the phonological properties of items.

The studies of Wimmer and his associates (Wimmer & Goswami, 1994; Wimmer & Hummer, 1990) have shown that German children used a phonological procedure from the very beginning of learning to read. The same result was observed with five-year old Spanish children who managed to read and write more than 90% of the bisyllabic pseudowords with which they



were presented (Cuetos, 1989). In addition, Valle Arroyo (1989) found a length effect, but no frequency effect, with 8- to 13-year old Spanish children. A length effect was also reported in the Cossu, Gugliotta and Marshall study (1995) with Italian children, and in the Goswami, Gombert and Barrera (in press) study with Spanish and English children. However, in the Goswami et al. study, the English-speaking children read shorter pseudowords with more difficulty than longer pseudowords, contrary to the length effect observed with Spanish children (Goswami, et al., in press; Valle Arroyo, 1989) and with Italian children (Cossu et al., 1995). If length effect is clearly a manifestation of the use of the phonological route, these results show that, in reading, English children rely less strongly on this route than both Spanish and Italian children. This conclusion may also be inferred from the fact that English children performed less well on pseudoword reading tasks than Spanish and French children (Goswami et al., in press) and than German children (Wimmer & Goswami, 1994).

The principal aim of the Goswami, Gombert and Barrera study was to assess analogical reading development with English, French and Spanish children. They used monosyllabic and bisyllabic pseudowords that either shared both orthography and phonology at the level of the rime or of the rhyme<sup>2</sup> with real words (O+P+: cake-dake or ticket-bicket), phonology only (O-P+: cake-daik), or neither (O-P-: faish or derak). The results showed that pseudowords sharing both phonology and orthography with real words (O+P+) were better read than pseudowords that shared neither phonology, nor orthography (O-P-); however, the difference between these two types of pseudowords was less salient in the performance of Spanish children than in the French and English ones. Pseudowords that only shared phonology with real words (O-P+) were compared to pseudowords that shared both phonology and orthography (O+P+), or neither (O-P-) in two other experiments. Spanish children were not included in these comparisons because O-P+ pseudowords are not possible in Spanish. English and French children were observed to read better with O+P+ as compared with O-P+ stimuli, but this effect was less strong for French than for English children. Alternatively, the orthographically and phonologically unfamiliar

pseudowords (O-P-) were less well processed than O-P+ pseudowords, but the effect of phonological similarity was more pronounced in French children than in English children.

These results suggest that Spanish children relied on orthographic and phonological similarities to a lesser extent than both French and English children. In addition, English children seemed to benefit more from orthographic similarities than French children who appeared to rely more on phonological similarities. These data indicate that the weight of analogical reading in a given language may depend on its orthographic nature. Studies in this field should, then insure control that the chosen items represent the main characteristics of each language. It seems not to be entirely the case in the Goswami et al.'s study for the French O-P- items that contained very rare or even non-existent bi- and trigraphs (according to the data provided by Content & Radeau, 1988). Therefore, the fact that French children obtained higher scores on O+P+ or O-P+ items as compared to O-P- might not be only due to the use of an analogical reading mechanism. Moreover, as no developmental change in the use of orthographic and/or phonological similarity has been reported, the prediction that rime (or rhyme) level coding would be more important for younger readers than for older ones was not supported by these experiments.

The analogical reading mechanism was also assessed in young Spanish children by Sebastian and Vacchiano (1995) using the context dependent pronunciation of letters C and G. Pseudowords were constructed by modifying one or two letters of real words. This modification could, or could not, change the pronunciation of letters C and G with respect to their original pronunciation in words. For example, in the "no-change pseudoword" encogedo, the letter G is pronounced in the same manner than in the word encogido. On the other hand, in the "change pseudoword" arrugedo, the letter G is not pronounced in the same manner as in the word arrugado. These pseudowords, embedded in a text, were presented to 6, 8 and 10 years old children. Sebastian and Vacchiano, found that "no-change pseudowords" were read better than "change pseudowords". Nevertheless, similar to the Goswami, Gombert and Barrera study (in press), they observed that this analogical effect is the same in younger and in older children. It is

then impossible to know if the use of analogical reading is less likely (as presupposed by the stage models) or greater (as presupposed by Goswami & Bryant model) in younger children as compared to older.

On the whole, these results suggest that, 1. the logographic stage appears to be non-existent in French and in German (see Wimmer & Hummer, 1990; Sprenger-Charolles & Bonnet, 1996), 2. the use of an analogical reading mechanism is not clear (Goswami et al., in press; Sebastian & Vacchiano, 1995), and 3. phonological processing seems to be more significant in beginning reading (and spelling) for Italian, Spanish, German and French children than for English children (Cossu et al., 1995; Cossu, Shankweiler, Liberman & Gugliotta, 1995; Cuetos, 1989; Goswami et al., in press; Valle Arroyo, 1989; Wimmer & Goswami, 1994; Wimmer & Hummer, 1990). Differences in the weight of phonological processing in beginning reading and spelling acquisition may depend on the degree to which alphabetic writing systems represent the phoneme string of the language they encode. According to Scheerer (1986) and De Francis (1989), there is a continuum of orthographic transparency, Spanish and Italian are more transparent than German, which is more transparent than English. The more transparent the writing system is, the more strongly children may rely on phonological processing. It seems important to examine in depth reading and spelling acquisition in French whose orthography is often seen as deep, but, in fact, is not as deep as English orthography.

One of the main characteristics of French orthography is the high number of digraphs or complex graphemes which represent a single phoneme, and not a diphthong (Catach, 1980; Gak, 1976). Some of these digraphs have no simpler orthographic equivalents (for example, ou, in, on, an, ch, etc.) when others have simpler allographs (au, eau, also spelled o, and ph, also spelled f). Moreover, GPC in French are highly consistent, even for both kinds of complex graphemes. For example, the graphemes o, au, or eau and f, or ph always refer to the same phoneme, respectively to /o/ and /f/. This is not true for PGC as the same phoneme may be spelled in different ways (f or ph for /f/ and o, au or eau, for /o/). Therefore, GPC in French are complex

and predictable, whereas PGC are not so easy to manipulate because it is often necessary to choose between alternative spellings for a particular sound.

One of the other main characteristics of French is the difficulty of isolating word unit in the speech stream because of the presence of a word-group stress instead of a word stress (Delattre, 1940; Encrevé, 1988; see also DeJean, DeLaBatie & Bradley, 1995). In English, words have a relatively large degree of phonetic independence as each full English word has its own stress. In addition, there is a preponderance of open syllables in French (as in Spanish) when in English (as in German) the majority of syllables have a closed structure (Delattre, 1965, 1966, Goldman, Content & Frauenfelder, 1996). Finally, in French, when a word ending with a consonant is placed before a word beginning with a vowel, the final consonant is pronounced in connection with the following vowel. The same is true for words ending in an usually silent consonant when followed by a word beginning with a vowel (e. g. petit lit is pronounced /pti/li/ while petit ami is pronounced /pti/ta/mi/, not /ptit/a/mi/ nor /pti/a/mi/). This rule concerning the "resyllabation" of final silent consonants is specific to French as compared to English (Delattre, 1947, 1966). In French, therefore, the space between words in spelling does not always correspond to a perceptual speech reality.

These features of oral and written French may affect reading and spelling. First, the predictable regularity of GPC in French may lead to a great reliance on phonological mediation in reading and spelling when the fact that the word unit is not easily accessible in speech may minimize the reader's (and speller's) dependency on the direct lexical route. It is, therefore, reasonable to hypothesize that the first stage in the acquisition of reading and spelling in French will be phonological. Second, a reading (or spelling) strategy using rime analogies may be of no use in French, a language which has predominantly open syllables and vowels whose pronunciation is not, like in English, highly constrained by the following graphemic environment (see Sprenger-Charolles & Siegel, in press). Third, if children rely on letter-sound relationships, and not on GPC or on PGC (the term used by Morton and Frith is the "alphabetic" phase), a graphemic complexity effect should be observed in French for regular items. For example, a

word such as table or a pseudoword such as lople (which have only simple letter graphemes) would be read and spelled more accurately than the word route or the pseudoword moube (which have a complex grapheme, ou, /u/). Finally, we also hypothesized that phonological mediation is a mechanism which allows a child to set up an orthographic lexicon (Share, 1995).

In order to test these hypotheses, we assessed effects related to word level as compared to effects related to subword level. Effects related to word level are assumed to be a manifestation of the use of the orthographic processing, for example, frequency effect (comparison between high and low frequency words), lexicality effect (comparison between words and pseudowords), and analogy effect (comparison between analog and non-analog pseudowords). Alternatively, effects located at the subword level are attributed to the phonological processing, that is regularity effect (comparison between regular and irregular words) and graphemic complexity effect (comparison between the processing of simple and complex graphemes).

The questions outlined above were examined in a study in which we evaluated how reading and spelling procedures develop at the beginning of acquisition. This study was longitudinal. Such a method is indispensable when testing developmental hypotheses, for, if the same children are examined at different times, the differences observed in performance can be attributed to developmental changes, not to sample differences. These longitudinal studies can only be conducted within a short period of time because of floor and ceiling effects. In the beginning of acquisition, very poor scores in both modalities, but particularly in word spelling, are generally obtained. However, very quickly performance in reading, and to a lesser extent in spelling, reaches ceiling levels. For this reason, the study was designed to observe the development of reading and spelling skills when the children's scores are not yet biased by floor or ceiling effects, that is at the middle and at the end of the first grade.

## Method

### Subjects

Kindergarten schools had been chosen in different suburbs of Paris which are representative of the socio-economic variety of the French society. Seven classes interested in

participating in the study were recruited. At the end of the last year of kindergarten, only the sixty children who met the following criteria were enrolled, 1. Parental permission, 2. French as native language, 3. no language or motor problems or psychological difficulties according to the teachers or school psychologists, 4. average or above average cognitive functioning (fiftieth centile or higher on the Raven Progressive Matrices), 5. non readers as evaluated by the BAT-ELEM reading test (Savigny, 1974). In first grade, which is the first year of reading instruction in France, only fifty seven of these children remained. They attended 20 different classes, in 9 primary schools and were tested in January and June (mean age in January 77.91 months, sd 3.18). The fact that these children were enrolled in so many classes reduces the probability of teacher and method effects.

#### Tasks

Four tasks were used: word reading, word spelling, pseudoword reading and pseudoword spelling. For the word tasks, the items were chosen from three categories, simple regular words, complex regular words, and irregular words. Each list contained 12 words from each category, 6 high frequency and 6 low frequency words.

A word was defined as regular in terms of GPC if it contained only high frequency graphemes (Catach, 1980; Gak, 1976). A word was defined as irregular if it contained either a low frequency grapheme (i.e. a grapheme with a highly particular pronunciation) or a silent grapheme in a non terminal position (for example, the p in sept or compte)<sup>4</sup>. An item was said to be simple if a phoneme corresponded to every letter (except the final silent e). It was defined as complex in those cases where a grapheme contained more than one component. Only two digraphs were used; a vocalic digraph ou and a consonantal digraph, ch. These digraphs were selected because no frequent alternative spelling exists for them. There should, in consequence, be no more difficulties in spelling than in reading these digraphs -- unlike the case of au which is always read as /o/ although the sound /o/ can be written as o, au, or eau.

Word frequency was defined on the basis of the "Listes Orthographiques de Base" (LOB, Catach, 1984), which by combining several frequency tables (Juilland, Brodin & Davidovitch,

1970; Gougenheim, Michéa, Rivenc & Sauvageot, 1964; Trésor de la langue française, 1971) give the 1600 most frequent French words and their 4000 most frequent inflections. Our high frequency words had a mean frequency of 679 for simple words, 811 for complex words, and 649 for irregular words. Our low frequency words had a frequency exceeding 2000 in the LOB. The words were also matched for initial letter, number of letters, and number of syllables in oral pronunciation.

Pseudowords were matched in orthography with regular simple and regular complex words. They contained only bi- or trigrams which were common in French according to the data of Content & Radeau (1988). Analog pseudowords were formed by modifying the initial consonant letter of **our** high frequency words (table versus mable). Thus our analog pseudowords have the same rime (and the same rhyme, see Goswami et al., in press) than words from which they are derived. For non analog pseudowords, additional letters were modified in such a way that it is not possible to find high frequency words with the same endings or beginnings. The pseudoword list contained 8 items from each category, 4 simple regular pseudowords and 4 complex regular pseudowords. The pseudowords were also matched for initial letter, number of letters, and number of syllables in oral pronunciation. The stimuli are shown in the appendix.

#### Procedure

Each child was asked to read each item aloud when it appeared on a PC computer monitor. The computer had an integrated speech sampler which was used to record responses. There were three familiarization trials which could be re-administered if the child failed to understand the instructions. Based on pilot results, the test items were displayed on the screen for a maximum of seven seconds. The data were recorded during the test session by the computer and later re-examined from the recordings. The word list was presented first, and, to avoid excessive failure, more regular words appeared at its beginning. The pseudoword list was presented two weeks after the word list to avoid risk of priming. All the test items for each task were presented in one test session, and no feedback was provided.

The word spelling task was administered one week after the word reading task. This procedure was used to prevent the children having an auditory image of the words before the reading test. The pseudoword spelling task was also administered after the reading of pseudowords, but in this case at least one day after. For the pseudowords, the items were repeated twice by the examiner. Because of the risk of confusion between homophones, words were read in a sentence context first and later dictated in isolation. The items were dictated to small groups of two or three children.

### Reading Tasks

The main hypothesis was that, because of the characteristics of development and of the French language, French-speaking children would use phonological mediation from the very beginning of reading acquisition. To corroborate this hypothesis, it was necessary to observe effects of regularity and graphemic complexity during the first months of the acquisition of reading independently of effects arising from frequency, analogy and lexicality. Moreover, if all the items that can be processed by phonological mediation are actually processed in such a way, we expected high correlations between analog and non analog pseudowords as well as between regular words and pseudowords. This hypothesis was also evaluated by an error analysis. In this analysis we examined errors that can be attributed to phonological processing, that is regularizations and minus one errors. No responses and atypical errors indicate that phonological processes are not primarily being used. Regularization errors were defined as responses obtained through a complete parsing of the graphemic structure leading not to the correct response, but to a possible pronunciation according to the usual GPC. For example, album read as /albym/. Strictly sequential parsing of complex regular words was also classified as regularization; for example, route read as /royt/ and not /rut/. This second kind of regularization is the only possible regularization error for pseudowords since those items were regular. For minus one errors, the pronunciation of the words or pseudowords was phonologically accurate except for one letter, for example, table /tabl/ read /tab/, /tapl/, /talb/ or /tablo/. We also analyzed non responses and atypical errors that could not be classified in either of the two categories above<sup>5</sup>.



We also hypothesized that phonological mediation would permit the establishment of the orthographic lexicon (see Share, 1995). In such a case, high correlations would be observed between early phonological skills and later orthographic skills. To test this hypothesis, pseudoword and regular word performance, as well as regularization errors, were used as measures of phonological skills. As a measure of orthographic skills, irregular word performance was used because reading this type of items cannot -- by definition -- be entirely dependent on decoding skills.

## Results

### Correct responses

The results of the word reading task are shown in Table 1. An analysis of variance was conducted on the following factors: Session (January and June), Frequency (high or low frequency words) and Orthography (simple regular words, complex regular words, and irregular words). When main effects emerged for orthography, two orthogonal contrasts were used. The first contrast compared both simple and complex regular words with irregular words (Regularity effect) whereas the second contrast compared simple regular words with complex regular words (Graphemic complexity effect).

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 Insert Table 1 about here  
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There were main effects for Session ( $F[1,56] = 281.90, p < .01$ ), Orthography ( $F[2,112] = 276.18, p < .01$ ) and Frequency ( $F[1,56] = 29.13, p < .01$ ). All the interactions were significant (Session x Orthography,  $F[2,112] = 6.33, p < .01$ , Frequency x Orthography,  $F[2,112] = 14.32, p < .01$ ; Session x Frequency,  $F[1,56] = 14.90, p < .01$ ; Frequency x Orthography x Session,  $F[2,112] = 3.61, p < .04$ ). The three way interaction can be explained by the fact that, 1. there was no frequency effect in January ( $F[1,56] = 2.35$ ) while there was an effect in June ( $F[1,56] = 41.77, p < .01$ ), 2. this frequency effect was stronger for irregular words and 3. the differences between simple regular words or complex regular words and irregular words increased between

sessions. The main orthography effect was due to a difference between simple/complex regular words and irregular words (Regularity effect,  $F[1,56] = 360.72$ ,  $p < .01$ ), since regular simple words were not read more accurately than regular complex words (Graphemic complexity effect,  $F[1,56] = 2.96$ ).

The results of the pseudoword reading task are presented in Table 2. The analysis of variance was conducted on three factors: Session (January and June), Analogy (analog and non analog pseudowords) and Graphemic complexity (simple pseudowords and complex pseudowords). We observed a main effect for Sessions ( $F[1,56] = 85.12$ ,  $p < .01$ ), Graphemic complexity ( $F[1,56] = 4.63$ ,  $p < .05$ ) and Analogy ( $F[1,56] = 10.92$ ,  $p < .01$ ). Contrary to predictions, complex pseudowords were read better than simple pseudowords, and analog pseudowords better than non analog pseudowords. All the interactions were non significant including the one between Graphemic complexity and Analogy. Thus, the effect of graphemic complexity was the same for both analog and non analog pseudowords.

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 Insert Table 2 about here  
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The lexicality effect was analyzed by comparing word and pseudoword performance on the 16 paired items (see appendix). The analysis was conducted on three factors: Session (January and June), Lexicality (word vs. pseudoword) and Graphemic complexity (simple vs. complex). The results are presented in Table 3. We observed a significant difference between Sessions ( $F[1,56] = 135.65$ ,  $p < .01$ ). The main effect of Lexicality was not significant ( $F[1,56] = 1.07$ ) and the effect of Graphemic complexity did not reach conventional levels of statistical significance ( $F[1,56] = 3.48$ ,  $p < .09$ ). Only the interaction between Lexicality and Session was significant ( $F[1,56] = 17.44$ ,  $p < .01$ ). This interaction was the result of the fact that pseudowords were read less accurately than words in June but not in January (June session:  $F[1,56] = 14.37$ ,  $p < .01$ ; January session:  $F[1,56] = 3.19$ ). As the Graphemic complexity and

Lexicality interaction was not significant, our results indicated that the graphemic complexity effect had the same impact on words as on pseudowords.

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Insert Table 3 about here

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We also observed high correlations between the regular words and the pseudowords matched in orthography ( $r = .84$  in January and  $.81$  in June), between analog and non analog pseudowords ( $r = .90$  in January and  $.86$  in June) and between high and low frequency regular words ( $r = .90$  in January and  $.92$  in June). Correlations between regular and irregular words were lower but still significant ( $r = .51$  in January and  $.54$  in June,  $p < .01$ ). These results were indicative of the fact that children processed all items which can be read by phonological mediation in a similar manner.

We also hypothesized that phonological mediation permits the establishment of the orthographic lexicon. Consistent with the hypothesis, we observed a positive and significant correlation between correct responses for words and regularization errors in January ( $r = .54$ ,  $p < .01$ ). Significant correlations were also found between correct responses for pseudowords in January and irregular words in June ( $r = .63$ ,  $p < .01$ ), as well as between regular words in January and irregular words in June ( $r = .69$ ,  $p < .01$ ). Alternatively, there were no significant correlations between irregular words in January and pseudowords or regular words in June ( $r = .27$  and  $.25$ ; respectively). The two last correlations were the only non significant ones in the entire  $3 \times 3$  matrix of correlations between January and June reading scores. The correlations between the two sessions for pseudowords, regular and irregular words were significant ( $r = .61$ ,  $.49$  and  $.58$  respectively) as well as the correlations between pseudowords in January and regular words in June ( $r = .55$ ) and between regular words in January and pseudowords in June ( $r = .54$ ). The difference between the correlations for pseudowords in January and irregular words in June and between irregular words in January and pseudowords in June was significant ( $p = .009$ ) as well as

the difference between regular words in January and irregular words in June versus irregular words in January and regular words in June ( $p = .001$ ).

#### Error analysis

This error analysis considered the mean percentage of the different types of errors for each child. Four children in January and 20 in June made no errors in pseudoword reading, but every child made at least one error in word reading. For the statistical analysis, the missing cells have been eliminated. Table 4 shows the mean percentage of errors for words and pseudowords.

For words, the mean percentage of regularizations and minus one errors increased from January to June ( $t[56] = 6.24, p < .01$ ;  $t[56] = 4.22, p < .01$ ). At the same time, non responses and atypical errors declined ( $t[56] = 3.15, p < .01$ ;  $t[56] = 5.44, p < .01$ ). We found very few regularizations for pseudowords. This phenomenon can be explained by the fact that the only regularizations possible for pseudowords concerned the decomposition of the digraphs which corresponded to one phoneme (for example ou /u/ read /oy/). Owing to the floor effects for these errors, we did not consider them in the analyses. Between the two sessions, we observed an increase for minus one errors ( $t[35] = 4.05, p < .01$ ) while atypical errors declined ( $t[35] = 2.86, p < .01$ ) but not non responses ( $t[35] = 1.75$ ) in pseudoword reading.

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 Insert Table 4 about here  
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Thus errors involving complete phonological processing, i.e. regularization errors, increased between sessions. The same result was only observed for minus one errors which can be seen as indicating a partial use of phonological processing.

#### Discussion

In the January session children mainly relied on phonological mediation, as suggested by the finding that irregular words were read less accurately than regular words (simple and complex) while high frequency words (as compared with low frequency ones) and words (as compared with pseudowords) were not read more accurately. However, an effect of analogy was

observed in that session. This result cannot readily be interpreted as evidence for the dependence of the analogy effect on the orthographic lexicon because 1. the sublexical effect of graphemic complexity was the same for analog and non analog pseudowords, 2. strong correlations were observed between analog and non analog pseudowords and 3. frequency and lexicality had no impact in the January session. Since analog pseudowords were derived from high frequency words and differed only in the first letter (for example, mable versus table), analogy in reading may be due to the facilitative effect of the oral lexicon. If this interpretation were valid, the same effect would not be observed in spelling because knowing a word orally does not make spelling it easier.

The significant correlation between irregular words in January and June suggested a stability across sessions in the reading of irregular words which could not be completely processed by phonological mediation. Moreover, in the January session, the error analyses revealed some evidence of what has been attributed by Seymour to logographic processing, that is, non responses. However, non responses can hardly be attributed to a specific form of processing. Non responses, in all likelihood, were due to the fact that, if a child partially decoded a word and obtained a pseudoword, he or she, knowing that the task was a word reading task, might hesitate to respond. It is possible that the oral lexicon acts as a censor for response production which explains why fewer non responses were found for the reading of pseudowords (22.2% in January) as compared with words (53.6% in the same session). Similarly, it is far from clear that atypical errors are necessarily non phonological errors. They may well be the result of an incomplete or incorrect grapheme-phoneme mapping as for example, when table is read as ta. In fact, analyses of these errors, revealed that in approximately half of these incorrect responses, the word differed from the target by only two letters (see Sprenger-Charolles & Siegel, 1994). Thus, a significant proportion of errors which have been classified as atypical might actually be attributed, like minus one errors, to incomplete phonological processing.

The frequency and lexicality effects obtained in June suggested the gradual establishment of an orthographic lexicon that allows the use of the direct route. However, this procedure did

not entirely replace phonological mediation. The fact that 1. the regularity effect was greater in June than in January, and that 2. the mean percentage of errors that could be attributed to a complete phonological processing (regularization) or to a partial one (minus one errors) increased from January to June, offer support for this view.

It was also found that simple items (words and pseudowords) were never read better than complex items. For words, there was no graphemic complexity effect and the complex pseudowords were even read better than the simple ones. These results suggest that, contrary to predictions, the children -- at this stage -- do not only use letter-to-sound correspondences but are capable of understanding more complex relationships of letters and sounds.

Finally, the results showed that significant correlations exist between early phonological skills (pseudoword reading, regular word reading) and later orthographic skills (irregular word reading). Similarly, we found positive and significant correlations between regularization errors and correct responses in the January word reading task. These results lend support to the argument that phonological mediation plays an important role in the development of reading. In the next section, we examine the extent to which these patterns are replicated in spelling tasks.

### Spelling

As for the reading study, we examined the effects of regularity and graphemic complexity as compared to the effects of frequency, analogy and lexicality. However, a direct comparison between word spelling and pseudoword spelling is necessarily problematic because there are more acceptable responses for pseudoword spellings, for example, the pseudoword lourire may be spelled lourire, lourir, lourrire, lourrir, lourirre. All these responses are acceptable, whereas for a similar regular word (for example, sourire) there is only one acceptable spelling. This means that the pseudoword spelling task is easier than the word spelling task (however, this is not the case for the reading tasks). Nevertheless, it is important to test the lexicality effect in spelling in the same way as in reading in order to compare the acquisition of these two skills.

We also examined the development, between January and June, of errors that can be attributed to phonological processing, i.e., regularizations and minus one errors as compared to

other errors, i.e., non-responses and atypical errors. Regularization was defined as a non-normative spelling which yielded the pronunciation of the dictated items (for example, album spelled albom). This category included the addition or the deletion of the schwa which has no effect on the pronunciation of the item (moule spelled moul). Furthermore, those errors included both simplifications of the target word and the use of a double letter instead of a simple one (route spelled rouutte). For minus one errors, the pronunciation of the word or pseudoword resulting from the written item had to be phonologically accurate except for one phoneme, for example, table /tabl/ spelled tab(e), talb(e), or tablo.

Finally, we evaluated the relationships between early phonological skills (correct responses for pseudowords and regular word spelling, regularization errors) and later orthographic skills (correct responses for irregular words).

## Results

### Correct responses

An analysis of variance was conducted on the factors of Session (January and June), Frequency (high and low frequency words) and Orthography (simple regular words, complex regular words, and irregular words). When main effects for Orthography emerged, two orthogonal contrasts were used. The first compared both simple and complex regular words with irregular words (Regularity effect). The second compared simple and complex regular words (Graphemic complexity effect). The results are presented in Table 5.

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 Insert Table 5 about here  
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There was a significant difference between Sessions ( $F[1,56] = 133.45, p < .01$ ), a main effect for Orthography ( $F[2,112] = 256.06, p < .01$ ) and for Frequency ( $F[1,56] = 5.72, p < .05$ ). All the two way interactions (but not the three way interaction:  $F[2,112] = 1.62$ ) were significant. The Session x Frequency interaction ( $F[1,56] = 15.27, p < .01$ ) was due to an increase in the frequency effect; in fact, there was no main effect of frequency in January ( $F[1,56] = 1.05$ ), such

an effect was observed only in June ( $F[1,56] = 12.38, p < .01$ ). The Frequency x Orthography interaction ( $F[2,112] = 22.47, p < .01$ ) was the result of a more marked frequency effect on irregular words. We also observed an increase between sessions of the difference between simple regular words or complex regular words, on the one hand, versus irregular words on the other (Session x Orthography interaction:  $F[2,112] = 33.17, p < .01$ ). It should yet be noted that there were very low scores for irregular words in January, and floor effects for low frequency irregular ones. Therefore, the interaction between orthography and frequency may be a result of these low scores.

The main orthography effect was due to a difference between regular words (simple/complex) and irregular words (Regularity effect,  $F[1,56] = 313.73, p < .01$ ) and between regular simple words and regular complex words (Graphemic complexity effect,  $F[1,56] = 8.58, p < .01$ ). The latter effect showed that simple words were spelled better than complex ones.

The data for the pseudoword spelling task are shown in Table 6. An analysis of variance was conducted on the factors Session (January and June), Analogy (analog and non analog pseudowords) and Graphemic complexity (simple and complex pseudowords). We observed main effects for Session ( $F[1,56] = 63.36, p < .01$ ), for Analogy ( $F[1,56] = 10.40, p < .01$ ) but not for Graphemic complexity ( $F[1,56] = 0.21$ ). The Analogy x Session interaction did not reach conventional levels of statistical significance ( $F[1,56] = 3.19, p < .09$ ). Nevertheless, independent analysis indicated that analog pseudowords were spelled more accurately than non analog pseudowords in June but not in January (January,  $F[1,56] = 1.05$ ; June,  $F[1,56] = 12.59, p < .01$ ). All the other interactions were non significant. Therefore, as in reading, the graphemic complexity effect was the same on analog and non analog pseudowords.

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 Insert Table 6 about here  
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The lexicality effect was analyzed with a comparison between the 16 paired words and pseudowords. An analysis of variance was conducted on the factors Session (January and June),



Lexicality (word and pseudoword) and Graphemic complexity (simple versus complex). The results are shown in Table 7. We observed a main effect for Session ( $F[1,56] = 95.18, p < .01$ ) and for Graphemic complexity ( $F[1,56] = 4.36, p < .05$ ) but not for Lexicality ( $F[1,56] = 1.83, ns$ ). However, there was a Lexicality x Session interaction ( $F[1,56] = 10.97, p < .01$ ). This interaction was due to the fact that words were spelled less accurately than pseudowords in January but not in June (January session:  $F[1,56] = 7.82, p < .01$ ; June session:  $F[1,56] = 0.67, ns$ ). None of the other two or three ways interactions were significant. Therefore, the sublexical factor of graphemic complexity affects words and pseudowords in the same way.

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 Insert Table 7 about here  
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We also observed high correlations between regular words and the pseudowords matched to them in orthography ( $r = .80$  in January and  $.81$  in June), between analog and non analog pseudowords ( $r = .86$  in January and  $.80$  in June) as well as between high and low frequency regular words ( $r = .92$  and  $.76$ , respectively). However, there were no significant correlations between regular and irregular words in January ( $r = .23$ ), and significant correlations between these two types of words in June ( $r = .46$ ). These results indicated that items that can be processed by phonological mediation were likely to be processed in this manner by the children.

A positive and significant correlation was found between correct responses for words and regularization errors in January ( $r = .42, p < .01$ ). We also observed significant correlations between correct responses on pseudowords and on regular words in January, and results obtained for irregular words in June ( $r = .55$  and  $.48$  respectively,  $p < .01$ ). In addition, there were no significant correlations between irregular words in January, and pseudowords or regular words in June ( $r = .27$  and  $.15$ ). The latter results may be due to the low scores observed for irregular words in January which may have reduced the magnitude of the correlations. Nevertheless, the correlations between the two sessions for irregular words were significant ( $r = .42$ ). This result suggests a certain stability in irregular word spelling performance. Moreover, all the other

correlations between sessions were significant (correlations between January and June for pseudowords and between January and June for regular words:  $r = .61, .51$ , respectively; correlations between pseudowords in January and regular words in June:  $r = .48$ ; correlations between regular words in January and pseudowords in June:  $r = .48$ ). In addition, the differences between the correlations for pseudowords in January and irregular words in June, on the one hand, and between irregular words in January and pseudowords words in June, on the other hand, were significant ( $p < .04$ ) as well as the difference in correlations between regular words in January and irregular words in June versus irregular words in January and regular words in June ( $p < .03$ ). These results suggest that, in spelling, as in reading, phonological mediation may play a role in the establishment of the orthographic lexicon.

#### Error analysis

The error analysis was conducted by assessing the different error categories for each child. Every child made at least one error in word spelling but in pseudoword spelling, 4 children in January and 13 in June made no errors. The missing cells have been eliminated for the statistical analysis. Table 8 shows the mean percentage of errors for words and pseudowords.

For words, the mean percentage of regularizations increased from January to June ( $t[56] = 10.71, p < .01$ ) but not the mean percentage of minus one errors ( $t[56] = 1.83$ ). We observed a decrease for atypical errors and non responses ( $t[56] = 8.64, p < .01$ ;  $t[56] = 2.78, p < .01$ ). Between the two pseudoword spelling sessions, an increase in minus one errors ( $t[41] = 4.37, p < .01$ ) was observed when atypical errors declined ( $t[41] = 3.87, p < .01$ ), but not non responses ( $t[41] = 0.87$ ).

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Insert Table 8 about here

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#### Discussion

The spelling results replicated those observed in reading with four exceptions. First, the effect of analogy was not observed in the first spelling session when it was already in evidence in

the first reading session. Second, in the first spelling session, but not in the first reading session, non responses were very few (around 5% for words and pseudowords as compared to 53.6% in word reading and 22.2% in pseudoword reading). Third, in spelling, no lexicality effect was observed in the second session and, in the first one, pseudowords were even more accurately spelled than words while, in reading, words were more accurately processed than pseudowords in the second session but not in the first one. These differences between spelling and reading results will be reexamined later, in the general discussion. The fourth difference between spelling and reading in the graphemic complexity effect, necessitates a more thorough investigation of the processing of complex graphemes. This analysis is presented in the following section.

#### The Processing of Complex Graphemes

In spelling, complex words were less well processed than simple words but there was no complexity effect for pseudowords. In reading, there was no difference between simple and complex words, and complex pseudowords were even better read than simple pseudowords. The differences between reading and spelling for the effect of graphemic complexity may have been due to the processing of complex grapheme per se or may have been the result of compound factors. To examine this possibility, we compared the processing of simple and complex graphemes in complex items. In these comparisons, we considered the mean percentage of orthographically correct responses for complex graphemes and for simple graphemes -- with the exception of the final silent *e* -- in word reading and spelling. The same comparison was made for pseudowords but in this case, since items had no canonical spelling, we considered all phonologically plausible responses as correct.

#### Results

The results for the reading and spelling tasks are presented in Table 9. In the word reading task, we observed no difference between simple and complex graphemes in January ( $t[56] = .41$ ) while in June the complex graphemes were even read better than the simple ones

( $t[56] = 2.24, p < .015$ ). For the pseudoword reading task, the simple graphemes were better read than complex graphemes in January ( $t[56] = 3.98, p < .01$ ) but not in June ( $t[56] = 1.19$ ).

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 Insert Table 9 about here  
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The results for the spelling tasks showed that simple graphemes were better spelled than complex graphemes in January ( $t[56] = 2.36, p < .01$ , for words;  $t[56] = 2.86, p < .01$ , for pseudowords) while in June there were no differences ( $t[56] = 0.36$ , for words;  $t[56] = 1.05$ , for pseudowords).

### Discussion

The direct comparison between the processing of simple and complex graphemes showed a very clear developmental trend for spelling. Complex graphemes were less well spelled than simple graphemes in the January session and in the June session there was no longer a difference. The fact that complex graphemes were less well read than simple graphemes only in the pseudoword task during the January session showed that children typically applied graphemes in reading. Moreover, in reading, complex graphemes were better processed than simple ones in one case (for word reading in June).

These results differ slightly from those of the analyses of variance. Such differences may result from the fact that in the former case, account was taken only of correct responses for words and for pseudowords, while in this present case, only correct graphemes were assessed whether surrounded by incorrect letters or not. For example, in case of tabale in reading or spelling, all the expected graphemes were correct, even though the response for the complete word was incorrect.

### General discussion

The objective of this study was to elucidate the mechanisms of reading and spelling acquisition in French. The principal hypothesis was that, because the aspects of reading and characteristics of the French language, French children would rely on phonological mediation in

the first stage of reading and spelling acquisition. The findings of the January session partially corroborated this prediction. Regular words were processed better than irregular words, and errors were predominantly regularizations. At the same time, performance was not superior for high, as compared to low frequency words, nor for words as compared to pseudowords. Very high correlations between words and pseudowords were also observed. These results were obtained both for reading and spelling.

The principal contradictory finding to the hypothesis of a pure phonological stage was the presence of an analogy effect in reading such that analog pseudowords were better read than non analog pseudowords. This effect was observed in reading when frequency and lexicality did not influence performance. Its origin may be the facilitating effect of the oral lexicon since analog pseudowords were constructed from high frequency words which have preprogrammed articulatory codes. Support for this interpretation comes from the lack of a comparable analogy effect in spelling, a modality in which the articulatory codes do not directly interfere with the production of the correct response as it does in reading aloud. The fact that, both in reading and in spelling, graphemic complexity had the same effect on analog and non analog pseudowords, together with the findings of very high correlations between these two types of pseudowords were further indicators that children used the same processing for analog and non analog pseudowords in the beginning of reading and spelling acquisition in French.

These results were not consistent with Goswami and Bryant's model (1990) since the effect of analogy -- observed only in reading -- appeared to depend on the oral lexicon rather than on the orthographic one. No clear evidence of the coexistence of logographic and phonological procedures proposed by Seymour, 1990, 1994, was found; however, in the first session, the correct responses analysis revealed that children mainly relied on phonological processing and the error analysis revealed non responses, which are attributed by Seymour to logographic strategies. However, if non responses were linked to logographic strategies, identical results for these errors should have been found in both reading and spelling. In fact, non responses were obtained mostly in word reading. Non responses are, therefore, not a good

indicator of logographic strategies. Such errors may therefore be due to the fact that the child censored his/her response in cases where, in word reading, partial decoding yielded an item he/she did not know. Censorship through the oral lexicon cannot exist in word spelling because knowing a word orally is not a reliable indicator of its correct spelling. The same results in a previous longitudinal study with French first graders were obtained (see Sprenger-Charolles & Casalis, 1995). The lack of real trace of logographic strategies in French may be because the January session is already too late to observe logographic processing. Yet, it is important to note, first, that, in the present study, when the children were selected (at the end of the last year of kindergarten) they were actually non readers. Second, in kindergarten, no clear evidence of logographic strategies as described in developmental models was observed in a group including most of the children of the present study (37 out of the 57, see Sprenger-Charolles & Bonnet, 1996). Nevertheless, it was not possible to assume that our French beginner readers or spellers relied only on phonological processing from the first test session mainly because, both in reading and in spelling, we observed significant correlations between the two sessions for irregular words. This result indicates a stability of performance for these items which cannot be processed only by phonological mediation and suggests that some parts of the orthographic lexicon are in place from the first test session.

Our data demonstrate that this orthographic lexicon is, in fact, working only by the end of the first grade. Support for this interpretation comes from the fact that the frequency effect was observed -- both in reading and in spelling -- only in June. The same developmental trends were observed for the lexicality effect in reading, as words were read better than pseudowords in June but not in January. In spelling, no difference between words and pseudowords was observed in June when, in the January session, pseudowords were spelled more accurately than words. The fact that we did not observe a lexicality effect in spelling in the June session is evidence of the strong impact of orthography on spelling, even for regular words.

However, although children used orthographic processing in the later stage of reading and spelling, this procedure did not entirely replace phonological mediation. Evidence for this

position was provided by the regularity effect which was obtained in the June session and which was greater than in January. Moreover, the errors which we have attributed to a complete phonological processing (regularizations) or to a partial one (minus one errors) increased with time in both reading and spelling and for both words and pseudowords (except for minus one errors in word spelling). These data suggest that an orthographic phase in which phonological mediation would exert no influence does not exist.

Another central hypothesis of this study was that phonological mediation allows the construction of the orthographic lexicon (Share, 1995). We observed that, in reading and to a lesser extent in spelling, 1. the early phonological skills, as evaluated by pseudoword or regular word processing, were predictive of later performance on irregular words, whereas the reverse was not observed, and that 2. the correlations between correct responses and regularization errors in the early stage of reading and spelling acquisition were positive and significant. These results, which replicate those obtained in reading in English studies (Byrne, Freebody & Gates, 1992; Gough & Walsh, 1991; Jorm, Share, MacLean & Matthews, 1984) suggest that phonological processing contributes to the establishment of the orthographic lexicon, especially in reading. We observed a similar phenomenon in a French study in which most of the same children than the ones enrolled in the present study (48 out of 57) were assessed phonological and orthographic skills in silent reading through the middle of first grade to the end of second grade (Sprenger-Charolles, Siegel & Béchennec, in press).

The reading results may be explained by the fact that, through the use of phonological mediation, and through the comparison between their decoding outcomes and words that are part of their oral vocabulary, children can infer GPC, as well as other types of spelling to sound relations. It is important to note that irregular words contain some regular GPC, that some irregularities are purely a question of grapheme frequency and that the comparison with the oral lexicon might allow the learning of low frequency GPC. For instance, the use of GPC in French leads to the pronunciation of the irregular word femme (/fam/) as /fɛm/. Knowing that /fɛm/ does not exist, but that /fam/ exists, the subject can infer that e must be read as /a/ in this context. It is

reasonable to postulate that children learn most of the relationships between orthography and phonology through this procedure. As a function of spelling to sound and word frequencies, strong associations between orthographic and phonological units enable the child to gradually construct an orthographic lexicon which permits the use of the direct route. Nevertheless, even when the direct route is functional, children may still have recourse to phonological mediation and this procedure becomes more and more effective as a result of the reinforcement of associations. In this framework, it is possible to understand the nature of the links between early reading strategies based on partial phonological cues (see, for example, Stuart & Coltheart, 1988; Sprenger-Charolles & Bonnet, 1996), phonological processing used by young readers (for example, the present results) and later very elaborated phonological processing of mature readers which might be automatic (see Berent & Perfetti, 1995).

The problem is not exactly the same in spelling because in that modality control by the oral lexicon does not provide help. For example, the knowledge of the oral form /bato/ does not facilitate the spelling of this word, although this knowledge may facilitate the reading of tableau. This phenomenon is a result of the asymmetry between GPC and PGC; on the one hand, regular words may have several possible spellings using PGC (we can spell /bato/ as bato, batto, batau, battau, bateau, or batteau); on the other hand, there is only one possible way to read bateau using complete GPC (/bato/). This may explain why the June results for word spelling (53% of correct responses) were inferior to those obtained in word reading (71%) and why we did not find a similar difference for pseudowords, which have no canonical spelling (76% and 80% of correct responses respectively). This was observed despite the fact that all the spelling skills were assessed after reading skills.

There was a further difference between reading and spelling. In spelling, complex words were less well processed than simple ones and there was no complexity effect for pseudowords. In reading, complex items were read as well as (in the word task), or even better than (in the pseudoword task) simple items. Besides the results of the ANOVA, the direct comparison between the processing of simple and complex graphemes indicated that complex graphemes



were less well spelled than simple graphemes in the January session, but not in the June session. On the other hand, complex graphemes were less well read than simple graphemes only in the pseudoword task during the January session; moreover, complex items were better read than simple ones in one case (for word reading in June). These results suggest that French children are using graphemes -- and not letters -- in the early stages of reading, and to a lesser extent, in spelling.

The difference between reading and spelling for the graphemic complexity effect may be explained by the fact that, if the basic unit of phonological processing is the grapheme, readers have fewer units to assemble when items contain a digraph than when they are only composed of single letter graphemes. In the former case, they also have fewer phonemic units to program for an oral response. On the other hand, the use of PGC in spelling items which contain a complex grapheme necessitates the transformation of a simple unit (one phoneme) to a complex one (a digraph). This latter operation might have a higher cognitive cost. In spite of these differences between reading and spelling, the correlation analysis indicated strong relationships between these two modalities (in January .70, .82 and .65 respectively for pseudowords, regular words and irregular words, and in June .85, .80 and .72 for the same items).

In conclusion, it is important to note that when we compare our results with those obtained in studies dealing with the development of reading and spelling skills in English, German, Italian and Spanish children, we observed some differences which may be related to the language in which these skills are acquired. First, phonological processing seems to be very important in beginning reading and spelling for French children. This seems also to be the case for Italian, German and Spanish children (Cossu et al., 1995; Cuetos, 1989; Goswami et al., in press; Valle Arroyo, 1989; Wimmer & Goswami, 1994). When French and Spanish children were directly compared to English children (Goswami et al., in press), it appears that phonological processing is more important in Spanish than in French and more important in French than in English. Second, English children, as suggested by Goswami et al.'s results (in press), seemed to rely more on orthographic rime (and rhyme) units than Spanish or French

children, and, in our study, we observed no definitive evidence for an early use of this analogical processing in French.

The stronger reliance on GPC than on rime units observed in French and in Spanish may be explained by the fact that French and Spanish have predominantly open syllables and vowels whose pronunciation is not highly constrained by the following graphemic environment. Therefore, in French and in Spanish, unlike in English, spelling to sound correspondences are not more predictable at the rime level than at the GPC level. All the more, even if the GPC in French are not so shallow than the Spanish, Italian or German ones, there are largely predictable. This could explain differences in the use of GPC as compared to rime units across languages. Thus, it seems critical to study the development of reading and writing using comparative studies with children learning to read and write in different writing systems in order to develop a clearer understanding of the process involved.

## Footnotes

1. Some data on metaphonological skills also suggest that English pre-readers, or children in the very earliest stages of reading, were unable to perform rhyme as well as phonemic awareness tasks. As reading progressed, they developed a capacity for segmentation which was more effective for small units (phoneme, for example) than for larger units (onset-rime, Seymour & Evans, 1994).
2. Fountain can either be read by making an analogy to mountain, by making rime analogy to single syllable words (count and rain) or by using GCPs. If mountain is used as a basis for an analogy to fountain then this implies that children have represented the orthographic units corresponding to the onset -- f -- and the entire rhyme (ountain).
3. In France, it is difficult to know exactly how the teachers conduct reading instruction in their classes. The Ministry of Education gives only very general guidelines on the teaching of reading and no specific reading method has ever been officially prescribed. Most of the French readers, and most of the teaching methods, present elements of both the "global method" (using key words and short texts) and the "analytical" approach (focusing on simple vowels and consonants in nonsense syllables and in words) (see Béchenec & Sprenger-Charolles, in press). In our sample, only one reader (used in one class in which were enrolled 4 children out of our 57) was mainly phonics for the first months of reading instruction, but the teacher may have used additional techniques.
4. The "irregular" grapheme was never the final consonant of a word because, in certain cases, it is possible to read correctly this kind of "irregular" word with a strictly sequential phonological decoding which stops before the last letter (as in porc, banc, tabac, etc., in which the final consonant is a silent letter). In other cases however, a complete decoding based on usual GPC will generate the correct pronunciation (as in ours, iris, déficit, granit, etc., in which the final consonant is not a silent letter) (see Content, 1991).

5. Lexicalizations have not been considered because of the difficulty of determining what constitutes a lexicalization for a young child learning to read. In many cases, partial decoding of a word results in a word. If children read only the first letters of porte (door) several possible words are produced by this incomplete decoding. For example, /p/ (peu or peu(t/x), [little or can]), /po/ (peau [skin] or pot [pot]), /por/ (porc [pig] or port [harbour]). In cases such as these, it is impossible to differentiate between a decoding error and a lexicalization.

## Appendix

## LIST OF WORDS USED IN EXPERIMENTS

## Frequency

## Orthography

## high frequency

## low frequency

## simple

porte\*

pile\*

table\*

tomate\*

minute\*

marmite\*

samedi\*

sable\*

livre

lavabo

arbre

abri

## complex

poche\*

poudre\*

tour\*

tache\*

marche\*

moule\*

sourire\*

four

riche

ruche\*

ouvre

écharpe

## irregular

pied

poêle

compte

punition

noël

noeud

femme

scie

sept

short

attention

album

\* = words used for the comparison between words and pseudowords

## LIST OF PSEUDOWORDS USED IN EXPERIMENTS

	analog	non analog
simple	lorte	lople
	mable	mirpe
	sinute	sinope
	tamedi	tanepi
complex	soche	sulche
	mour	moube
	tarche	turche
	lourire	loumi

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### Author Notes

This research was partially supported by a grant from the National Institute for Studies in Education, Paris, France to L. Sprenger-Charolles and by a grant from the Natural Sciences and Engineering Research Council of Canada to L. S. Siegel. We would like to thank Eric Beltrando for designing the computer system for the reading tests and Danielle Béchenec for helping with the data collection. We would also like to thank Philip Gough, Jose Morais, Hayne Reese, and two anonymous reviewer for their thoughtful comments.

Table 1

Mean number of correct responses on the word reading task for the January and June sessions  
(maximum: 6 for each cell)<sup>a</sup>

	Simple regular words	Complex regular words	Irregular words
Session			
January			
High frequency	2.26 (2.03)	2.61 (2.14)	0.60 (0.73)
Low frequency	2.47 (1.88)	2.44 (2.04)	0.21 (0.53)
June			
High frequency	5.32 (1.44)	5.37 (1.36)	2.82 (2.06)
Low frequency	5.00 (1.65)	5.21 (1.48)	1.75 (1.50)

<sup>a</sup>Standard deviations are in parentheses

Table 2

Mean number of correct responses on the pseudoword reading task for the January and June sessions (maximum: 4 for each cell)<sup>a</sup>

Session	Simple regular pseudowords	Complex regular pseudowords
January		
Analog	1.88 (1.46)	2.18 (1.31)
Non analog	1.84 (1.50)	1.81 (1.54)
June		
Analog	3.19 (1.20)	3.37 (1.01)
Non analog	3.02 (1.30)	3.25 (1.12)

<sup>a</sup>Standard deviations are in parentheses



Table 3

Mean number of correct responses on the word and pseudoword reading task for the January and June sessions (maximum: 8 for each cell)<sup>a</sup>

Session	Simple words	Complex words	Simple pseudo words	Complex pseudo words
January	3.51 (2.56)	3.51 (2.71)	3.72 (2.76)	3.98 (2.69)
June	6.96 (2.04)	7.11 (1.81)	6.21 (2.34)	6.61 (2.02)

<sup>a</sup>Standard deviations are in parentheses

Table 4

Errors in the word and pseudoword reading tasks: mean percentages<sup>a</sup>

Session	Regularizations	Minus 1	Atypical errors	Non responses
Word Reading				
January	4.9%	15.8%	25.8%	53.6%
	(9.2)	(13.6)	(23.6)	(33.4)
June	27.4%	31.8%	16.5%	24.3%
	(26.9)	(25.8)	(17.7)	(28.9)
Pseudoword reading				
January	1.8%	45.6%	30.4%	22.2%
	(8.4)	(31.7)	(26.2)	(26.7)
June	0.7%	66.6%	17.6%	15.1%
	(4.2)	(36.7)	(24.1)	(31.5)

<sup>a</sup>Standard deviations are in parentheses

Table 5

Mean number of correct responses on the word spelling task for the January and June sessions  
(maximum: 6 for each cell)<sup>a</sup>

	Simple regular words	Complex regular words	Irregular words
Session			
January			
High frequency	2.11 (2.07)	1.98 (1.82)	0.51 (0.50)
Low frequency	2.68 (1.91)	2.07 (1.83)	0.04 (0.19)
June			
High frequency	4.53 (1.65)	4.37 (1.70)	1.28 (1.42)
Low frequency	4.39 (1.58)	4.26 (1.34)	0.33 (1.58)

<sup>a</sup>Standard deviations are in parentheses

Table 6

Mean number of correct responses on the pseudoword spelling task for the January and June sessions (maximum: 4 for each cell)<sup>a</sup>

	Simple regular pseudowords	Complex regular pseudowords
Session		
January		
Analog	2.02 (1.40)	1.95 (1.30)
Non analog	1.91 (1.57)	1.86 (1.41)
June		
Analog	3.18 (1.12)	3.26 (1.19)
Non analog	2.93 (1.27)	2.84 (1.21)

<sup>a</sup>Standard deviation are in parentheses

Table 7

Mean number of correct responses on the word and pseudoword spelling task for the January and June sessions (maximum: 8 for each cell) <sup>a</sup>

Session	Simple words	Complex words	Simple pseudo words	Complex pseudo words
January	3.4 (2.64)	3.02 (2.67)	3.93 (2.80)	3.81 (2.53)
June	6.42 (1.97)	6.12 (1.96)	6.11 (2.22)	6.11 (2.21)

<sup>a</sup>Standard deviations are in parentheses

Table 8

Errors in the word and pseudoword spelling tasks: mean percentages<sup>a</sup>

Session	Regularizations	Minus 1	Atypical errors	Non responses
	Word spelling			
January	35.2%	29.4%	29.9%	5.5%
	(27.6)	(14.8)	(23.3)	(8.4)
June	64.4%	24.5%	8.9%	2.2%
	(24.3)	(14.7)	(17.9)	(5.4)
	Pseudoword spelling			
January		58.1%	37.0%	4.9%
		(33.1)	(30.4)	(11.4)
June		77.2%	19.5%	3.3%
		(26.7)	(26.1)	(9.6)

<sup>a</sup>Standard deviations are in parentheses

Table 9

Reading and spelling tasks: Mean percentages of correct responses for simple and complex graphemes in the items with a complex grapheme<sup>a</sup>

Session	Reading tasks		Spelling tasks	
	Simple graphemes	Complex graphemes	Simple graphemes	Complex graphemes
January				
Words	57.13 (30.86)	56.28 (35.19)	74.45 (24.17)	68.71 (32.89)
Pseudowords	77.59 (22.34)	67.32 (29.38)	76.79 (23.96)	69.73 (31.86)
June				
Words	93.57 (15.98)	94.60 (15.30)	93.16 (14.99)	93.57 (17.54)
Pseudowords	92.18 (18.34)	91.01 (19.87)	92.74 (12.41)	90.57 (21.17)

<sup>a</sup>Standard deviations are in parentheses