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Learning to spell from reading: General knowledge about spelling patterns influences memory for specific words

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Adults often learn to spell words during the course of reading for meaning, without intending to do so. We used an incidental learning task in order to study this process. Spellings that contained double *n*, *r* and *t* which are common doublets in French, were learned more readily by French university students than spellings that contained less common but still legal doublets. When recalling or recognizing the latter, the students sometimes made transposition errors, doubling a consonant that often doubles in French rather than the consonant that was originally doubled (e.g., *tiddunar* recalled as *tidunnar*). The results, found in three experiments using different nonwords and different types of instructions, show that people use general knowledge about the graphotactic patterns of their writing system together with word-specific knowledge to reconstruct spellings that they learn from reading. These processes contribute to failures and successes in memory for spellings, as in other domains.

Keywords: Spelling; Graphotactic regularities; Implicit learning; Double letters.

Research on human memory has been devoted to examining its failures as well as its successes (e.g., Roediger & McDermott, 2000). The failures of memory are not random. People reconstruct events using their knowledge, culture, and prior beliefs, and this can cause them to make errors that are more or less systematic (see Suprenant & Neath, 2009, for a review). For example, university students who were asked to recall a story that was not very coherent to Western ears regularized it by making it follow the structure of more familiar stories (Bartlett, 1932; Bergman & Roediger, 1999). People's tendency to use their background knowledge to help reconstruct or build up a coherent memory is also central to studies of false memory (e.g., Hyman & Loftus, 1998; Loftus & Palmer, 1974), semantic memory (Hyman & Rubin, 1990), and memory for serial order (e.g., Botvinick & Bylsma, 2005). The present experiments were designed to explore the effects of general knowledge about the patterns of a system in the domain of spelling, a domain in which the idea of memory as a rote process has traditionally dominated (e.g., Jensen, 1962; Kooi, Schutz, & Baker, 1965). We asked whether the degree to which a new spelling fits the patterns of the writing system influences memory

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for its spelling and whether knowledge of the system's patterns can cause systematic distortions.

The general patterns that we investigated involve the arrangement of letters in words, or graphotactics. Some graphotactic patterns are all or none: *l* doubles in English and Spanish but *h* never does. Other patterns are probabilistic: *veau* is more common than *vo* at the ends of French words (Pacton, Fayol, & Perruchet, 2002). Our study focused on probabilistic patterns, in part because readers and writers are not limited to all-or-none regularities (Kessler, 2009). They learn about probabilistic patterns as well, including graphotactic ones. Simple recurrent networks provide one way to model the learning of graphotactic patterns (Pacton, Perruchet, Fayol, & Cleeremans, 2001). These models develop a sensitivity to patterns in the input using general learning mechanisms akin to those involved in other forms of statistical learning (e.g., Bates & Elman, 1996).

Much of the evidence for people's knowledge of graphotactic patterns comes from studies in which participants are presented with two nonwords and are asked which one looks more like a word of their language. As early as the first grade, for example, French children were more likely to choose nonwords including double letters for pairs like *imose–immose*, where *m* is frequent in both single and double formats, than for pairs like *idose–iddose*, where *d* is frequent as a single letter but rarely doubles in French (Danjon & Pacton, 2009; see also Cassar & Treiman, 1997; Pacton et al., 2001). In such studies, graphotactic knowledge is the only source of information on which participants can rely. In the present study, we examined the role of probabilistic graphotactic patterns in a more natural task in which other sources of information are available. Specifically, we examined whether knowledge of probabilistic graphotactic patterns plays a role when French adults learn to spell a new word incidentally, as a result of encountering it while reading.

Studies show that people who encounter new words while reading often learn about their spellings without intending to do so. Gilbert's early research with U.S. junior high school, high school, and university students showed that reading texts for the purpose of being able to answer questions on the content results in improvement in spelling for the words encountered in the texts (Gilbert, 1934a, 1934b, 1935). Ormrod (1986a, 1986b), similarly, found that university students can learn to spell novel words while reading them in context when they are not specifically instructed to remember the spellings, although instructions to learn the spellings yield better performance. To a large extent, people teach themselves to spell through reading (Burt & Butterworth, 1996; Burt & Furry, 2000; Share, 1995).

One factor that influences self-teaching is the amount of experience that people have with a spelling. In experiments in which people are exposed to novel spellings, they are more likely to learn spellings that are presented often than those that are presented less often (Nation, Angell, & Castles, 2007; Ormrod, 1986a). Likewise, in studies that examine real words, measures of the frequency with which a word has been encountered in texts are among the best predictors of spelling accuracy (e.g., Kreiner & Gough, 1990; Lété, Peereman, & Fayol, 2008). Some studies show that a word's conformity to the typical sound-to-spelling correspondences of a writing system influences learning, above and beyond frequency of exposure to the specific word (Lété et al., 2008; Wang, Castles, Nickels, & Nation, 2011). However, few studies have asked whether conformity to the graphotactic patterns of the system is also influential.

One previous study of the influence of graphotactic knowledge on misspellings was carried out by Campbell and Coltheart (1984) soon after the release of the film *Gandhi*. Although the English university students who participated in the main study had presumably seen the name *Gandhi* many times, most of them misspelled it as *Ghandi*. The absence of mistakes such as *Gandy* or *Gandi* suggests that participants remembered that the word included an *h* but did not remember its position. The frequency with which the misspelling *Ghandi* occurred relative to alternatives such as *Ganhdi* or *Gandih* may reflect the consistency of this misspelling with English graphotactic

patterns: *gh* is much more frequent than sequences such as *nh* or *ih*. However, this study used only one item, and there was no control over how often participants had seen the correct spelling.

Other evidence that graphotactic patterns influence memory for spellings, this time from children, comes from a study by Wright and Ehri (2007) in which U.S. 6-year-olds were taught to pronounce isolated words. Some of the items began with consonant doublets, such as *rrug*, and others ended with doublets. The former spellings deviate from the graphotactic patterns of English. When children were later asked to spell the words, they recalled the final doublets much better than the initial doublets. Many children misremembered words containing initial doublets without any doublets (e.g., *rrug* as *rug*), but a number of children doubled the final consonant instead of the initial one (e.g., *rrug* as *rugg*). Children rarely erroneously doubled final consonants when an item like *tub* had been taught, suggesting that a memory that some letter was doubled in *rrug* caused them to produce the error *rugg*. Children's knowledge of graphotactic patterns apparently led them to double the consonant in a legal rather than an illegal position. We call this movement of the doubling feature from one letter to another a doublet transposition error.

The children in the Wright and Ehri (2007) study were presented with spellings of isolated words in an explicit teaching situation. In the present study, we exposed French university students to novel spellings in the context of meaningful texts; students were not specifically asked to remember the spellings. Instead of using spellings such as *rrug* that are blatantly illegal to participants (no English word that a typical 6-year-old would have seen begins with a double consonant, and the only such word that most adults would know is *llama*), we investigated patterns that are probabilistic in nature. Specifically, we exploited the fact that *n*, *r*, and *t* double frequently in the medial positions of French words. Other medial consonants, including *b*, *d*, and *g*, are less likely to double. The frequency of occurrence of these doublets in a corpus of French books (New, Pallier, Ferrand, & Matos, 2001) is 78,699 per million for *nn*, 7171.8 for *rr*, and 8955.5 for *tt*, as compared to 54.1 for *bb*, 31.8 for *dd*, and 67.7 for *gg*. Thus, although French includes words such as *addition* and *toboggan*, these are less numerous than words such as *annoncer* and *arranger*. French consonant doubling is a good test case for graphotactic knowledge because it does not usually serve a phonological function. The single and double consonants used in the present study are pronounced alike in French words.

In the learning phase of the three experiments we report, students were exposed to three types of nonword spellings. Each participant saw two no-doublet items that contained only single consonants (e.g., *tidunar*), two frequent-doublet items that contained one frequent consonant doublet (e.g., *tidunnar*), and two rare-doublet items that contained one rare consonant doublet (e.g., *tiddunar*). The three types of nonword spellings all had the same pronunciations. The use of these three types of items allowed us to explore whether participants learned which items contained a doublet and which did not, whether they recalled spellings containing a rare doublet less well than spellings containing a frequent doublet, whether they committed transposition errors on items containing a doublet, and whether these transpositions varied as a function of doublet frequency. In the test phase of Experiment 1, participants answered questions about the content of the stories. One question required them to write the novel item. Participants were not explicitly asked to spell the item as it was written in the story, and they did not know that spelling was the researchers' focus of interest. In the test phases of Experiments 2 and 3, participants were explicitly instructed to spell the item as it was written in the story. We hypothesized that, regardless of the type of instructions, participants' memory for spelling would be influenced by the probabilistic graphotactic patterns. Therefore, participants should be more accurate at spelling no-doublet and frequent-doublet items than rare-doublet items. Moreover, transpositions of the doublet feature should be more common for rare-doublet items than frequent-doublet items. For example, *tidunar* and *tidunnar* would be more often correctly spelled than *tiddunar*, and this last

word would sometimes be misspelled *tidunnar*, with transposition of the doubling from *d*, which does not often double in French, to *n*, which often doubles.

EXPERIMENT 1

Method

Participants

The participants were 54 undergraduates (32 females) from Université Clermont-Ferrand/Aurillac, France. They were native speakers of French between 19 and 22 years old, with a mean age of 19 years, 8 months.

Stimuli

We constructed trisyllabic nonwords, as shown in the Appendix. Each nonword included two target consonants, which were the onsets of the second and third syllables. One of the two target consonants in each nonword was *n*, *r*, or *t* (three consonants that frequently double in French), and the other was *b*, *d*, or *g* (three consonants that rarely double). Each target consonant was the onset of the second syllable in one nonword and the onset of the third syllable in another. We created no-doublet, frequent-doublet, and rare-doublet spellings of each nonword, as in *bagotin* (no doublet), *bagottin* (frequent doublet), and *baggotin* (rare doublet).

The nonwords were embedded in stories, a sample of which appears in the Appendix. The average length of the stories was 256 words. A nonword occurred four times within a story as the name of the hero. The order of the stories and the nonwords embedded in them were randomized across subjects. For this and the other experiments, each story was printed on a single page of a booklet. Test questions were printed on the other side of the page so that participants could not see the story when answering the questions. The first question in Experiment 1 required participants to select a title for the story from a list. Participants were then asked to complete five items about the story with a single-word answer, for one question the name of the hero. A final question required a longer answer. The questions were designed to be simple for university students.

Procedure

Participants were tested in groups of 10 to 20. In this experiment, as in Experiments 2 and 3, the experimenter told the participants that he needed help in calibrating some texts that would be used to assess the reading comprehension of fifth graders. He provided participants with booklets that included six stories along with a series of questions designed to assess the stories' comprehensibility. Participants were asked to read one text silently and move to the next page to answer questions about it, without rereading the text, then go to the next text, and so on.

Results

As expected, participants performed at ceiling on the questions that did not involve spelling the hero's name. Our main interest was in their spelling of this novel word. For each participant, we counted the number of spellings that contained only single consonants, the number of spellings that contained a frequent doublet, and the number of spellings that contained a rare doublet. The mean values for the 24 participants, transformed into percentages, are shown in Table 1.

Table 1. *Percentage of different types of spellings produced in Experiment 1*

Type of spelling produced	*Type of item presented*		
	No doublet	*Frequent doublet*	*Rare doublet*
No doublet	**92.6 (20.4)**	2.8 (11.6)	4.6 (14.6)
Frequent doublet	1.9 (9.5)	**92.6 (17.9)**	*18.5 (29.6)*
Rare doublet	2.8 (11.6)	*1.9 (9.5)*	**72.2 (34.6)**

Note: Correct spellings are in bold and transposition errors in italics; standard deviations are in parentheses. The percentages of the three types of spellings do not sum to 100 because, for each type of item, 2.8% of the errors had the phonological rendition of at least one of the target consonants incorrect and because 1.9% of the rare-doublet items were spelled with both target consonants doubled.

Correct spellings, defined as those in which both target consonants were spelled as in the story, were more common on no-doublet and frequent-doublet items (92.6% for both) than on rare-doublet items (72.2%). Analyses of variances (ANOVAs) on the number of correct spellings using subjects and items as random variables confirmed the main effect of item type [$F_1(2, 106) = 12.30$, $MSE = 0.37$, $p < .001$, $\eta_p^2 = .19$; $F_2(2, 10) = 6.05$, $MSE = 4.86$, $p = .019$, $\eta_p^2 = .55$]. Planned comparisons showed that correct spellings were significantly more common for no-doublet and frequent-doublet items than for rare-doublet items [$F_1(1, 53) = 17.19$, $MSE = 0.38$, $p < .001$, $\eta_p^2 = .24$; $F_2(1, 5) = 6.60$, $MSE = 8.91$, $p = .05$, $\eta_p^2 = .57$], with no difference between no-doublet and frequent-doublet items (Fs < 1).

The error type of primary interest here was transposition, which involved movement of the doubling feature to the wrong target consonant: the consonant that is frequently doubled in French instead of the consonant that is rarely doubled for rare-doublet items (e.g., *lirobban* spelled *lirroban*) and the consonant that is rarely doubled instead of the consonant that is frequently doubled for frequent-doublet items (e.g., *lirroban* spelled *lirobban*). Transposition errors on rare-doublet items far outnumbered those on frequent-doublet items (18.5% vs. 1.9%) [$t_1(53) = 3.80$, $p < .001$; $t_2(5) = 3.67$, $p = .014$]. As Table 2 shows, of the 19 participants who made transposition errors, 17 made them only on rare-doublet items.

Omission errors, defined as those in which a doublet consonant in a frequent-doublet or rare-doublet item was spelled with a singleton, were low in frequency. Their occurrence did not differ between frequent- and rare-doublet items [respectively, 2.8% and 4.6%, $t_1(53) = 0.70$, $p = .48$; $t_2(5) = 1.58$, $p = .17$].

Importantly, the predominance of transposition errors on rare-doublet items did not arise because of a tendency to use frequent doublets irrespective of the type of item that had been presented. Indeed, an examination of the pattern of correct responses and errors on the three types of items shows that rare doublet items were spelled with a frequent doublet (18.5% transposition errors) both less often than frequent-doublet items (92.6% correct) and more often than no-doublet items (1.9% addition errors). An ANOVA on the number of spellings that contained frequent doublets revealed a main effect of item type [$F_1(2, 106) = 298.82$, $MSE = 0.17$, $p < .001$, $\eta_p^2 = .85$; $F_2(2, 10) = 443.70$, $MSE = 1.02$, $p < .001$, $\eta_p^2 = .99$], with more use of frequent doublets for frequent-doublet items than for rare-doublet and no-doublet items [$F_1(1, 53) = 658.01$, $MSE = 0.15$, $p < .001$, $\eta_p^2 = .93$; $F_2(1, 5) = 1365.69$, $MSE = 0.64$, $p < .001$, $\eta_p^2 = 1.00$] and more use of frequent doublets for rare-doublet items than for no-doublet items [$F_1(1, 53) = 15.90$, $MSE = 0.19$, $p < .001$, $\eta_p^2 = .23$; $F_2(1, 5) = 19.29$, $MSE = 1.40$, $p = .007$, $\eta_p^2 = .79$].

Discussion

French university students had more difficulty recalling spellings that contained rare doublets

Table 2. *Numbers of participants who made transposition errors in each experiment*

Experiment and condition	*Total* N	N *with transposition errors*	N *with transposition errors only on rare-doublet items*	N *with transposition errors only on frequent-doublet items*
Experiment 1	54	19	17	2
Experiment 2	24	15	12	3
Experiment 3, recall condition	36	20	16	3
Experiment 3, recognition condition	36	22	18	3

Note: One participant in the recall condition and another in the recognition condition of Experiment 3 committed transposition errors on both rare- and frequent-doublet items.

(e.g., *tiddunar*) than spellings that contained common doublets (e.g., *tidunnar*) or no doublets (e.g., *tidunar*), even though they had seen the three types of spellings equally often in the texts that they read. About two thirds of the students' errors on rare-doublet items were transpositions. The prevalence of transposition errors on rare-doublet spellings, their uncommonness on frequent-doublet spellings, and the rare use of frequent doublets for no-doublet items suggest that participants sometimes remembered the presence of doubling but not the specific letter that was doubled. When this happened, participants sometimes reconstructed a spelling based on their knowledge of which letters are most likely to double and in which positions. This reconstruction yielded correct spellings for frequent-doublet items but transposition errors for rare-doublet items.

The participants in Experiment 1 did retain some memory for the specific spellings they had seen. For example, they were more likely to use a frequent doublet to spell frequent-doublet items than either rare- or no-doublet items, and they were more likely to use a rare doublet to spell rare-doublet items than either frequent- or no-doublet items. However, participants supplemented this word-specific memory with their knowledge of the graphotactic patterns of French—specifically, patterns related to consonant doubling.

The results of Experiment 1 suggest that the reconstructive view of memory, according to which memory is influenced by both general knowledge about a domain and specific experience with an item or event (Suprenant & Neath, 2009), applies to spelling. However, the experiment has some limitations. One limitation is that, because participants read the texts silently, we do not have direct evidence that they pronounced the spellings with single and double consonants alike. In Experiment 2, therefore, we had participants read the texts aloud.

Another change for Experiment 2 was to add a control group of participants who spelled the same nonwords as the experimental participants but who had not previously read or heard the nonwords. The inclusion of a control group provides information about whether French university students double letters spontaneously and, if so, which ones. In addition, it allows us to examine the role of word-specific memory in more depth than in Experiment 1. Thus, in addition to asking whether experimental group participants use frequent doublets more often when they had read an item spelled with a frequent doublet than an item spelled with a rare doublet or no doublet, we can ask whether participants who read a spelling with a frequent doublet are more likely to spell the item with this frequent doublet and less likely to spell it without a doublet than control group participants.

Through their reading of the successive texts, participants in Experiment 1 might have noticed that one question always required them to spell the nonword. Therefore, they may have allocated more attention to the nonword over the course of the experiment. This strategy may have been strengthened by the fact that the nonword was always the hero's name. If participants used such a strategy, learning of the nonwords' spellings could no longer be considered implicit. Speaking against this view, the percentage of correct spellings of the nonword was rather stable across the six stories—87.0%, 83.3%, 83.3%, 83.6%, 87.0%, and 88.7%, respectively. An ANOVA with the variable of text order did not reveal a significant effect ($p = .91$ and $p = .97$ for analyses using subjects and items as random variables, respectively). If participants adopted an explicit, intentional, learning strategy, it clearly did not improve their orthographic learning. Experiment 2 addressed this issue more directly by using a procedure that makes it very unlikely that participants would increasingly focus on remembering the nonwords' spellings as they progressed through the texts. Specifically, we embedded the same nonwords used in Experiment 1 in new stories in which they no longer corresponded to the name of the hero. Once participants had finished reading a story, they answered several questions about it, as in Experiment 1. Unlike in Experiment 1, no question focused on the nonword. Memory for the nonwords' spellings was tested only at the end of the experiment, after participants had spent 10 minutes performing a filler task.

A last change compared to Experiment 1 concerned the instructions for the spelling task. The participants in Experiment 1 were not specifically asked to spell the nonwords as they were spelled in the stories in which they were embedded. It is possible that the transposition errors reflected, in part, the nature of the instructions. Experiment 2 addressed this issue by asking participants to spell nonwords as they were written in the stories in which they were embedded. If Experiment 2 replicates the main findings of Experiment 1, this will suggest that the findings are robust despite changes in the instructions.

EXPERIMENT 2

Method

Participants

The participants were 48 undergraduates (34 females) from Université Paris Descartes, France. They were native speakers of French between 18 and 27 years old, with a mean age of 22 years, 0 months. Half of the participants were assigned to the experimental group, reading stories that included the nonwords that they were subsequently asked to spell. The other half of the participants, the control group, took the same spelling test without having read or heard the nonwords.

Stimuli

The nonwords were the same as those of Experiment 1, but instead of being the names of the hero of each story, they served as nouns, for example the name of a type of fruit. Given this change, there was no reason to use only one nonword in each story. Therefore, we created three new stories, with an average length of 157 words, in which we embedded two nonwords. Two nonwords of the same type (i.e., no, frequent, or rare doublet) were not included in the same story. A sample story appears in the Appendix. Each nonword occurred five times in each story. The first test question about each story required participants to select an appropriate title from a list of three. The next three questions were true/false questions, none of which was about the nonword. The order of the stories and the nonwords embedded in them was randomized across subjects.

Procedure

Participants in the experimental group were tested individually. Participants were asked to read one story aloud and move to the next page to answer questions about it, without rereading the story, then go the next story, and so on. The participants' reading was tape-recorded. After this, participants performed a letter cancellation task for 10 min. Then the experimenter pronounced each of the six nonwords and asked participants to spell them as written in the texts they read. The control group participants, who were also tested individually, took only the final spelling task. They were asked to spell the nonwords as if they were real words that they were encountering for the first time.

Results

Experimental group

When reading the stories, the participants always pronounced the target consonants and their surrounding vowels alike, whether the target consonant was single or double. They performed at ceiling on the questions assessing understanding of the stories.

Table 3 provides information about the percentage of types of spellings produced for each type of item presented. An ANOVA on the number of correct spellings with the variable of item type (no, frequent, or rare doublet) revealed a significant effect [$F_1(2, 46) = 8.64$, $MSE = 0.59$, $p = .001$, $\eta_p^2 = .27$; $F_2(2, 10) = 10.61$, $MSE = 20.39$, $p = .003$, $\eta_p^2 = .68$]. Planned comparisons showed that correct spellings were more common for no-doublet items (85.4%) than for items requiring a doublet [$F_1(1, 23) = 13.75$, $MSE = 0.49$, $p = .001$, $\eta_p^2 = .37$; $F_2(1, 5) = 17.10$, $MSE = 1.56$, $p = .009$, $\eta_p^2 = .77$] and more common for frequent- than rare-doublet items [respectively, 66.7% and 39.6%, $F_1(1, 23) = 5.07$, $MSE = 0.69$,

Table 3. *Percentage of different types of spellings produced in Experiment 2*

		Experimental group		
Type of spelling produced	*Control group*	*No doublet item presented*	*Frequent doublet item presented*	*Rare doublet item presented*
No doublet	86.1 (19.4)	**85.4 (27.5)**	27.1 (38.9)	29.2 (29.2)
Frequent doublet	12.5 (17.9)	8.3 (19.0)	**66.7 (45.8)**	*29.2 (32.7)*
Rare doublet	1.4 (4.7)	6.3 (16.9)	*6.3 (1.4)*	**39.6 (32.9)**

Note: Correct spellings are in bold and transposition errors in italics; standard deviations are in parentheses. The percentages of spellings produced of different types do not sum to 100 in the rare-doublet condition because one error in this condition, 2.1%, involved the doubling of both consonants.

$p = .03$, $\eta^2_p = .18$; $F_2(1, 5) = 6.17$, $MSE = 2.28$, $p = .043$, $\eta^2_p = .55$].

Transposition errors on rare-doublet items, which involved moving the doublet feature from the consonant that rarely doubles in French to the consonant that frequently doubles, were more common than those on frequent-doublet items, which involved moving the doublet feature from the consonant that frequently doubles in French to the consonant that rarely doubles (29.2% vs. 6.3%). A t test on the number of transpositions showed that this difference was significant [$t_1(23) = 2.69$, $p = .013$; $t_2(5) = 3.05$, $p = .028$]. The prevalence of transposition errors on rare-doublet items also appeared in the analysis of individual profiles, as Table 2 shows. It did not reflect a general trend to use frequent doublets irrespective of the type of item that had been presented. Indeed, the number of spellings that contained a frequent doublet varied as a function of item type [$F_1(2, 46) = 26.51$, $MSE = 0.32$, $p < .001$, $\eta^2_p = .54$; $F_2(2, 10) = 17.16$, $MSE = 1.96$, $p = .001$, $\eta^2_p = .77$], with more frequent doublets used for frequent-doublet items (66.7% correct) than for rare-doublet items (29.2% transposition errors) and no-doublet items (8.3% addition errors) [$F_1(1, 23) = 39.12$, $MSE = 0.38$, $p < .001$, $\eta^2_p = .63$; $F_2(1, 5) = 49.91$, $MSE = 1.18$, $p = .001$, $\eta^2_p = .91$] and more frequent doublets used for rare- than no-doublet items in the by-participant analysis [$F_1(1, 23) = 8.10$, $MSE = 0.26$, $p = .009$, $\eta^2_p = .26$; $F_2(1, 5) = 3.05$, $MSE = 2.73$, $p = .14$, $\eta^2_p = .38$].

The participants in Experiment 2 produced many more omission errors than in Experiment 1 (28.2% vs. 3.7%). This probably reflects the fact that the delay between reading a nonword and spelling it was over 10 minutes, as compared to less than about one minute in Experiment 1. There was no significant difference between the number of omission errors with frequent and rare doublets (respectively, 27.1% and 29.2%) [$t_1(23) = 0.27$, $p = .79$; $t_2(5) = 0.67$, $p = .53$].

Control group

As Table 3 shows, most of the spellings produced by the control group did not include any double consonants. When doublets were used, they were more likely to involve a consonant that frequently doubles in French than a consonant that rarely does. The control group participants never doubled a consonant that cannot double in French, they never used a legal consonant doublet in an illegal position (i.e., in initial or final position of a word), and they never doubled a vowel.

Comparisons between experimental and control group participants

A series of t tests to compare the number of spellings including no doublet, a frequent doublet, or a rare doublet produced by the experimental group and the control group for each type of item revealed significant effects when the participants of the experimental group saw frequent- and rare-doublet items. When the experimental group saw frequent-doublet items, they spelled these items less often without a doublet but more often with a frequent doublet than the control group [respectively, $t_1(46) = 6.64$, $p < .001$; $t_2(5) = 6.45$, $p = .001$, and $t_1(46) = 5.4$, $p < .001$; $t_2(5) = 6.15$,

$p = .002$]. When the experimental group saw rare-doublet items, they spelled these items less often without a doublet but more often with a rare doublet as well as more often with a frequent doublet than the control group [respectively, $t_1(36) = 7.95$, $p < .001$; $t_2(5) = 5.52$, $p = .003$, $t_1(36) = 5.63$, $p < .001$; $t_2(5) = 4.20$, $p = .008$, and $t_1(36) = 2.19$, $p = .034$; $t_2(5) = 6.15$, $p = .001$].

Discussion

A key result of Experiment 1—the higher rate of transposition errors on rare-doublet items than frequent-doublet items—was replicated in Experiment 2. This occurred even though there were several procedural differences between the experiments. One difference is that participants in Experiment 2 read the stories aloud whereas participants in Experiment 1 read them silently. A second difference is that orthographic learning was assessed in Experiment 2 with a task that emphasized that participants should spell the items as they were spelled in the stories. Moreover, this spelling task was given only after all of the stories had been read. This makes it very unlikely that participants in Experiment 2 increasingly focused on remembering the spellings of the nonwords as they progressed through the stories.

Most of the transposition errors that we observed involved the transposition of the doublet feature from a consonant that rarely doubles in French to a consonant that frequently doubles. This outcome reveals participants' knowledge that some consonants are more likely to double than others and their use of this knowledge in spelling production. The spellings produced by the control group further show that French university students are knowledgeable about constraints on doublets. Although most of these spellings included only singletons, those that included doublets always used doublets that are permissible in French in a permissible (medial) position. Furthermore, the doublets were far more often frequent doublets than legal but rare doublets.

Comparisons of the spellings produced by the experimental and control participants shed light on the interplay between general knowledge and word-specific knowledge. The control group participants, who had no word-specific knowledge, were more likely to include singletons than frequent doublets in their spellings, and they almost never used rare doublets. The experimental group participants had acquired word-specific information with regard to the presence of a doublet in a specific item. However, they were affected by general knowledge too, as their transposition errors indicate.

Although the pattern of transposition errors was similar in the two experiments, omission errors were far more frequent in Experiment 2 than in Experiment 1. The omissions that occurred for both frequent- and rare-doublet items explain why frequent-doublet items were correctly spelled less often than no-doublet items in Experiment 2. In Experiment 1, in contrast, accuracy on both frequent- and no-doublet items was close to ceiling. The higher rate of omissions in Experiment 2 probably results from the longer delay between the reading of a nonword and the assessment of memory for its spelling. Indeed, previous studies have reported better performance on measures of orthographic learning after short than after long delays (e.g., Nation et al., 2007).

To summarize, the results of both Experiments 1 and 2 suggest that people sometimes remember the presence of doubling but not the specific letter that was doubled. In such situations, they use their knowledge of which letters are most likely to double. This leads them to correctly spell frequent-doublet items but to make transposition errors on rare-doublet items. This result seems to be robust given that the two experiments differed on several dimensions, including the delay between exposure to a nonword and retrieval of its spelling, whether the test emphasized correct spellings, whether the nonwords were proper names or common nouns, and whether reading was silent or oral. To further investigate the generalizability of the findings, we used a new and larger sample of nonwords in Experiment 3. Moreover, as in some studies investigating the role of

self-teaching in orthographic learning (e.g., Share, 1995), we assessed whether learning had occurred using a recognition task as well as a recall task.

EXPERIMENT 3

Method

Participants

The participants were 72 undergraduates (40 females) from Université Paris Descartes, France. They were native speakers of French between 18 and 28 years old and with a mean age of 21 years, 9 months. Half of the participants were assigned to the recognition task condition and the other half to the recall condition.

Stimuli

Eighteen trisyllabic nonwords including two target consonants were created. One of the target consonants was *n*, *r*, or *t* (three consonants frequently doubled in French) and the other was *b*, *d*, or *g* (three consonants rarely doubled). Two nonwords used each of the following pairs of target consonants: *n/b*, *n/d*, *n/g*, *r/b*, *r/d*, *r/g*, *t/b*, *t/d*, and *t/g*. In one nonword, the onset of the second syllable was the frequently doubled consonant, and the onset of the third syllable was the rarely doubled consonant (e.g., *cinabé* for the pair *n/b*). In the other nonword, the onset of the second syllable was the rarely doubled consonant, and the onset of the third syllable was the frequently doubled consonant (e.g., *cibané* for the pair *n/b*). Three spellings, all of which had the same pronunciation, were created for each nonword: a no-doublet spelling (e.g., *cinabé*), a frequent-doublet spelling (*cinnabé*), and a rare-doublet spelling (*cinabbé*).

The nonwords were embedded in the same three stories as those in Experiment 2, with the constraint that the two nonwords in each story did not belong to the same spelling category. Given that three spellings were created for each of the 18 nonwords and that six nonwords were used for each participant, each spelling form of each nonword was used for four participants. For the recognition test, three spellings that differed only in the form of the target consonants were written on each page of a booklet. One spelling did not include any doublet, one spelling included a frequent doublet, and one spelling included a rare doublet (e.g., *cibané, cibanné, cibbané*).

Procedure

The procedure for the recall condition was the same as that in Experiment 2. The procedure for the recognition condition differed only in that participants were asked to indicate which of the three spellings was in the text that they read.

Results

When reading the stories aloud, the participants always pronounced the target consonants and their surrounding vowels in the same way whether the target consonant was single or double. They performed at ceiling on the questions assessing understanding of the texts. Table 4 shows the percentage of different spellings produced (in recall condition) or chosen (in recognition condition).

Recall condition

An ANOVA on the number of nonwords with the two target consonants correctly spelled with the variable of item type (no, frequent, or rare doublet) revealed a significant effect [$F_1(2, 70) = 26.89$, $MSE = 0.44$, $p < .001$, $\eta_p^2 = .43$; $F_2(2, 16) = 24.90$, $MSE = 46.93$, $p < .001$, $\eta_p^2 = .76$]. Planned comparisons revealed that there were significantly more correct spellings for no-doublet items (87.5%) than for frequent- and rare-doublet items (respectively, 55.6% and 30.6%) [$F_1(1, 35) = 50.91$, $MSE = 0.37$, $p < .001$, $\eta_p^2 = .59$; $F_2(1, 8) = 117.87$, $MSE = 0.64$, $p < .001$, $\eta_p^2 = .94$] and, among items requiring a doublet, for frequent- than for rare-doublet items [$F_1(1, 35) = 9.00$, $MSE = 0.50$, $p = .005$, $\eta_p^2 = .20$; $F_2(1, 8) = 5.76$, $MSE = 3.13$, $p = .043$, $\eta_p^2 = .42$].

Transposition errors were significantly less common for frequent-doublet items than rare-doublet items (29.2% vs. 5.6%) [$t_1(35) = 3.66$, $p = .001$; $t_2(8) = 4.15$, $p = .003$]. This result, which was confirmed by the analysis of individual profiles (see Table 2), did not reflect a general

Table 4. *Percentage of different types of spellings produced or chosen in Experiment 3*

	Recall condition			*Recognition condition*		
Type of spelling produced or chosen	*No-doublet item presented*	*Frequent-doublet item presented*	*Rare-doublet item presented*	*No-doublet item presented*	*Frequent-doublet item presented*	*Rare-doublet item presented*
No doublet	**87.5 (22.0)**	38.9 (39.8)	40.3 (33.4)	**75.0 (25.4)**	30.6 (36.4)	27.8 (25.2)
Frequent doublet	4.2 (14.0)	**55.6 (42.7)**	*29.2 (34.6)*	13.9 (22.7)	**63.9 (38.9)**	*31.9 (34.1)*
Rare doublet	8.3 (18.9)	*5.6 (15.9)*	**30.6 (27.5)**	11.1 (21.1)	*5.6 (15.9)*	**40.3 (28.8)**

Note: Spellings produced in recall condition; spellings chosen in recognition condition. Correct spellings are in bold and transposition errors in italics; standard deviations are in parentheses.

trend to use frequent doublets irrespective of the type of item that was presented. Indeed, the number of items spelled with a frequent doublet varied as a function of item type [$F_1(2, 70) = 29.82$, $MSE = 0.32$, $p < .001$, $\eta_p^2 = .46$; $F_2(2, 16) = 17.94$, $MSE = 2.12$, $p < .001$, $\eta_p^2 = .69$], with more frequent doublets used for frequent doublet items (55.6% correct) than rare-doublet items (29.2% transposition errors) and no-doublet items (4.2% addition errors) [$F_1(1, 35) = 39.65$, $MSE = 0.36$, $p < .001$, $\eta_p^2 = .53$; $F_2(1, 8) = 20.26$, $MSE = 2.86$, $p = .002$, $\eta_p^2 = .72$] and more frequent doublets used for rare- than no-doublet items [$F_1(1, 35) = 16.58$, $MSE = 0.27$, $p < .001$, $\eta_p^2 = .32$; $F_2(1, 8) = 13.09$, $MSE = 1.37$, $p = .007$, $\eta_p^2 = .62$].

As in Experiments 1 and 2, the number of omission errors did not vary significantly between frequent- and rare-doublet items. The percentage of omissions was, respectively, 38.9% and 40.3% [$t_1(35) = 0.25$, $p = .80$; $t_2(8) = 0.15$, $p = .89$].

Recognition condition

An ANOVA on the number of selection of correct spellings revealed a main effect of item type [$F_1(2, 70) = 9.43$, $MSE = 4.53$, $p < .001$, $\eta_p^2 = .21$; $F_2(2, 16) = 12.91$, $MSE = 18.11$, $p < .001$, $\eta_p^2 = .62$]. Planned comparisons showed that correct spellings were more often chosen for no-doublet items (75.0%) than for frequent- and rare-doublet items (respectively, 63.9% and 40.3%) [$F_1(1, 35) = 10.30$, $MSE = 0.49$, $p = .003$, $\eta_p^2 = .23$; $F_2(1, 8) = 32.27$, $MSE = 0.63$, $p < .001$, $\eta_p^2 = .80$] and that, among items requiring a doublet, scores were better for frequent- than for rare-doublet items [$F_1(1, 35) = 8.52$, $MSE = 0.47$, $p = .006$, $\eta_p^2 = .20$; $F_2(1, 8) = 7.36$, $MSE = 2.18$, $p = .027$, $\eta_p^2 = .48$]. Indeed, the selection rate of the correct spelling did not differ from chance (1/3) for rare-doublet items, $t(35) = 1.45$, $p = .16$, whereas it was significantly above chance for no-doublet items, $t(35) = 9.86$, $p < .001$, and frequent-doublet items, $t(35) = 4.71$, $p < .001$.

Participants selected more choices that involved transpositions for rare- than for frequent-doublet items (31.9% vs. 5.6%). A t test on the number of transposition errors showed that this difference was significant [$t_1(35) = 3.66$, $p = .001$; $t_2(8) = 4.15$, $p = .003$]. As Table 2 shows, this pattern of results was confirmed in the individual profiles. The prevalence of transposition errors on rare-doublet items did not result from a general preference for spellings that included a frequent doublet, irrespective of the type of item presented. Indeed, the number of selection of spellings with a frequent doublet varied as a function of item type [$F_1(2, 70) = 30.0$, $MSE = 0.30$, $p < .001$, $\eta_p^2 = .46$; $F_2(2, 16) = 43.8$, $MSE = 0.84$, $p < .001$, $\eta_p^2 = .85$], with more choices of spellings with a frequent doublet for frequent-doublet items (63.9% correct) than for rare-doublet items (31.9% transposition errors) and no-doublet items (13.9% addition errors) [$F_1(1, 35) = 42.1$, $MSE = 0.38$, $p < .001$, $\eta_p^2 = .55$; $F_2(1, 8) = 49.7$, $MSE = 1.3$, $p < .001$, $\eta_p^2 = .86$] and more choices of spellings with a frequent doublet for rare- than for no-doublet items [$F_1(1, 35) = 10.1$,

$MSE = 0.23$, $p = .003$, $\eta_p^2 = .22$; $F_2(1, 8) = 24.1$, $MSE = 0.39$, $p = .001$, $\eta_p^2 = .75$]. These results confirm that participants had some memory for which items included a doublet and which did not.

While transposition errors were almost restricted to frequent-doublet items, the number of omissions did not differ between frequent- and rare-doublet items (30.6% vs. 27.8%) [$t_1(35) = 0.53$, $p = .60$; $t_2(8) = 0.32$, $p = .75$].

Discussion

The results of the recall condition were similar to those of Experiment 2. Specifically, participants in this condition had more difficulty recalling spellings that contained rare doublets than spellings that contained frequent doublets or no doublets. They made more transposition errors for rare doublets than for frequent doublets as well. Participants' difficulty with spellings containing uncommon doublets was also obvious in the recognition task. Here, the selection rate of the correct spelling was above chance level for both frequent- and no-doublet items but did not differ from chance for rare-doublet items. However, the chance level performance for rare-doublet items does not mean that participants learned nothing about the spellings. As in Experiment 2, participants chose more rare-doublet spellings when a rare-doublet item had been presented than when it had not been presented. This result, coupled with the fact that spellings that included only single consonants were more often selected when the presented items lacked doublets than when they contained doublets and the fact that spellings that included frequent doublets were more often selected when the presented item contained frequent doublets, show that participants acquired some word-specific knowledge.

GENERAL DISCUSSION

According to the reconstructive view of memory, memory is influenced by the specific item or event that was experienced as well as by general knowledge about a domain (Suprenant & Neath, 2009). In the present study, we show that this reconstructive view of memory, previously studied with respect to such things as stories (e.g., Bartlett, 1932; Bergman & Roediger, 1999) and songs (Hyman & Rubin, 1990), applies to spelling. With frequency of exposure to different types of spellings equated, the degree to which a spelling fitted the graphotactic patterns of the language influenced university students' memory for it.

In our three experiments, nonwords whose spellings varied in conformity to French graphotactic patterns were embedded in texts that participants read for meaning, without intending to learn their spellings. The graphotactic patterns that we investigated were probabilistic in that the spellings included frequent patterns (spellings containing only single consonants and spellings containing a frequent doublet) or less common but still legal patterns (spellings containing an uncommon doublet). We assessed memory in different ways across the three experiments. In Experiment 1, participants spelled the nonwords in order to answer a question about the text, and correct spelling was not emphasized. In Experiment 2 and the recall condition of Experiment 3, the target nonwords were dictated to participants, and they were asked to spell them as written in the texts. In the recognition condition of Experiment 3, participants indicated which of three phonologically plausible spellings corresponded to the spelling in the texts.

In all three experiments, accuracy was higher for spellings that contained only singletons or frequent doublets than for spellings that contained less common but still legal doublets. In the case of word recognition in reading, Grainger and Ziegler (2011) argued that letter combinations that are encountered less often in other words are more diagnostic of the identity of a word, at least when readers are processing words along what they call the coarse-grained route. Spellers, unlike readers, must attend to all of the letters in a word and their positions (Frith, 1980). Even if readers benefit in some ways from less frequent letter combinations, any benefits for spelling due to distinctiveness seem to have been outweighed in our experiments by the difficulty of remembering the uncommon chunks. In future research, it would

be useful to examine whether the situation is different with orthographic patterns that are even more unusual than those used in the present experiments or patterns that are blatantly illegal. It would also be useful to examine whether and how the way in which people read—their use of the coarse-grained and fine-grained routes, in Grainger and Ziegler's terms—influences their memory for spellings.

In all three of our experiments, transposition errors were far more frequent on rare-doublet items (e.g., *tiddunar* misspelled as *tidunnar*) than on frequent-doublet items (e.g., *tidunnar* misspelled as *tiddunar*). Indeed, transposition errors on rare-doublet items represented 90.7% of the transposition errors in Experiment 1, 82.3% in Experiment 2, 83.9% in the recall condition of Experiment 3, and 85.1% in the recognition condition of Experiment 3. Importantly, the pattern of results for transposition errors did not reflect a general trend to use frequent doublets independently of any item-specific knowledge concerning the presence of a doublet in a nonword. The prevalence of transposition errors on rare-doublet spellings, their uncommonness on frequent-doublet spellings, and the fact that spellings including a doublet (frequent or rare) were used far less often for no-doublet items than for frequent- and rare-doublet items suggest that participants sometimes remembered the presence of doubling but not the specific letter that was doubled. Participants reconstructed a spelling based on general graphotactic knowledge about which letters are most likely to double and in which positions. Thus, participants sometimes mistakenly doubled a letter that by virtue of its identity and position often doubles: a frequently doubled medial consonant. Only very occasionally did they double a letter in a position that permits doubling but that does not often double: a rarely doubled medial consonant. Participants never incorrectly doubled a vowel or an initial or final consonant, which never or virtually never double in French.

One difference between the results of the three experiments was that misspellings were more frequent in Experiments 2 and 3 (with lower accuracy for frequent- than for no-doublet items) than in Experiment 1 (with the same level of accuracy for frequent- and no-doublet items.[1] This difference reflects the longer delay between the reading of a nonword and the assessment of spelling knowledge in Experiments 2 and 3. The results suggest that when participants have less word-specific memory, due to a longer delay, they tend to use singletons rather than doublets. This leads them to correctly spell no-doublet items but to omit doublets in frequent- and rare-doublet items. This outcome may reflect another type of general knowledge: that singletons are more common than doublets, even for consonants such as *n* or *t* that double relatively often in French. This knowledge is shown in the fact that the control group of Experiment 2 favoured single-letter spellings, and it influences performance even when word-specific knowledge is available.

Previous studies have assessed people's knowledge about the letter sequences that occur in words and the positions in which they occur by using judgement tasks with isolated nonwords that differ only in their conformity to graphotactic patterns of the language. For example, researchers have asked children to choose the nonword in a pair such as *imose* and *immose* that looks more like a real word (e.g., Danjon & Pacton, 2009). Only a few previous studies, including those of Campbell and Coltheart (1984) and Wright and Ehri (2007), have investigated the possible role of graphotactic knowledge in the learning of new spellings. Our results suggest that it is influential. We extended previous findings by using more than a single item (as in the study by Campbell and Coltheart, 1984), by examining probabilistic

[1]An ANOVA on the number of correct spellings with the variables of experiment (1, 2, and 3) and item type (no, frequent, and rare doublet) using subjects as random variables revealed main effects of experiment and item type and an interaction between experiment and item type (Fs > 4.55, ps $> .001$). The interaction reflected the fact that correct spellings varied as a function of experiment for frequent- and rare-doublet items (Fs > 13.73, ps $> .001$) but not for no-doublet items (ps $> .36$). For both frequent- and rare-doublet items, planned comparisons showed that correct spellings were more common in Experiment 1 than in Experiments 2 and 3 (Fs > 23.72, ps $> .001$), with no difference between Experiments 2 and 3 (ps $> .22$).

graphotactic patterns (as opposed to the virtually all-or-none pattern studied by Wright and Ehri, 2007), and by using a task that closely mirrors the everyday situation of encountering a novel word while reading and attempting to spell it later. Together, the findings of our experiments show that knowledge of graphotactic patterns influences memory for the spelling of different types of words and in different learning and testing situations. Together with the results of previous studies, the findings suggest that the same pattern of results holds in different populations (beginning readers and university students) and different languages (French and English).

The influence of graphotactics on the acquisition of word-specific knowledge that we found in our experiments aligns with previous suggestions that people use their knowledge of graphotactic patterns even when other sources of information would logically suffice to produce correct spellings (e.g., Kemp & Bryant, 2003; Pacton & Deacon, 2008; Pacton, Fayol, & Perruchet, 2005). In English, for example, both children and adults are more likely to correctly spell the noun plural marker /z/ with *s* after a consonant than after a long vowel. Such a difference should not be observed if spellers rely on a rule specifying that plurals are marked with *s* whether they are pronounced with final /s/ or /z/. The difference appears to reflect spellers' knowledge that a sequence such as word-final *bz* is graphotactically illegal.

Our findings about the role of general knowledge in memory for spellings fit well with findings in other domains of memory, including memory for stories (e.g., Bartlett, 1932) and immediate recall of spoken pseudowords (Botvinick & Bylsma, 2005). Across domains, reconstructive processes that rely on regularities in the world often aid memory retrieval. However, these processes can lead to errors when the most probable response is incorrect. The errors are not random but show a bias toward the most likely event. This bias, found in our study with the prevalence of transposition errors on rare-doublet items, is found across domains (e.g., Dell, Reed, Adams, & Meyer, 2000, for language production errors).

Although we have emphasized the role of general knowledge in memory for spellings, our participants acquired some word-specific memory as well. One type of word-specific information that our participants acquired, in many cases, was whether a word contains a doublet. The idea that word-specific memory includes not only the identity of individual letters but also the presence of more abstract features such as doubling has been suggested based on studies of brain-damaged patients, some of whom appear to remember that a particular word contains a doublet but not which letter is doubled. For example, the patients L.B. (Caramazza & Miceli, 1990) and H.E. (McCloskey, Badecker, Goodman-Shulman, & Aliminosa, 1994) made substitution errors that almost invariably involved both members of a doublet (e.g., *sorella* misspelled as *soretta*) and transposition errors in which they doubled the wrong letter (e.g., *sorella* misspelled as *sorrela*). The patients almost never introduced doubling into a word that does not have it. Likewise, F.M. (Tainturier & Caramazza, 1996) produced only one letter of a target pair less frequently on words with double letters (*rabbit* misspelled as *rabit*) than on words without double letters (*basket* misspelled as *baket*). He used an erroneous double letter more frequently on words with double letters (e.g., *rabbit* misspelled *rappit*) than on words without double letters (e.g., *basket* misspelled *bappet*). The patient did not show this pattern of performance for repeated but nonadjacent letter pairs (e.g., *cactus*) or digraphs (e.g., *rocket*). Based on these findings, the researchers proposed that the identity of graphemes is specified independently of information about their quantity.

Rumelhart and Norman (1982) made similar proposals with regard to typing. In their model, each letter is represented by a single node, which must be active in order for the letter to be typed. What the researchers called a doubling schema must be active when a letter is doubled. Activation of the doubling schema at the wrong time yields transposition errors such as *scrren* for *screen*. The competitive queuing model of serial order representation in spelling postulates a similar mechanism (Glasspool & Houghton,

2005; Houghton, Glasspool, & Shallice, 1994). Glasspool and Houghton (2005) applied their model to neuropsychological data, but they noted that data are lacking about whether the errors of brain-damaged patients take account of conventions of the target language, such as the fact that certain letters frequently double whereas others rarely or never do. Our results provide such data for adults without brain damage and suggest that their representations of words' spellings separately encode information about the identity of letters and whether the letters are doubled. It would be worthwhile to carry out similar experiments with children in order to determine when and how such representations develop.

We have argued that memory for spellings, like memory for other things, is influenced by experience with specific items and by general knowledge built from experience with sets of items. That general knowledge is often probabilistic in nature; it is not limited to all-or-none patterns. In spelling, as in other domains, reliance on probabilistic patterns to reconstruct an event can yield systematic errors when that event includes less common patterns. More often, however, it yields correct responses. The errors made by individual people over short delays, as in our study, cause spellings to become more homogeneous, more typical of the system. Errors by many people, over longer delays, may cause permanent changes to a spelling system. Supporting this idea, loan words tend to be adapted over years or centuries to fit the graphotactic patterns of a language. As one example, the original German spelling *Kobalt* changed to *cobalt* after the word began to be used in English and some other languages, initial *c* being more common than initial *k* in these languages. The mechanisms of reconstruction that we observed in our experiment may help to explain such changes. More generally, our findings suggest, viewing spelling in light of modern ideas about learning and memory rather than as a rote process can help us to understand it better.

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APPENDIX A

Nonwords used in Experiments

No-doublet, frequent-doublet, and rare-doublet spellings used in Experiments 1 and 2

bagotin	*bagottin*	*baggotin*
finodus	*finnodus*	*finoddus*
liroban	*lirroban*	*lirobban*
maboron	*maborron*	*mabboron*
pitegure	*pittegure*	*piteggure*
tidunar	*tidunnar*	*tiddunar*

No-doublet, frequent-doublet, and rare-doublet spellings used in Experiment 3

coubatan	*coubattan*	*coubbatan*
coutaban	*couttaban*	*coutabban*
sidaté	*sidatté*	*siddaté*
sitadé	*sittadé*	*sitaddé*
bagotou	*bagottou*	*baggotou*
batogou	*battogou*	*batoggou*
lobanin	*lobannin*	*lobbanin*
lonabin	*lonnabin*	*lonabbin*
tidunar	*tidunnar*	*tiddunar*
tinadur	*tinnadur*	*tinaddur*
fagona	*fagonna*	*faggona*
fanoga	*fannoga*	*fanogga*
maboron	*maborron*	*mabboron*
marobon	*marrobon*	*marobbon*
miduré	*midurré*	*midduré*
mirudé	*mirrudé*	*miruddé*
vagoran	*vagorran*	*vaggoran*
varogan	*varrogan*	*varoggan*

APPENDIX B

Stories used in Experiments

Sample story used in Experiment 1

Tidunnar était un monstre marin redoutable qui, monté sur son rocher, engloutissait l'eau de la mer avec un bruit terrible et la vomissait trois fois par jour. Ce monstre n'avait qu'un œil. Sans doute n'avait-il pas besoin d'un second œil car il ne regardait pas ce qu'il dévorait: il avalait tout sur son passage, sans prêter attention à ce qu'il ingurgitait.

Bien sûr, Tidunnar avait une énorme bouche. Si un navire était pris dans les flots qu'il engloutissait, même l'homme le plus fort sur terre ne pouvait pas résister. Tidunnar habitait dans une profonde caverne d'où il projetait ses six cous terminés par six têtes portant chacune trois rangées de dents avec lesquelles il dévorait tous les êtres vivants et tous les objets qui passaient à sa portée. Il était très difficile de l'éviter.

Six de mes amis furent ses victimes. Nous étions tous les sept à bord du même navire, partis à la recherche de trésors engloutis. Arrivés à proximité du rocher sur lequel était installé le monstre, nous regardions Tidunnar, craignant pour notre vie quand, tout à coup, il emporta mes six amis qui se trouvaient sur la passerelle du navire. Comme je tournais les yeux vers mon navire et mes compagnons, je n'aperçus plus que leurs pieds et leurs mains levés. Ils criaient, m'appelant par mon nom. C'est bien le spectacle le plus pitoyable et le plus terrible qu'aient vu mes yeux pendant toute ma vie de marin.

(Tidunnar was a fearsome sea monster who, having climbed onto his rock, gobbled up the seawater with a terrible noise and vomited it three times a day. This monster had only one eye. Without doubt, he did not need a second eye because he did not look at what he devoured: He swallowed everything in his way, without paying attention to what he swallowed.

Of course, Tidunnar had an enormous mouth. If a ship was in the waves that he swallowed up, even the strongest man on the earth could not resist. Tidunnar lived in a deep cavern from which he stuck out his six necks ending with six heads, each with three rows of teeth, with which he devoured all human beings and objects at hand. He was very difficult to avoid.

Six of my friends were his victims. We were all seven aboard the same ship, looking for buried treasures. When we were close to the rock where the monster was, we looked at Tidunnar, afraid for our life, when suddenly he took away my six friends who were on the ship's bridge. When I looked toward my ship and my companions, I saw only their feet and their hands raised. They were screaming, calling my name. This is the most pitiful and terrible sight I ever saw during my life as a sailor.)

Sample story used in Experiments 2 and 3

Autrefois, les habitants de la campagne se retrouvaient pour le tidunnar, la fête du village. C'était l'occasion de chanter, de danser et de déguster les spécialités de la région. Au tidunnar, la coutume était de s'amuser toute la nuit et d'attendre que le jour se lève pour partager un énorme gâteau au bagotin. Le bagotin est un fruit délicieux que l'on trouvait dans les forêts. Lors d'un tidunnar, une drôle d'histoire est arrivée à Loura, une jeune villageoise curieuse et intrépide qui aimait faire des blagues. La fillette a voulu goûter le gâteau avant la fin du tidunnar parce qu'elle adorait le goût du bagotin. Malheureusement, le gâteau se renversa. La pauvre fillette passa le reste de la nuit à chercher la plante qui donne le bagotin, pour que sa mère prépare un autre gâteau. Finalement, personne ne se rendit compte de rien et le tidunnar se termina comme prévu. Le bagotin fit encore beaucoup d'heureux.

(In the past, the people of the country met for a tidunnar, the party of the village. It was an opportunity to sing, dance, and

savour the specialties of the area. At the tidunnar, people would play all night and wait for dawn in order to share a big cake made with bagotin. Bagotin is a delicious fruit that is found in forests. During a tidunnar, something funny happened to Loura, a young, curious, and intrepid villager who loved playing jokes. This young girl wanted to taste the cake before the end of the tidunnar because she loved the taste of bagotin. Unfortunately, the cake fell over. The poor girl spent the rest of the night looking for the plant that provides the bagotin so that her mother could make a new cake. In the end, nobody noticed anything and the tidunnar finished as anticipated. The bagotin made a lot of people happy.)