

The acquisition of untaught orthographic regularities in French*

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Many alphabetic languages like English or French do not have one to one mapping between phonemes and graphemes. Those linguistic systems are not completely irregular however and there are various ways to solve the phoneme-to-grapheme inconsistencies. In certain cases, spellers can use graphotactic regularities (i.e., regularities at the level of the graphemes that are independent of regularities at the level of the phonemes, Jaffré & Fayol, 1997). For instance, English spellers can use their knowledge of the fact that /k/ is never transcribed "ck" in the beginning of words and French spellers can use their knowledge that the phoneme /o/, which can be spelled among other "o", "au", "ot", "eau", is never spelled "eau" in the initial position of words. In other cases, spellers can solve phoneme-to-grapheme inconsistencies by using morphological information. For instance, English spellers can use their knowledge of the spelling of the word "heal" in order to spell the related word "health". Likewise, French spellers can use their knowledge of the fact that the sound /et/ is transcribed "ette", rather than "ète", "aite" or "ête" when it corresponds to a diminutive suffix (e.g., "une fille" means a girl; *une fillette* means a little girl).

Classical models of spelling development have depicted children's initial spellings as an attempt to spell words strictly on the basis of sound, without regard for acceptable letter sequence or other conventions of their written language (e.g., Ehri, 1986; Frith, 1985; Gentry, 1982; Henderson, 1985; Marsh, Friedman, Welch & Desberg, 1980). It would be later only that children reach an "orthographic stage" in which they grasp the higher order, more sophisticated, aspects of the nature of written language. However, recent studies have shown that children use a wide range of sources of information in spelling, albeit imperfectly, very early during spelling development (e.g., for a naturalistic study, Treiman, 1993; for

experimental studies: Cassar & Treiman, 1997; Nation, 1997; Nation & Hulme, 1996; Pacton, Fayol & Perruchet, 1998; Pacton, Perruchet, Fayol & Cleeremans, 2001). These studies show the importance to develop theories of spelling acquisition that are less stage like and take into account the relationships between the different sources of information (e.g., phonological, morphological and lexical) that influence spelling (e.g., Lennox & Siegel, 1994, 1998; Seymour & Evans, 1994; Snowling, 1994).

In what follows, we first review studies investigating the role of graphemic and morphological regularities in spelling acquisition. Then, we report two studies that explore the impact of graphotactic and morphological regularities, as well as the interactions between those two orthographic features on French children's spelling of nonwords including phonemes that can be transcribed with various graphemes.

Graphemic regularities in spelling acquisition

In Frith's (1985) model, after an alphabetic stage characterized by the strict use of phoneme-grapheme correspondences, children would move into an orthographic stage of development when extensive reading and spelling experience has been provided. A first set of studies aimed at testing this hypothesis investigated whether and when the spelling of nonwords can be lexically biased. Early experimental studies have suggested that analogies are used only late in development (Campbell, 1985; Marsh et al., 1980). Campbell (1985) used an experimental technique called "lexical priming" in which children heard a mixed list of words (e.g., crane or brain) and nonwords (e.g., /prein/) and were asked to ignore the words but attempt to spell the nonwords. She found that the spelling of the nonwords was biased by the words previously heard only for children with a reading age of greater than 11 years. For instance, the nonword /prein/ was more often spelled "prane" when children had previously heard the word "crane" and "prain" when they had previously heard the word "brain". An important limit to these studies, however, is that they did not ensure that the children do spell words such as brain or crane correctly.

Contrary to these studies, Goswami (1988) reported that children could much earlier (i.e. 6-year-old) use the spelling pattern of a clue word remaining in children's view in order to spell a target word, especially when the analogies were based on the rime unit. For instance, the presentation of the word "beak" helped children to spell the word "peak". Using the same paradigm, Nation and Hulme (1996) also found that 6-year-old children made analogies between a visible clue word and a similar sounding target nonword (Experiment 1). However they reported that analogies occurred to the same extent regardless of whether the unit shared by the clue and the target words was a rime, a consonant + a vowel or a vowel alone. Moreover, they obtained similar results when the clue word was not visible (i.e., as in Campbell's experiment), showing that children did not use analo-

gies when spelling unfamiliar words simply because the clue word acts as a visual prime (Experiment 2). Extending this finding, Nation (1997) showed that 8–9 year-old children were sensitive to rime unit frequency when spelling monosyllabic words (Experiment 1) and nonwords (Experiment 2) without using a priming paradigm.

In a naturalistic study, Treiman (1993) showed that adherence to simple orthographic conventions or regularities begins very early by examining writings produced over the course of a school year by first graders whose teacher encouraged creative writing but did not stress correct spelling. For instance, children's erroneous doubling involved more often frequently doubled letters (e.g., *ll*, *ee*) than letters that are never doubled in English (e.g., *hh*, *kk*). Likewise, children rarely used double consonants or *ck* in initial position where they never occur in English. This shows that untaught orthographic regularities that are without phonological counterpart influence children's spellings earlier than previously thought. Similar results have been reported in studies involving nonwords judgment tasks in English (e.g., Cassar & Treiman, 1997; Treiman, 1993) and in French (Pacton et al., 2001). For instance, Pacton et al showed that, as early as in Grade 1, children's judgments of nonwords reflected their sensitivity to the identity of the consonants that can (or can not) be doubled and to the legal position of double consonants.

Thus, there is convincing evidence that, very early in spelling development, children's orthographic behavior is influenced by graphemic regularities that do not have a phonological counterpart and that are not explicitly taught.

Morphological regularities in spelling acquisition

According to Henderson (1985), the role of meaning would become conspicuous for morphological aspects such as the past tense ending from the third grade and above. However, it would be at best at the end of the elementary grades that the spelling relationships among words in terms of roots, origins, and meanings are used to assist spelling. Beers and Beers (1992) found that children's productions were initially massively alphabetic and that their ability to use morphological information concerning three spelling patterns (*-s* for plurals, *-ed* for past regular verbs, and *-ing* for the continuous) develops only later. These results have been recently confirmed by Nunes, Bryant, and Bindman (1997) as concerns the *-ed* inflection. In their longitudinal study, children first spelled past regular verbs with little regard for their morphological basis. In a second phase, children generalized the written form "ed" to grammatically inappropriate words (e.g., writing *sofed* for *soft*) as if they would consider the "ed" spelling pattern merely as an exception to the phonemic system. Then, in a third phase, children's over-generalizations were confined to the right grammatical category (e.g., *keped* for *kept*). Finally, in a fourth phase, children used "ed" only for regular verbs.

The initial concentration on letter-sound correspondences, rather than on

morphology, has also been observed in Treiman's (1993) naturalistic study in which US first graders spelled the past regular with the correct "ed" ending in only about 12% of the time. However, in subsequent experimental studies, Treiman, Cassar, and Zukowski (1994), and Treiman and Cassar (1996) have reported results that could be indicative of an early use of morphology. For example, Treiman et al. (1994) found that children were more likely to spell correctly the "t" of two-morpheme words based on a stem ending with /t/ plus a suffix (e.g., dirt-y), than the "t" of one-morpheme words which contain no smaller related word (e.g., city).

Recently, with a pseudo-word spelling task, Bryant, Nunes, and Snaith (2000) have investigated whether 8- to 11-year-old children learn implicitly that English verbs whose stems sound the same in the present and past forms (e.g., clear and peel) are given the "ed" spelling (e.g., cleared; peeled) whereas verbs whose stems sound different in the present and past have phonetically spelled endings (e.g., heard; slept). Regular pseudo-verbs, whose stems sound the same in the present and past (e.g., /krel/ — /kred/) and irregular pseudo-verbs, whose stems sound different in the present and past (e.g., /prel/ — /prold/) were embedded in sentences such as "My friend always *prells* at bedtime. We usually *prell* in the morning, but last week we /prold/ in the afternoon". Children spelled regular past-pseudo-verbs with an "ed" ending more often than they did the irregular ones and, conversely, spelled the endings of the irregular past pseudo-verbs phonetically more often than they did the regular ones.

What types of linguistic information do French spellers use in spelling?

The transcription of certain phonemes (e.g., /o/ in French) can be constrained by both graphotactic and morphological regularities. This characteristic is interesting because it allows to study the interactions between those two types of constraints, the influence of which is most of the time explored independently. The experiments reported in this chapter focus on the transcription of /o/ in French for four reasons. First, there are many possible transcriptions of /o/ (e.g., "o", "au", "eau", "ot", "aut", "aud", "os", "aux", "eaux", "ho", "hau") that vary in terms of frequency. The most frequent transcription of /o/ is "o". Transcriptions such as "aud" or "os" are far more rare. Secondly, the transcription of /o/ depends on its position within words. For instance, /o/ is transcribed "ho" and "hau" only in initial position of words. The transcriptions "ot", "aut", "aud", "os" and "aux" occur only in final position of words. Note that, using "aut" or "ot" instead of "o" or "au" does not lead to a modification in the phonological form of words in final position but does in non-final position. However, the grapheme "eau" which occurs frequently at the end of words, infrequently in medial position of words and never at the beginning of words is pronounced /o/ wherever it occurs within words. Thirdly, the transcription of /o/ varies as a function of its consonantic context. For instance, in medial position, /o/ is more often spelled "o" than "au" between "b" and "r" but is more often spelled "au" than "o" between "p" and "v". Likewise,

/o/ is frequently transcribed "eau" after "t" or "t" but is never transcribed "eau" after "f" at the end of words. Fourthly, the transcription of /o/ can be guided by morphology. In certain polymorphemic words, /o/ set in the final position, corresponds to a diminutive suffix (Catach, 1986). For instance, "éléphanteau" (baby elephant) and "renardeau" (fox cub) are two-morpheme words based on a stem "éléphant" (elephant) and "renard" (fox) followed by the diminutive suffix "eau". The key point is that /o/ is transcribed "eau" when it corresponds to a diminutive morpheme.

The influence of graphotactic constraints on children's transcription of /o/

We have asked 20 second graders, 20 third graders and 20 fourth graders to spell 48 tri-syllabic nonwords in which the phoneme /o/ was located in initial (16), medial (16) or final (16) position. We used a nonword spelling task because the use of a word spelling task to explore children's sensitivity to orthographic regularities is problematic. Indeed, a child who has already seen a given word should retrieve it in his orthographic lexicon whereas another child who has never seen this word would spell it using regularities. In those conditions, it is not possible to determine whether a child writes a word such as "ordre" (order) correctly instead of "eaurdre" because he/she knows the spelling of this specific word or because he/she is sensitive to the fact that /o/ is never transcribed "eau" in the beginning of words.

We first explored the variety of the spellings of /o/ used by children at each grade level. We also assessed the influence of the position of /o/ within nonwords on its transcription. For instance, we explored whether and when children used the grapheme "eau" more often in final than in initial and medial positions. Finally, we investigated the impact of the consonantic context in which /o/ occurred on its transcription. We explored whether children used differently the graphemes "o" and "au" as a function of the consonants which follow /o/ when /o/ occurred in initial position and as a function of the consonants which precede and follow /o/ when /o/ occurred in medial position. For instance, we assessed whether /o/ was more often spelled "au" for nonwords such as /povila/ (/o/ is frequently spelled "au" between "p" and "v") than for nonwords such as /borile/ (/o/ is infrequently spelled "au" between "b" and "r"). We also explored whether and when children's use of the grapheme "eau" differed as a function of the preceding consonants when /o/ occurred in final position by assessing whether children transcribe /o/ "eau" more often for nonwords such as /bitavo/ (/o/ is frequently transcribed "eau" after "v") than for nonwords such as /bylefo/ (/o/ is never transcribed "eau" after "f").

The orthographic regularities exploited in this study have been obtained using a computerized database for written and spoken French Brulex (Content, Mousty & Radeau, 1990). Although this database may be unrepresentative of the words children are exposed to, we have assumed that the infra-lexical orthographic regularities present in this database do not differ from those present in children books.

In 16 nonwords, /o/ occurred in the beginning of nonwords, followed by one

of the eight following consonants /b/, /d/, /f/, /g/, /m/, /p/, /r/ and /t/ (e.g., /obevy/; /obidar/). The phoneme /o/ always formed the first syllable of those items and the consonants which followed /o/ always belonged to the second syllable.

Sixteen nonwords included the phoneme /o/ in medial position (i.e. neither at the beginning, nor at the end). In eight nonwords, called "o > au", /o/ occurred in a consonantic context (the consonants that precede and follow /o/) in which /o/ is more frequently spelled "o" than "au" in French (e.g., /borile/; /ribore/: /o/ is more often spelled "o" than "au" between "b" and "r"). In eight other nonwords called "au > o", /o/ occurred in a consonantic context in which /o/ is more frequently spelled "au" than "o" in French (e.g., /povari/; /ripove/: /o/ is more often spelled "au" than "o" between "p" and "v"). The phoneme /o/ and the following consonants of these 16 nonwords belonged to two different syllables.

In 16 other nonwords, the phoneme /o/ was in final position. In eight nonwords, called "eau Frequent", /o/ occurred in a consonantic context (i.e. the consonant that precede /o/) in which /o/ is frequently transcribed "eau" in French (e.g., /bitavo/: /o/ is frequently transcribed "eau" after "v"). In eight other nonwords, called "eau Never", /o/ occurred in a consonantic context in which /o/ is never transcribed "eau" in French (e.g., /bylefo/: /o/ is never transcribed "eau" after "f").

Children were told that the experimenter had made up new words that no one had ever seen or heard before and that their task consisted in listening to and writing these "new words" as they would do in a dictation, when they encounter new words they ignore the spelling form.

Number of different graphemes used by children to transcribe /o/

Table 1 shows the number of different spellings of /o/ used by children. Only one participant, a second grader, used one unique grapheme ("o"). Among the other second graders, six used two graphemes and 13 used at least three different graphemes. Four third graders used only two different graphemes; the 16 others used at least three different graphemes. Every fourth graders used at least three different graphemes. Thus, the variety of the spellings of /o/ increased with grade level, with differences according to the position of /o/ within nonwords.

Influence of the position of /o/ within words

Table 1 shows that participants used more different graphemes in initial position, and even more in final position, than in medial position. This corresponds to the distribution of the possible transcriptions of /o/ in French: four alternatives in initial position ("o", "au", "ho" or "hau"); three in medial position ("o", "au" and, very rarely, "eau"); at least eight in final position ("o", "au", "eau", "ot", "aut", "aud", "os", "aux").

Figure 1 indicates the mean percents of occurrences of graphemes — used to transcribed /o/ — as a function of the grade level and the position of /o/ within the items. At each grade level, "o" was the most frequent transcription of /o/ (73.4% in Grade 2; 47.6% in Grade 3; 52.2% in Grade 4) and "au" was the second most frequent transcription of /o/ (21.8% in Grade 2; 35.8% in Grade 3; 30.8% in Grade

Table 1. Number of graphemes used by children to transcribe /o/ (20 children per grade)

		Number of graphemes				
		1	2	3	4	>4
Overall positions	grade 2	1	6	11	1	1
	grade 3	0	4	4	6	6
	grade 4	0	0	7	8	5
Initial Position	grade 2	7	10	3	0	0
	grade 3	1	11	5	3	0
	grade 4	1	10	8	1	0
Medial Position	grade 2	3	14	3	0	0
	grade 3	0	11	9	0	0
	grade 4	0	10	10	0	0
Final Position	grade 2	2	10	6	1	1
	grade 3	3	1	6	9	1
	grade 4	0	0	12	4	4

4). Those two graphemes occurred in the three (initial, medial and final) positions. The other transcriptions were very less frequent and varied as a function of the position of /o/ within the items (see Figure 1). At each grade level, children spelled /o/ "ho" or "hau" only at the beginning of the nonwords. Likewise, they spelled /o/ "ot", "aut", "aux", "aud" and "os" only in final position. However, this could be due to the fact that those graphemic forms end by consonants that are silent in final position but are pronounced in non-final positions.

The case of the grapheme "eau", which is the third most frequent transcription of /o/ at each grade level (3.7% in Grade 2; 9.0% in Grade 3; 11.3% in Grade 4), is interesting because "eau" is pronounced /o/ irrespective of its position within words. The grapheme "eau" was more often used in final position (18%) than in initial (2.2%) and medial (4.1%) positions. This effect was significant as early as in Grade 2 where children used "eau" more often in final position (7.0%) than in initial (2.2%) and medial position (2.0%) and the size of this position effect (initial and medial vs. final) increased with grade level (5.0% in Grade 2; 15.0% in Grade 3 and 23.7% in Grade 4). Note however that spellers who used "eau" became more and more numerous (7/20 in Grade 2, 15/20 in Grade 3 and 20/20 in Grade 4) but, that at each grade level, about one third of them (2/7 in Grade 2; 4/15 in Grade 3 and 5/20 in Grade 4) used "eau" even in initial position where it never occurs in French. This suggests that many of them did not rely on a rule specifying that /o/ is never transcribed "eau" at the beginning of French words.

Influence of the consonantic context

In French, the relative proportions of "o" and "au" to transcribe /o/ in initial position vary as a function of the consonants that follow /o/. The characteristics of

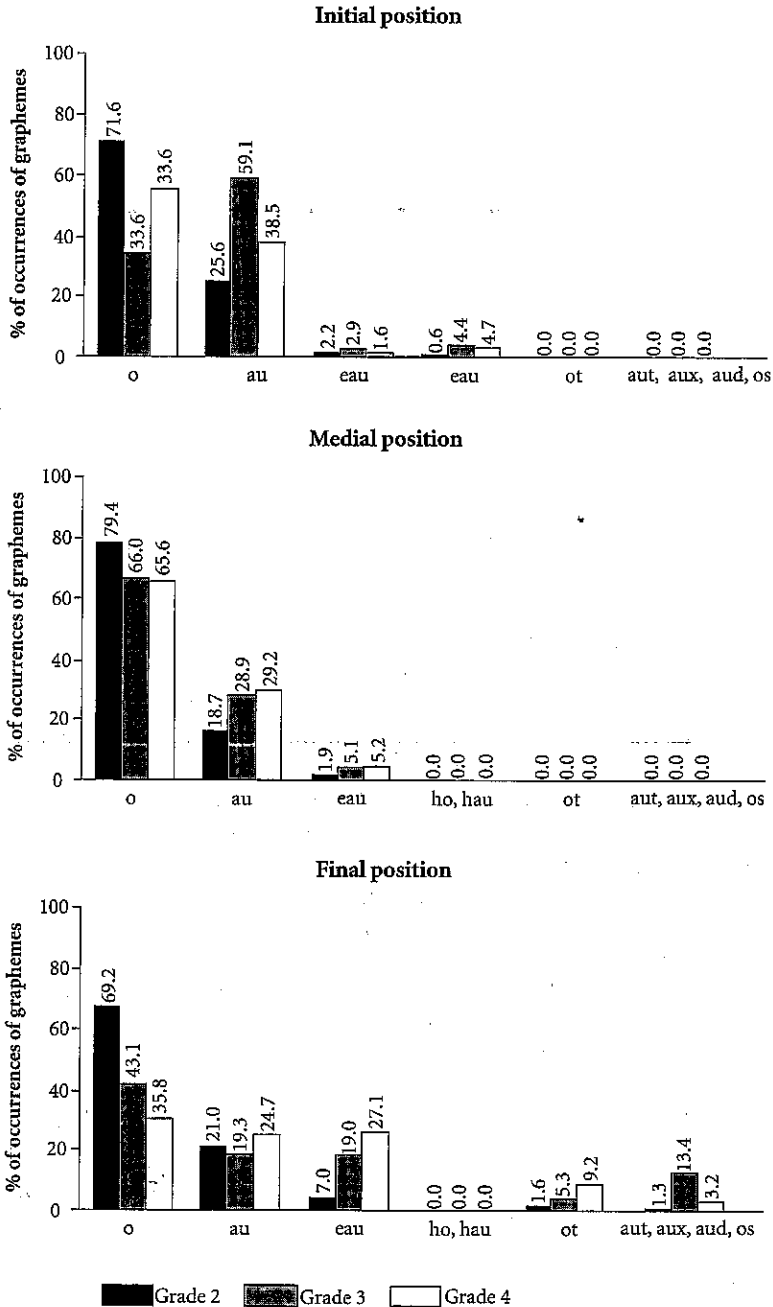


Figure 1. Proportion of occurrences of the different transcriptions of /o/ as a function of the position within nonwords

the French orthography prevent to make a clear distinction between contexts in which "o" is more frequent than "au" versus contexts in which "au" is more frequent than "o" in initial position. Because this feature is gradual, rather than dichotomic, children's sensitivity to the consonantic context has been assessed by computing correlations between the relative use of "o" and "au" as a function of the consonants that follow /o/ in Brulex database on the one hand and in children's spellings on the other hand across the eight consonantic contexts (/ob/, /od/, /of/, /og/, /om/, /op/, /or/, /ot/). In order to compute those correlations, we averaged the proportion of /o/ transcribed "au", rather than "o", (a) in children's spellings for the two nonwords in which /o/ occurred in the same consonantic context and (b) in Brulex for all the words in which /o/ occurred in the same consonantic context — for both Type and Token frequency. The correlation between the distribution of "o" and "au" as a function of the consonants that follow /o/ in children's spellings and in Brulex database increased from $r = .07$ in Grade 2 to $r = .53$ in Grade 3 and $r = .92$ in Grade 4 when correlations were performed with Brulex Type frequency. Similar results were observed when correlations were performed with Brulex Token frequency ($r = .21$ in Grade 2; $r = .56$ in Grade 3 and $r = .88$ in Grade 4). This shows that children's spelling of the initial /o/ became more and more influenced by the consonant that followed /o/ even though /o/ and this following consonant belonged to different syllables.

In the medial position of French words, the relative proportions of "o" and "au" (to transcribe /o/) vary as a function of the consonants that precede and follow /o/. Figure 2 represents the mean proportion of /o/ spelled "au" (rather than "o") as a function of grade level and consonantic context. The phoneme /o/ was more often transcribed "au" in Grade 3 (31.7%) and in Grade 4 (32.6%) than in Grade 2 (20.2%). There was a main effect of the consonantic context showing that /o/ was more often transcribed "au" for "au > o" items (43.1%) than for "o > au" items (13.3%). The size of this consonantic effect, that was significant as early as in Grade 2, increased with grade level (from 16.2% in Grade 2 to 32.3% in Grade 3 and 41.1% in Grade 4).

In French, "eau" is used to transcribe /o/ mainly in final position. Previous analyses showed that children often used "eau" in final position. The use of "eau" further varies as a function of the consonants that precede /o/. Figure 3 represents the mean proportion of /o/ transcribed "eau" in final position as a function of the consonantic context in which /o/ occurred. The mean proportion of /o/ transcribed "eau" increased as a linear function of the grade level. There was a main effect of the consonantic context, indicating that /o/ was more often spelled "eau" for "eau Frequent" nonwords (30.8%) than for "eau Never" nonwords (4.6%). The amplitude of this context effect further increased with grade level (6.0% in Grade 2; 27.0% in Grade 3 and 45.8% in Grade 4).

To summarize, as early as in Grade 2, children used many different written forms to transcribe /o/, varied their transcriptions of /o/ as a function of its position and its consonantic context and those effects increased with grade level. Those results show that the size of the sound-to-spelling correspondences on which

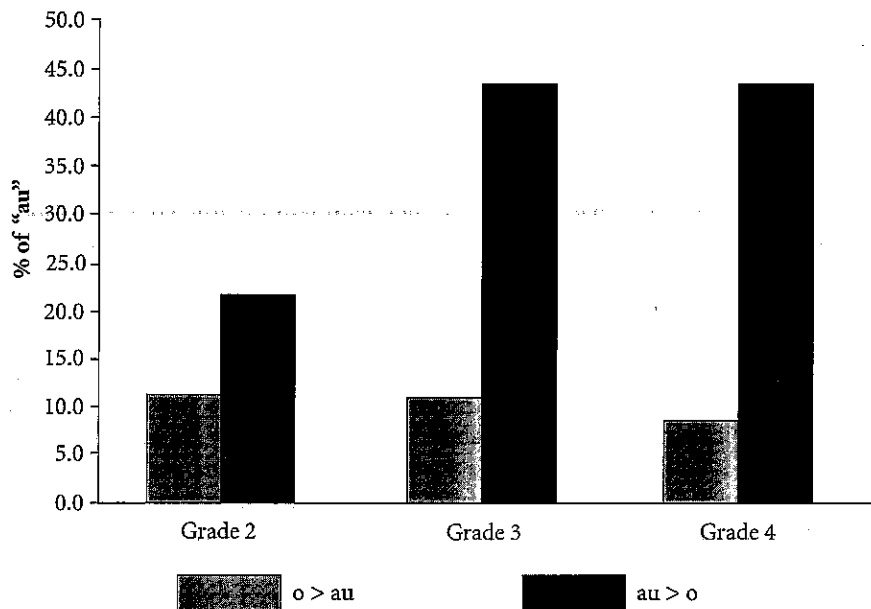


Figure 2. Proportion of /o/ transcribed "au" (rather than "o") in medial position as a function of consonantic context ("o > au" nonwords vs. "au > o" nonwords) and Grade level

children base their spellings — when they spell a new word — is larger than the phoneme-grapheme unit. This confirms and extends previous studies showing that children's spellings can not be simply described as an attempt to represent the sounds of their language without regard for orthographic regularities or conventions (e.g., Nation, 1997; Pacton et al., 2001; Treiman, 1993). It is worth stressing that the impact of the graphotactic constraints on children's spellings has been obtained with a methodology different from the common priming paradigm (e.g., Campbell, 1985; Nation & Hulme, 1996) and with polysyllabic nonwords that differed from words more extensively than in most existing studies (e.g., /zisk/ that differs slightly from "disk", Nation, 1997).

The influence of both graphotactic and morphological constraints on the transcription of /o/

We (Pacton, Fayol & Perruchet, 1999, submitted) have took advantage of the fact that, in French, the transcription of /o/ can be constrained by *both* graphotactic regularities and derivational morphology in order to assess how those orthographic constraints are integrated during spelling acquisition.

Concerning graphotactic regularities, we exploited again the fact that the probability to transcribe "eau" the final /o/ varies as a function of the consonants that precede /o/. The influence of the graphotactic constraints has been assessed by

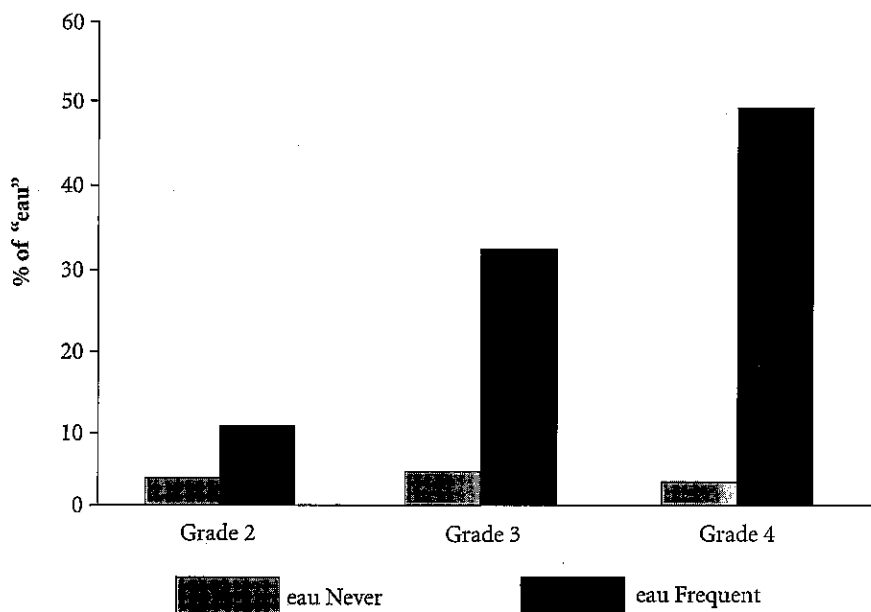


Figure 3. Proportion of /o/ transcribed "eau" in final position as a function of the consonantic context ("eau Frequent" nonwords vs. "eau Never nonwords") and Grade level

asking children to spell nonwords such as /vitaro/ and /vitafo/ that differ only regarding the consonants that precede the final /o/. An effect of the graphotactic regularities should result in a wider use of "eau" for /vitaro/ (/o/ is frequently spelled "eau" after "r" in French) rather than for /vitafo/ (/o/ is never spelled "eau" after "f" in French). Concerning morphological constraints, we exploited the fact that /o/ is spelled "eau" when it corresponds to a diminutive suffix. One week after having performed the above-mentioned task, the impact of this untaught morphological dimension — that can be described with a rule — on children's spelling has been assessed by asking children to spell the same nonwords embedded within a sentence that provided information about the morphological structure of the nonword (i.e. a stem followed by the diminutive suffix /o/, e.g., "a little /vitar/ is a /vitaro/"). We postulated that a morphological effect would result in a wider use of "eau" in the "diminutive" (second) condition rather than in the "base" (first) condition.¹ We further addressed the question of whether morphological constraints would reduce, or even suppress, the impact of graphotactic constraints in the "diminutive" condition. We hypothesized that, if spellers relied on an abstract rule such as 'if the word ends in /o/ and if the word is a diminutive, then /o/ is transcribed "eau"', the impact of the graphotactic constraints expected in the first "base" condition should no longer be observed in the second, "diminutive" condition.

We have constructed six pairs of nonwords in order to test the impact of graphotactic and morphological constraints on the transcription of /o/. The two nonwords of each pair differed only with regard to their final consonants. One nonword ended with a consonant after which /o/ is frequently transcribed "eau" in French (e.g., /vitar/). The other nonword ended with a consonant after which /o/ is never transcribed "eau" in French (e.g., /vitaf/). A diminutive corresponding to each of those 12 nonwords was elaborated by adding /o/ after the final consonant of those nonwords. For example, the diminutive of /vitaro/ was composed of the stem /vitar/ followed by the diminutive suffix /o/. Hereafter, nonwords in which /o/ followed a consonant after which /o/ is frequently transcribed "eau" in French are labelled "eau Frequent" nonwords. Those in which /o/ followed a consonant after which /o/ is never transcribed "eau" in French are labelled "eau Never" nonwords.

The experiment included two sessions separated by a one week interval. In the two conditions ("base" and "diminutive"), children had to spell the nonword preceded by the indefinite article "un" (a or an). The difference between the two conditions was that children heard "a vitaro" in the "base" (first) condition but heard "a little /vitar/ is a /vitaro/" in the "diminutive" (second) condition.

Figure 4 represents the mean proportion of /o/ transcribed "eau" as a function of graphotactic constraints, morphological constraints and grade level.

The use of "eau" differed as a function of the grade level (21.0% in grade 2, 17.9% in grade 3 and 34.6% in grade 5). There was a main effect of graphotactic constraints, showing that /o/ was more often transcribed "eau" for "eau Frequent" nonwords (33.6%) than for "eau Never" nonwords (15.4%). There was also a main effect of the morphological constraints, showing that /o/ was more often transcribed "eau" in the "diminutive" condition (29.6%) than in the "base" condition (19.4%). The Grade level by Morphological constraints interaction indicated that while "eau" was not significantly more often used in the "diminutive" condition — rather than in the "base" condition — in Grade 2 (+1.3%, both $F_s < 1$), this effect was significant in Grade 3 (+5.8%) and even more in Grade 5 (+23.3%). Importantly, the effect of the graphotactic constraints did not differ significantly according to whether nonwords were spelled in the "base" or in the "diminutive" condition (no Graphotactic constraints by Morphological constraints interaction) and this result was stable across grade levels (no Grade level by Graphotactic constraints by Morphological constraints interaction).

To summarize, as in the previous study, graphotactic constraints influenced children's spellings: as early as in Grade 2, the transcription of the final /o/ differed as a function of the consonants that precede /o/. With regard to morphology, from Grade 3 onward, /o/ was more often spelled "eau" in the "diminutive" condition than in the "base" condition. A major result was that the effect of the graphotactic constraints persisted in the "diminutive" condition and, further, that the size of the graphotactic effect did not differ according to whether nonwords were spelled in the "base" condition or in the "diminutive" condition in a very stable way across grade levels. The persistence of the effect of the graphotactic

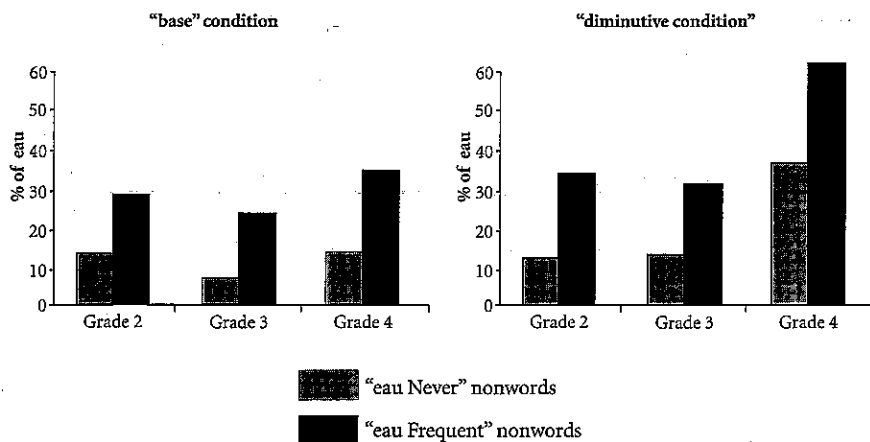


Figure 4. Proportion of /o/ transcribed "eau" as a function of morphological constraints (base vs. diminutive), graphotactic constraints ("eau Frequent" nonwords vs. "eau Never nonwords") and Grade level

constraints in the "diminutive" condition in spite of the possibility to rely on an orthographic rule suggests that, even after at least five years of exposure to print, children did not rely on a rule specifying how to transcribe /o/ when it stands for a diminutive suffix. Indeed, reliance on such a (morphological) rule would predict that morphological constraints should suppress or, at least, reduce the effect of the graphotactic constraints in the "diminutive" condition.

Discussion

In spite of the facts that "o" is the most frequent transcription of /o/, that "o" is the simplest graphemic form of /o/ (one single letter) and that reading instruction starts with the grapheme-phoneme association "o" → /o/, 19 out of the 20 first graders of our experiment did not systematically transcribe /o/ "o" but, on the contrary, used at least two different graphemes. This inclination to vary the possible transcriptions of /o/, which increased with grade level, echoes Treiman's (1993) observation that American first graders used different graphemic forms (e.g., "c", "ck" and "k") in order to transcribe /k/. Our study also revealed that children's spellings were influenced by positional regularities. For instance, children used "eau" more frequently in final position (where "eau" is frequent in French) rather than in initial and medial positions (where "eau" infrequently or never occurs in French) and this effect increased with grade level. This sensitivity to positional regularities is congruent with Treiman's (1993) findings that American first graders used "ck" (to transcribe /k/) as well as double letters in medial and final positions, where they are legal in English, but rarely used "ck" or double

letters in initial position where they never occur in English. It is worth stressing however that, in spite of the possibility to rely on a rule specifying that /o/ is never transcribed "eau" in initial position in French, about one third of the spellers of each grade level used "eau" sometimes at the beginning of the items.

In the two experiments reported in this chapter, children's spelling of /o/ was influenced by the consonantic context in which it occurred. Those contextual effects indicate that children based their sound-to-spelling correspondences on units that are larger than the phoneme-grapheme unit when they spell new words. These effects were significant from the second grade onward in medial and final positions. Furthermore, in Grade 3 and even more in Grade 4, children's spelling of the initial /o/ was influenced by the consonants that follow /o/ even though /o/ and the following consonants belonged to different syllables. This thus suggests that children's spelling were influenced by regularities of the written language that go beyond the syllabic unit.

With regard to the influence of morphology on children's spelling, we showed that, from Grade 3 onward, children's use of "eau" increased when the nonwords were embedded within sentences that make their morphological structure clear (i.e. a stem followed by the diminutive suffix "eau"). This is much in accord with Bryant et al.'s (2000) study in which English children's spellings of pseudo-words were influenced by inflectional morphology. Note that in a control experiment, we have shown that embedding the same nonwords within sentences such as "a tall /vitar/ is a /vitaro/" did not increase the use of "eau". This indicates that the wider use of "eau" in the "diminutive" condition, rather than in the "base" condition, did reflect children's use of the morphological information provided by the "a little . . ." sentences and not the insertion of nonwords within any sentences. Getting an effect of morphology with nonwords so early is all the more relevant since participants may be more inclined to use phoneme-grapheme correspondences with unfamiliar and meaningless items than with words. Therefore, one might expect the impact of morphology to be even more precocious when children write words.

A specificity of the second experiment reported in this paper was to assess the joint influence of derivational morphology — an orthographic feature that can be described with a rule — and graphotactic regularities — an orthographic feature that is probabilistic — on the transcription of the same phoneme. We showed that the effect of the graphotactic constraints did not differ significantly according to whether nonwords were spelled in the "base" or in the "diminutive" condition and that this effect was stable across grade levels. Importantly, the persistence of the effect of the graphotactic constraints in the "diminutive" condition can not be explained by children's trend to spell the nonwords as they previously did in the "base" condition. Indeed, in a control experiment (Pacton et al., submitted), similar results were obtained when the experiment was practiced in the reverse order namely, the "diminutive" condition followed by the "base" condition one week after. Thus, the persistence of the effect of the graphotactic constraints in the "diminutive" condition in spite of the possibility to rely on an orthographic rule shows that, even after at least five years of exposure to print,

children did not rely on a rule specifying that /o/ is transcribed "eau" when it stands for diminutive suffixes.

The persistence of the graphotactic effects in the "diminutive" condition of the present study meets the results reported by Pacton et al. (2001) in the case of the learning of regularities about the use of double letters in French. They assessed, for instance, whether children acquire genuine knowledge of the fact that consonants can only be doubled in medial position in French. They asked first to five graders to choose between one nonword including a doublet in legal (medial) position and another nonword including a doublet in illegal (initial or final) position the one which looked most like a word. The crucial point was that in half of the nonword pairs, doublets were formed with consonants that are doubled in French (e.g., "tiffol" and "ttifol") whereas, in the other half, doublets were formed with consonants that are never doubled (e.g., "xihhel" and "xxihel"). The results showed that (a) children's knowledge of the legal position of double consonants in French extended to never doubled consonants as early as in Grade 1 but (b) children's performance remained greater with frequently doubled consonants rather than with never doubled consonants, without any trend towards a reduction of the magnitude of this effect over the 5 years of training they examined.

Those results echo some of the results obtained in implicit learning studies in which transfer to novel material is never perfect, but, instead, depends on the familiarity of the material (the so-called transfer decrement effect, see Redington & Chater, in press, for a recent review). Taken as a whole, those results challenged the idea that learners acquire implicitly an abstract rule-based knowledge because an essential prediction of any system using abstract rules to represent its knowledge about some domain is that its transfer performance on novel items should be just as good as its performance on familiar items (e.g., Anderson, 1993; Smith, Langston & Nisbett, 1992; Whittlesea & Dorken, 1997). Note to conclude that the lack of reliance on orthographic rule does not seem to be restricted to untaught orthographic features. Indeed, Fayol and his colleagues (Fayol, Hupet & Largy, 1999; Largy, Fayol & Lemaire, 1996; Totereau, Barrouillet & Fayol, 1998; Totereau, Thévenin & Fayol, 1997) have shown that, instead of relying on the verb and noun agreement rule previously taught, 7 to 10 year-old children as well as adults retrieved instances — composed of word stem and its most frequent inflection. This leads both French children and adults to use in an erroneous way the nominal inflection "s" instead of the verbal inflexion "nt" for verbs which have nominal homophones than for verbs which do not, especially for homophones of which the nominal form is more frequent than their verbal counterpart.

Notes

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1. Experiment 2 also investigated the issue of the interactions between graphotactic regularities and morphological constraints by assessing children spell the sound /et/ which transcription varies as a function of the consonants that precede it and which is

systematically spelled "ette" when it corresponds to a diminutive suffix. However, because similar results were obtained for /o/ and /et/, only results relative to the transcription of /o/ are reported in this chapter.

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