Effect of grammatical gender on visual word recognition: Evidence from lexical decision and eye movement experiments

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Lexical decision times and eye movements were recorded to determine whether grammatical gender can influence the visual recognition of isolated French nouns. This issue was investigated by assessing the use of two types of regularities between a noun's form and its gender—namely ending-to-gender regularities (e.g., the final letter sequence *-at* appears only in masculine nouns and, thus, is predictive of masculine gender) and gender-to-ending regularities (e.g., feminine gender would predict the final letter *e*, whereas masculine gender would not). Previous studies have shown that noun endings are used by readers when they have to identify gender. However, the influence of ending-to-gender predictiveness has never been investigated in a lexical decision task, and the effect of gender-to-ending regularities has never been evaluated at all. The results suggest that gender information can influence both the activation stage (Experiments 1 and 3) and the selection stage (Experiments 2 and 3) of the word recognition process.

Grammatical gender is a phenomenon found in many languages, but not much is known about its communicative function. It is not a major subject of research in psycholinguistics, and few data are available on the role of gender in language comprehension. There are two reasons for this. First, rather than being studied in its own right, grammatical gender has generally been used as a tool for addressing other issues, such as anaphor resolution (Arnold, Eisenband, Brown-Schmidt, & Trueswell, 2000; Bates, Marangolo, Pizzamiglio, & Dick, 2001; Cacciari, Carreiras, & Cionini, 1997; Carreiras, Garnham, & Oakhill, 1993; Garnham, Oakhill, Ehrlich, & Carreiras, 1995; McDonald & MacWhinney, 1995; Vigliocco & Zilli, 1999), deficits in aphasia (Akhutina et al., 2001; Blumstein, Milberg, Dworetzky, Rosen, & Gershberg, 1991; Jakubowicz & Goldblum, 1995; Jarema & Friederici, 1994), and the autonomy of the subprocesses involved in visual word recognition (Colé & Segui, 1994; Gurjanov, Lukatela, Lukatela, Savic, & Turvey, 1985). Second, studies using gender have

been interested mainly in its syntactic component (Deutsch, Bentin, & Katz, 1999; Friederici & Jacobsen, 1999), which redundantly marks noun gender on items governed by gender agreement rules (adjectives, articles, personal pronouns, etc.). According to Corbett (1991), the agreement system is the essence of grammatical gender. Gender agreement is thought to facilitate the resolution of pronoun anaphors (Corbett, 1991) and help reinforce syntagmatic cohesion within utterances by pointing to the noun modified by an adjective (Desrochers, 1986; Lyons, 1968; Mel'cuk, 1993). As such, the part played by grammatical gender in language comprehension is generally reduced to its role in the agreement system. But gender also has a lexical component.

The French Gender System

The lexical component assigns every noun to a gender category. The number of genders is not limited to two: "Four is common and twenty is possible" (Corbett, 1991). In many languages around the world, there are obvious semantic principles behind the distinction of genders, at least for part of the lexicon (principles based on physical sex, animacy, and so forth). In Indo-European languages, whose gender systems are based on a division of masculine/feminine or masculine/feminine/neuter, there is a frequent connec-

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tion of grammatical gender and physical sex, but the degree of correspondence between the semantic and the grammatical categories is usually quite weak. In French, for example, each noun is either masculine or feminine. Few can be masculine and feminine, and a category change generally implies a meaning change (e.g., *le mémoire* [memoir]–*la mémoire* [memory]). Gender categorization is partly semantic, since nouns referring to males are generally masculine and nouns referring to females generally feminine (e.g., *le père* [the father]–*la mère* [the mother]). However, semantically motivated gender categories correspond only for 10.5% of French nouns (Séguin, 1969). For the remaining 89.5%, the assignment of a gender category is not based on any general rule (e.g., *le bureau* [the desk]–*la table* [the table]). In French, as in many other languages, gender is a property that appears to show no sign of any systematicity, and generative linguists have often adopted the view that gender is simply a lexical property, which has to be learned.

On the other hand, descriptions of the French noun classification system point out a number of correlations or co-variations between the phonological form of nouns and their grammatical gender. In an extremely detailed study, Tucker, Lambert, and Rigault (1977) looked at correlations between grammatical gender and noun ending. They showed that a noun's ending could be used to correctly determine its gender in 84.5% of the 31,619 noun entries in the *Petit Larousse Dictionary*. Their statistical data described various formal markers, including a word's last phoneme (/tis-y/ or /is-y/) or last two phonemes (/ti-sy/ or /i-sy/). No matter what type of marker is considered, there are always exceptions, sometimes many. The number of exceptions defines the *predictive value* of an ending (PVE) in such a way that the greater the number of exceptions, the lower the predictive value of the ending. For example, the final phoneme /e/ occurs in masculine and feminine nouns in approximately equal proportions in French, so its predictive value is low. As a general rule, the tendency for a given phoneme to occur in nouns of a given gender varies. If we look solely at the last phoneme, regularities that encompass larger phonological units may be masked. For example, the phoneme /ō/ is a poor predictor of the feminine gender (70%; i.e., 30% exceptions). However, if among these, we distinguish the ending /jō/ from /bō/, /rō/, and so forth, the predictive value changes: 91% of the nouns ending in /jō/ are feminine, and 87% of the nouns ending in /bō/, /rō/, and so forth are masculine. Obviously, the more phonemes considered, the greater the predictive value. Most final phonemes are also part of more regular orthographic patterns. Accordingly, if we take the orthographic form of the sole final phoneme into account, the predictive value of an ending can change significantly. For example, the final phoneme /e/, which is an ambiguous predictor of gender, is part of a number of different orthographic sequences, including the sequence –ée, which marks the feminine (92%), and the sequence –er, which marks the masculine (100%). These data suggest that noun endings are likely to provide some gender in-

formation, and one can wonder whether native speakers can use this information in order to determine the gender of new words. The fact that a connectionist network was able to "learn" the gender system for German nouns (MacWhinney, Leinbach, Taraban, & McDonald, 1989; Zubin & Köpcke, 1981) suggests that this is theoretically possible. Moreover, several studies have shown that native speakers of French take ending regularities into account by a very early age and use them to determine the grammatical gender of pseudonouns, as well as real nouns. Karmiloff-Smith (1979) found that native French-speaking 3-year-olds already relied on phonological ending to attribute a gender to pseudowords. Similar results were obtained by Tucker et al. (1977), whose speakers, 7 to 18 years of age, categorized pseudowords in a way that directly reflected the distribution of endings in the two genders. The more regular the relationship between a given final phoneme and a given gender, the greater the number of subjects who attributed that gender to the pseudowords with that ending. For example, 67% of nouns ending in /k/ are masculine, and 65% of the subjects categorized pseudowords with that ending as masculine. Moreover, when the subjects were given the written form of a pseudoword, their responses were found to reflect the predictive value of the orthographic transcription of the final phoneme. For example, 99% of the words whose final phoneme /k/ is spelled –c (as in *floric*) are masculine, and 90% of the subjects attributed masculine gender to such pseudowords. Similarly, the final phoneme /k/, spelled –que (as in *florique*), is ambiguous (55% masculine, 45% feminine), and only 30% of the subjects said that such pseudowords were masculine. Studies on gender categorization of real words have also shown that noun endings can be used as formal gender cues. Desrochers, Paivio, and Desrochers (1989) and Desrochers and Paivio (1990), who presented the written form of isolated nouns to native French speakers and asked them to state the gender, showed that gender was determined faster and more accurately when the noun's ending was predictive of its gender than when it provided little gender information (Desrochers & Paivio, 1990; Desrochers et al., 1989). Similar findings on the effect of ending-based gender predictability on the speed and accuracy of gender categorization were obtained by Bates, Devescovi, Pizzamiglio, D'Amico, and Hernandez (1995) with Italian stimuli presented aurally.

Gender in Visual Word Recognition

Going one step further, one can wonder whether this type of information can be used *on line* in reading situations in order to facilitate word recognition. For example, it could be argued that gender is identified at some point during the recognition process and that lexical search is subsequently restricted to those lexical units marked with that gender. The available empirical evidence concerning this question seems to favor a negative answer. For example, Desrochers et al. (1989; Desrochers & Paivio, 1990) found an effect of the predictive value of endings for the gender categorization task, but not for the naming task,

which suggests that gender can be taken into account only when subjects are explicitly required to determine noun gender. A similar finding was obtained by Bates et al. (1995). But it seems unwise to draw strong conclusions from these null results. So the first aim of the present study was to further examine the role of gender-related orthographic regularities as a function of task requirements in an experiment conducted with another widely used task—namely, the lexical decision task (Andrews, 1989; Balota & Chumbley, 1985; McRae, Jared, & Seidenberg, 1990).

Note that we will be concerned here only with the visual modality. As far as the auditory modality is concerned, an early influence of gender-related regularities is much more problematic. Speech stimuli are delivered over time, and for many words recognition occurs before the ending has had a chance to be processed (Marslen-Wilson & Welsh, 1978). In such circumstances, it can hardly be argued that final phonemes are used to predict the gender of the stimulus. This does not mean that gender cannot influence auditory word recognition (see Akhutina, Kurgansky, Polinsky, & Bates, 1999; Bates, Devescovi, Hernandez, & Pizzamiglio, 1996; Guillelmon & Grosjean, 2001). For example, Grosjean, Dommergues, Cornu, Guillelmon, and Besson (1994) observed earlier recognition points in gating and faster reaction times in lexical decision for nouns preceded by an article marked for gender (e.g., “une joli(e) table,” which means *a pretty table*) than for ones that were not gender marked. In this experiment, gender marking on the article apparently served as a powerful cue to recognition of the subsequent noun, probably by predicting the word ending. In other words, what Grosjean et al. showed is that gender-related regularities can be used in the gender-to-form direction (as opposed to the form-to-gender direction). This distinction will be further discussed in relation to the results of Experiment 2. By contrast, printed words are spatial objects, which means that all letters, including the last ones, are theoretically available for processing at the same time. Such an assumption is inherent in many models of word recognition—in particular, *activation* models (McClelland & Rumelhart, 1981; Paap, Newsome, McDonald, & Schvaneveldt, 1982), which take it for granted that all letter positions simultaneously activate a set of feature, letter, and, ultimately, word units. In this framework, predictive word endings are likely to help determine the stimulus gender before identification is completed (it can be assumed that, at some point during the activation process, most of the activated word units will share the same gender). On the other hand, the notion that all letters are processed in parallel can be questioned. It is a well-known fact that visual acuity rapidly drops off as soon as one moves away from the center of the fovea. As a consequence, the few letters around the fixation point are probably granted an advantage, as compared with letters located farther away (see Pynte, 1996, for a discussion). In other words, it is likely that the initial set of activated word units will be determined as a function of these central letters, rather than the final ones, with gender-related orthographic information

becoming available only at a later stage of the recognition process. This notion will be further discussed in relation to Experiment 3.

EXPERIMENT 1

Experiment 1 used a lexical decision task. The PVE was manipulated. The PVE was based here on gender information conveyed by the orthographic form of the word-final phoneme, whose transcription is usually a bigram. High-predictive endings were bigrams predicting gender with fewer than 30% exceptions (e.g., [un] *briqu-et* [*lighter*]; *-et* appears in masculine nouns in 100% of the cases); low-predictive endings were bigrams predicting gender with more than 30% exceptions (e.g., [un] *sty-le* [*style*]; *-le* appears in masculine nouns in 52% of the cases). The choice of final bigram predictivity was supported by Tucker et al.'s (1977) observations showing that when visual stimuli are used, orthography-based gender information takes precedence over phonology-based gender information. If gender information is used strategically when the reader has to consciously identify the gender of a stimulus, as was stated by Desrochers et al. (1989) and Desrochers and Paivio (1990), no gender information effects should be observed on lexical decision performance. In contrast, the existence of such effects would indicate that grammatical gender is processed and used automatically during isolated noun recognition. A second aim of Experiment 1 was to further examine the role of the PVE for low- versus high-frequency words. The lack of a PVE $\times$ word frequency interaction in Desrochers et al.'s experiments was interpreted as an indication that PVE does not play any role in lexical access. The relevance of this argument can be questioned, however, since the tasks used by Desrochers et al. (gender categorization and naming) were possibly not well adapted for tracking early lexical access processes. It thus seems important to determine whether a different result can be found with a different task—namely, lexical decision. In summary, Experiment 1 manipulated three factors: PVE (low vs. high), word frequency (high vs. low), and gender (masculine vs. feminine).

Method

Subjects. Twenty-three students (ages, 20–35 years) at the University of Nice-Sophia Antipolis, France, participated in the experiment and were given course credit. All were native speakers of French and had normal or corrected-to-normal vision.

Materials. Eighty-eight inanimate nouns were selected, 44 masculine and 44 feminine (see Appendix A). In each set, half of the nouns had a high word frequency (mean frequency: 432 occurrences per million for masculine nouns and 461 for feminine nouns), and the other half had a low word frequency (mean frequency: 9.5 occurrences per million for masculine nouns and 9.8 for feminine nouns), as defined by the computerized French lexical database Brulex developed by Content, Mousty, and Radeau (1990). In each subset, half of the noun endings had a high PVE (mean PVE: .99 for masculine nouns and .95 for feminine nouns), and the other half had a low PVE (mean PVE: .52 for masculine nouns and .52 for feminine nouns), according to Tucker et al.'s (1977) tables. The eight experimental

Table 1
Experiment 1: Mean Lexical Decision Time (in Milliseconds)
and Error Rate (% E) for the Eight Conditions Defined
by Taking All Combinations of Gender, Word Frequency,
and Predictive Value of Ending

Gender	Word Frequency	Predictive Value of Ending			
		Low		High	
		<i>M</i>	%E	<i>M</i>	%E
Masculine	low	715	8	654	4
	high	578	2	558	1
Feminine	low	678	7	697	6
	high	551	1	576	1

conditions defined by taking all combinations of the gender (masculine vs. feminine), word frequency (high vs. low), and PVE (high vs. low) factors were represented by 11 nouns each. The eight sets of nouns were matched for length (mean length: 6.36 [low PVE and frequency], 6 [low PVE and high frequency], 6 [high PVE and frequency], and 6.27 [high PVE and low frequency] for masculine nouns; 5.9 [low PVE and frequency], 6 [low PVE and high frequency], 6 [high PVE and frequency], and 6 [high PVE and low frequency] for feminine nouns) and were controlled for final bigram frequency. Final bigram frequency was defined as the number of lexical units in which a given bigram occurred in the last position, out of the 30,000 lexical units considered (Content & Radeau, 1988).

Procedure. At the start of each trial, a fixation point was displayed in the center of a computer screen. After 200 msec, it was replaced by a stimulus item, which remained on the screen until the subject's response. The subjects were instructed to determine as quickly and as accurately as possible whether the item was a word or a pseudo-word. They responded by pressing the *yes* or *no* button (lexical decision task). The *yes* button was associated with the subject's dominant hand. After a series of 20 practice trials, the experimental materials were presented. The presentation order was randomized for each subject, who saw a total of 140 items (88 test items and 52 word-like pseudowords).

Results

The average lexical decision times on correct responses and the error rates are given in Table 1. Lexical decision times below 300 msec and above 1,300 msec were elimi-

nated from the analyses. They represented 1% of the data. Analyses of variance were performed on correct responses, using subjects (F_1) and items (F_2) as random variables.

The analyses revealed that the only significant main effect was observed for word frequency [$F_1(1,22) = 154$, $p < .0005$; $F_2(1,80) = 119$, $p < .0005$]. Lexical decision times were significantly shorter for high-frequency nouns than for low-frequency ones. The main effects of gender and PVE were not significant [$F_s < 1$, and $F_1(1,22) = 2.21$, $p > .10$, $F_2(1,80) = 1.58$, $p > .10$, respectively]. The interaction between word frequency and PVE was significant [$F_1(1,22) = 4.89$, $p < .05$; $F_2(1,80) = 3.71$, $p = .05$; Figure 1]. Planned comparisons revealed a PVE effect that approached significance when word frequency was low [676 vs. 696 msec for high- and low-PVE low-frequency words, respectively; $F_1(1,22) = 4.87$, $p < .05$; $F_2(1,40) = 2.93$, $p = .09$], whereas no PVE effect was obtained when word frequency was high ($F_s < 1$).

The interaction between gender and PVE approached significance [$F_1(1,22) = 20.04$, $p < .0005$; $F_2(1,80) = 3.64$, $p = .06$; Figure 2]. Planned comparisons revealed that for masculine nouns, lexical decision times were significantly shorter in the high-PVE condition than in the low one [606 vs. 646 msec; $F_1(1,22) = 21.01$, $p < .0005$; $F_2(1,40) = 4.72$, $p < .05$]. Inversely, for feminine nouns, lexical decision times were longer with a high PVE than with a low PVE, but the difference was significant only in the subject analysis [636 vs. 614 msec; $F_1(1,22) = 4.95$, $p < .05$; $F_2 < 1$]. Furthermore, response times were longer for masculine nouns than for feminine ones in the low-PVE condition, although this difference was significant in the subject analysis only [646 vs. 614 msec; $F_1(1,22) = 12.98$, $p < .0025$; $F_2 < 1$], whereas they were longer for feminine nouns than for masculine ones in the high-PVE condition, and the difference approached significance [606 vs. 636 msec; $F_1(1,22) = 11.68$, $p < .005$; $F_2(1,40) = 3.42$, $p = .07$].

The interaction between word frequency and gender was not significant ($F_s < 1$), nor was the interaction be-

Figure 1. Experiment 1: Mean reaction time (in milliseconds) as a function of predictive value of ending (PVE) and word frequency.

Figure 2. Experiment 1: Mean reaction time (in milliseconds) as a function of predictive value of ending (PVE) and gender.

tween the three manipulated factors [$F_1(1,22) = 1.25, p > .10; F_2 < 1$]. The analysis of error rates revealed a significant main effect of word frequency [$F_1(1,22) = 20.04, p < .0005; F_2(1,80) = 17.20, p < .0005$].

The error rate was lower for high-frequency nouns than for low-frequency ones. No other effect was significant [gender, $F_s < 1$; PVE, $F_1(1,22) = 1.92, p > .10, F_2(1,80) = 2.13, p > .10$; word frequency $\times$ PVE, $F_1 < 1, F_2(1,80) = 1.80, p > .10$; gender $\times$ PVE, $F_1(1,22) = 1.60, p > .10, F_2 < 1$; word frequency $\times$ gender, $F_s < 1$; word frequency $\times$ gender $\times$ PVE, $F_s < 1$].

Discussion

The results of this first experiment are consistent with the notion that gender information can be used at some point during lexical access. As was expected, a significant interaction was found between PVE and word frequency, with a PVE effect approaching significance for low-frequency nouns only. For these nouns, lexical decision times were shorter in the high PVE condition than in the low one (676 vs. 696 msec). This result contradicts those obtained by Desrochers et al. (1989) with a gender categorization task, as well as those of Bates et al. (1995) obtained with a repetition task. Following Desrochers et al.'s (1989; Desrochers & Brabant, 1995; Desrochers & Paivio, 1990) line of reasoning, one can thus conclude that the predictive value of word endings exerts its influence during the word recognition process. In order to explain the lack of the PVE effect in the high-frequency condition, it could be argued that recognition was too fast in this case for the PVE to be taken into account. Colé, Magnan, and Grainger (1999) used a similar argument to account for the finding that phonological factors did not seem to affect recognition time in the case of high-frequency words, as opposed to low-frequency words.

The results also revealed an interaction between gender and PVE. Lexical decision times were shorter for masculine items with a high PVE than for masculine items with

a low PVE, whereas PVE exerted little influence for feminine items. This pattern of results can probably be better understood if one assumes that the cue to gender used by the subjects was not the whole ending (e.g., the final bigram corresponding to the orthographic transcription of the last phoneme), as was expected, but rather the last letter in the word. As was mentioned above, the feminine nouns we used all ended in *e*, a letter that supplies little information about gender on its own. Among nouns ending in *e* in French, 42% are masculine and 58% are feminine, so *e* has a low predictive value. On the other hand, endings predictive of the masculine gender generally end in a letter other than *e*. The fact that a word ends in a letter other than *e* is thus predictive of the masculine gender (among nouns without a final *e*, 80% are masculine). In summary, for most masculine nouns and for the masculine nouns we used, the ending (last bigram) and the last letter have similar predictive values (either low or high). Inversely, for most feminine nouns and for the feminine nouns we used, regardless of their PVE, the last letter is always nonpredictive. In order to investigate the role of the final letter (either *e* or a letter different from *e*) as a possible cue to gender, we conducted an experiment in which all items, including masculine ones, ended in *e*. If the unit readers use as a gender cue is the last letter, rather than a phonemic/orthographic unit corresponding to the final bigram, PVE effects on masculine nouns should disappear.

EXPERIMENT 2

In this experiment, all masculine and feminine nouns ended in *e*. This letter in final position has a low predictive value because it occurs equally often in feminine and masculine nouns (in 58% and 42% of the cases, respectively). Thus, if a noun's last letter is the intralexical cue to gender used by French readers, one could assume that no PVE effects would be observed in this second experiment. On the other hand, if such effects were still ob-

tained, this would suggest that larger units are used as a cue to gender.

Method

Subjects. Twenty-eight students (ages, 20–35 years) at the University of Nice-Sophia Antipolis, France, participated in the experiment. All were native speakers of French and had normal or corrected-to-normal vision.

Materials. Thirty-two inanimate nouns were selected (16 masculine and 16 feminine), all ending in the nonpredictive letter *e* (see Appendix B). In each set, the nouns were divided into two equal subsets: one with high predictive value of the final bigram (mean PVE: .93 for masculine nouns and .93 for feminine nouns) and one with low predictive value of the final bigram (mean PVE: .51 for masculine nouns and .50 for feminine nouns) according to Tucker et al.'s (1977) tables. The two factors, gender (masculine vs. feminine) and PVE (low vs. high), determined four categories, each represented by 8 nouns. The four sets of items were matched for length (mean length: 6.8 characters for masculine–low-PVE, 6 for masculine–high-PVE, 6.5 for feminine–low-PVE, and 6.6 for feminine–high-PVE) and for word frequency (mean word frequency: 9.8 occurrences per million for masculine–low-PVE, 10 for masculine–high-PVE, 10 for feminine–low-PVE, and 10.6 for feminine–high-PVE). Bigram frequency was again controlled using Content and Radeau's (1988) tables (mean bigram frequency: 2,469 for masculine–low-PVE, 2,379 for masculine–high-PVE, 2,494 for feminine–low-PVE, and 3,288 for feminine–high-PVE).

Procedure. The procedure was the same as that in the preceding experiment (lexical decision task). A series of 20 practice items were presented before the experimental materials. The stimulus presentation order was randomized for each subject, who saw a total of 104 items. There were 32 test items and 72 fillers: 40 pseudonouns, and 32 nouns ending with a letter other than *e* to avoid strategies based on list content.

Results

Average lexical decision times on correct responses, and error rates are given in Table 2. Lexical decision times below 300 msec and above 1,300 msec were eliminated from the analyses. They represented 1.4% of the data. Analyses of variance were performed using subjects (F_1) and items (F_2) as random variables.

The main effect of PVE was not significant [$F_1(1,27) = 1.05, p > .10$; $F_2 < 1$], whereas the main effect of gender was significant in the subject analysis [$F_1(1,27) = 23.37, p < .005$; $F_2(1,28) = 1.48, p > .10$]. Lexical decisions were shorter for feminine nouns than for masculine ones. The interaction between gender and PVE was not significant ($F_s < 1$). An analysis of the error rates yielded a main effect of PVE that approached significance [$F_1(1,27) = 28.79, p < .00025$; $F_2(1,28) = 3.25, p = .08$] and a main effect of gender, significant in the subject analysis [$F_1(1,27) = 17.67, p < .001$; $F_2(1,28) = 1.58, p > .10$]. The subjects made more errors on nouns with a high PVE than on nouns with a low PVE and on masculine nouns than on feminine ones. The interaction between these two factors was also significant in the subject analysis [$F_1(1,27) = 18.18, p < .005$; $F_2(1,28) = 2.1, p > .10$]. Planned comparisons revealed that the PVE effect approached significance for masculine nouns [$F_1(1,27) = 39.70, p < .0001$; $F_2(1,14) = 4.24, p = .06$], but not for feminine ones [$F_1(1,27) = 1.00, p > .10$; $F_2 < 1$].

Table 2
Experiment 2: Mean Lexical Decision Time (in Milliseconds)
and Error Rate (% E) for the Four Conditions Defined
by Taking All Combinations of Gender and Predictive Value
of Ending (Last Letter = e)

Gender	Predictive Value of Ending			
	Low		High	
	<i>M</i>	%E	<i>M</i>	%E
Masculine	635	4	624	17
Feminine	599	4	590	6

Discussion

The results showed that when the last letter was not predictive of the noun's gender, the predictive value of the noun's final bigram no longer influenced response times. Moreover, the error data yielded a reverse PVE effect for masculine nouns, with *more* errors when the noun ending (last bigram) was predictive of gender than when it was not. This finding may be the consequence of some kind of interference between the last letter and the last bigram in gender prediction. It is important to note, from this point of view, that the probability that a masculine noun will end with a final *e* is low. Even though the final *e* is not predictive of the feminine gender (as was indicated above, it is present in masculine and feminine nouns in nearly equal proportions), it is, in fact, typical of feminine nouns (73% of the feminine nouns actually end in the letter *e*, whereas 67% of the masculine nouns end in a letter other than *e*). In other words, the presence versus the absence of the letter *e* at the end of a given noun is relatively predictable, once the gender of this noun has been determined. This somehow paradoxical peculiarity of French orthography might have caused the interference effects mentioned above and could also explain why feminine items were apparently easier to identify than masculine ones. The latter effect can be interpreted in terms of last-letter predictability. Remember that all items, including masculine ones, ended in the letter *e* in Experiment 2, which means that last-letter predictability was high for feminine items and low for masculine ones, whatever the PVE.

In summary, the results of Experiment 2 suggest that two types of orthographic regularities associated with gender are likely to influence lexical decision times, the first one operating in the ending-to-gender direction (predicting gender from ending), and the second one in the gender-to-ending direction (predicting the last letter from gender). The aim of Experiment 3 was to further investigate the role of these two types of regularities in word recognition. Whereas ending-to-gender predictability (e.g., PVE) could, in principle, operate at a relatively early stage of lexical access (e.g., by reducing the set of lexical candidates to those belonging to the gender category predicted by the stimulus ending; see Bates et al., 1996, Schriefers, Friederici, & Rose, 1998, Tanenhaus, Dell, & Carlson, 1987, and more recently, Dahan, Swingle, Tanenhaus, & Magnuson, 2000, for discussions of this notion), gender-to-last letter predictability cannot enter into play

before gender has been determined, which probably means once the word has been fully identified. In this view, the locus of the effects found in Experiment 2 is probably to be looked for in some kind of postaccess verification stage, without any relevance vis-à-vis normal word recognition.

Although this might be true as far as isolated words are concerned, last-letter predictability is likely to play a role in connected reading, whenever the gender of a word can be predicted by the preceding context. French nouns are usually preceded by a gender-marked determiner (e.g., the articles *le* or *la* for masculine and feminine items, respectively), which means that gender is usually available in advance (e.g., before the eye has reached the noun), so that the last letter can in fact be predicted before recognition is completed. A third experiment was thus conducted, with the aim of analyzing how the two types of gender-related orthographic regularities identified in Experiment 2 (namely, PVE and last-letter predictability) influence lexical access processes when gender information is provided in advance by a gender-marked determiner.

EXPERIMENT 3

In Experiment 3, each item was preceded by the definite article *le* or *la*, depending on its gender. Again, high- and low-PVE feminine and masculine words were presented. As in Experiment 1, all feminine items, as well as low-PVE masculine items, ended in a final *e*. Only high-PVE masculine items ended in a letter different from *e*. In order to get a more precise idea concerning the locus of gender effects in this type of situation, an eye-tracking procedure was used. Eye movement analysis, unlike the more traditional measures of word recognition, allows for the possibility of mapping the time course of processing by way of a succession of fixations (Pynte, Kennedy, & Murray, 1991). If orthographic regularities are used during lexical access, gender-related effects can be expected to occur on early measures of visual inspection (e.g., first-fixation durations). By contrast, if orthographic regularities are exploited during a postaccess verification stage, gender effects should show up on later measures (e.g., refixation probability; see Pynte, 1996, for a discussion).

Method

Subjects. Twenty students (ages, 20–30 years) at the University of Provence participated in the experiment. All were native speakers of French and had normal, uncorrected vision.

Materials. Twenty masculine and 20 feminine inanimate nouns were selected (see Appendix C). In each set, half of the noun endings were highly predictive of the noun's gender (mean PVE: .99 for masculine nouns and .90 for feminine nouns), and the other half had a low predictive value, according to Tucker et al.'s (1977) tables (mean PVE: .52 for masculine nouns and .50 for feminine nouns). As in the first experiment, nouns in the masculine–low-predictive condition and nouns in both feminine conditions ended in *e*, whereas nouns in the masculine–high-predictive condition ended with a letter other than *e*. The four experimental conditions defined by taking all combinations of the gender (masculine vs. feminine) and PVE (low vs. high) factors were represented by 10 nouns each. The four

sets of nouns were matched for length (mean length: 6.6 for low-PVE masculine nouns, 6.4 for high-PVE masculine nouns, 6.3 for low-PVE feminine nouns, and 6.6 for high-PVE feminine nouns), word frequency (mean frequency: 101 occurrences per million for low-PVE masculine nouns, 100 for high-PVE masculine nouns, 100 for low-PVE feminine nouns, and 103 for high-PVE feminine nouns), and final bigram frequency, on the basis of Content and Radeau (1988) (mean frequency: 1,805 for low-PVE masculine nouns, 2,024 for high-PVE masculine nouns, 1,984 for low-PVE feminine nouns, and 2,129 for high-PVE feminine nouns). The stimulus presentation order was randomized for each subject, who saw a total of 90 items, 40 test items and 50 fillers (pseudonouns). Each item was presented with the article *le* or *la* (masculine and feminine forms of *the*) that agreed in gender with the item when it was a noun.

Procedure and Apparatus. During the experiment, the subject's head was held in place with adjustable head- and chinrests. Eye movements were monitored by a standard spectacle-mounted infrared limbus tracking device. Output from the horizontal detectors of the right eye was sampled every 5 msec by an OPUS 386 PC computer. The eye-tracking system was aligned and calibrated for each subject. The subjects were asked to look, in turn, at five points, the third of which was located in the center of the area to be occupied by the stimuli. A calibration phase was repeated every four trials. Stimuli (article + letter sequence) appeared centered on a computer screen, and the subjects had to indicate whether or not the letter sequence was a word by pressing one of two response buttons (lexical decision task). Each stimulus was preceded by a fixation point. When the subject first pressed the button, the fixation point was replaced by an item. The fixation point was located where the blank between the article and the target word would appear. Ten practice stimuli were presented before the experimental materials.

Results

As was mentioned above, the stimuli were presented in such a way that the blank between the article and the target noun coincided with the location of a preceding fixation point. The first fixation on the stimulus was thus expected to occur on the blank. This was not always the case, however. The first fixation sometimes occurred slightly to the left or right of the expected position. To eliminate any bias, all deviations above one character were eliminated from the analyses. These cases represented 7.8% of all the trials. Typically, the pattern of inspection recorded on a stimulus included a relatively quick saccade (mean latency: 195 msec) that took the eye to a position located approximately at the middle of the noun (position 2.7 from the noun beginning, on average). Seven percent of the trials did not involve such an initial rightward saccade and were excluded from the analyses. At that point, different cases can be distinguished, according to whether the eye moves or not (multifixation vs. single-fixation strategy), exits the noun or not (inspection of the article vs. noun refixation), or goes leftward or rightward (regressive vs. progressive refixation of the noun). The influence of gender and PVE at each of these decision points was analyzed in terms of probability and saccade latency. The results are summarized in Table 3.

Probabilities. The single-fixation strategy represented 37% of the cases, on average. This proportion did not vary significantly as a function of any of the experimental factors (all F s < 1). When a second saccade was observed on the stimulus (which occurred in 63% of the remaining

cases), the probability that the following fixation would be located on the article rather than on the noun was .40, on average. This probability varied as a function of the noun properties—namely, gender and PVE. The interaction between gender and PVE was marginally significant [$F_1(1,19) = 6.51, p = .02$; $F_2(1,36) = 3.00, p = .09$]. Planned comparisons indicated that the probability of observing a saccade toward the article was not affected by PVE for masculine nouns [$F_1(1,19) = 1.17, p > .10$; $F_2(1,18) = 1.36, p > .10$]. For feminine nouns, this probability was higher for the low-PVE condition than for the high-PVE condition. But this difference was significant for the subject analysis only [$F_1(1,19) = 5.90, p = .02$; $F_2(1,18) = 1.65, p > .10$]. The main effects of gender and PVE were not significant ($F_s < 1$). When the second saccade recorded on the stimulus was directed toward the noun, the probability that the following fixation would be at the noun ending rather than at the noun beginning was .55, on average. This probability varied as a function of the properties of the noun ending (high vs. low PVE), with more rightward refixations for the high-PVE condition than for the low-PVE condition. This was true for both feminine and masculine nouns. The main effect of PVE was significant [$F_1(1,19) = 5.97, p = .02$; $F_2(1,36) = 13.30, p = .001$]. The interaction between PVE and gender was nonsignificant ($F_s < 1$), as was the main effect of gender ($F_s < 1$).

Saccade latencies. When the second saccade was directed toward the article, saccade latencies were not significantly affected by any of the factors manipulated in the experiment (all $F_2s < 1.50$). The situation was different for noun refixations. Rightward-saccade latencies (refixation of the noun ending) were shorter for masculine nouns than for feminine nouns [$F_1(1,19) = 11.44, p < .003$; $F_2(1,36) = 3.72, p = .06$, for the main effect of gender]. No other significant effect was revealed by the analysis of variance (all $F_s < 1$ or close to 1). As far as leftward saccades are concerned (refixations of the noun beginning), the analysis of variance revealed a marginally significant interaction between gender and PVE [$F_1(1,19) = 6.08, p = .02$; $F_2(1,36) = 2.48, p > .10$]. Saccade latency was not affected by PVE for feminine nouns ($F_s < 1$) but was significantly shorter in the low-PVE condition than in

the high-PVE condition for masculine nouns [$F_1(1,19) = 29.80, p = .0001$; $F_2(1,36) = 4.45, p = .05$]. The main effects of gender and PVE were not significant (F_1 and F_2 close to 1 for the main effect of gender; $F_2 < 2$ for the main effect of PVE).

Duration of the subsequent fixation. Table 3 also indicates the duration of the *subsequent fixation* (third column), which corresponds to the total time spent on the noun (single-fixation strategy), to the duration of the fixation made on the article (article inspection strategy), or to the duration of the second fixation made on the noun (beginning- and ending-refixation strategies). None of these measures was affected by the noun properties (all $F_2s < 1$ or close to 1).

Discussion

The PVE was thus found to influence within-word inspection strategies: The probability of inspecting the word ending was higher for high-PVE items than for low-PVE ones. The effect was present for both feminine and masculine items (no significant gender $\times$ PVE interaction), although the difference was greater in the masculine condition (.72 vs. .55 for high-PVE and low-PVE masculine items, respectively, as compared with .58 vs. .53 for feminine items). Interestingly, rightward-saccade latencies were shorter for masculine items, as a whole, as compared with feminine ones, which suggests that the triggering mechanisms were possibly different (remember that both high- and low-PVE feminine items ended in the letter *e*, whereas the final letter was different for high- and low-PVE masculine items). Conversely, more leftward within-word saccades (i.e., saccades directed toward the noun beginning) were observed in the low-PVE condition than in the high-PVE condition, and again, the difference was greater for masculine items than for feminine ones. However, a significant gender $\times$ PVE interaction was found for saccade latencies in this case. When the refixation saccade was directed toward the word beginning, its latency was *longer* for high-PVE masculine items than for low-PVE masculine items (no difference between the two feminine conditions), which suggests that leftward within-word saccades were in the “wrong direction” for high-PVE masculine items.

Table 3
Experiment 3. Saccade Latency (Lat.; in Milliseconds), Probability of Inspection Strategies (Pb.), and Subsequent Fixation Duration (Dur.; in Milliseconds) as a Function of Gender and Predictive Value of Ending

Predictive Value of Ending	Single-Fixation (vs. Multifixation) Strategy		Multifixation Strategies								
			Article Refixation (vs. Noun Refixation)			Noun Refixation					
	Beginning Refixation					Ending Refixation					
	Pb.	Dur.	Lat.	Pb.	Dur.	Lat.	Pb.	Dur.	Lat.	Pb.	Dur.
Masculine											
Low	.36	423	344	.48	155	239	.45	226	266	.55	243
High	.37	377	366	.54	166	296	.28	190	249	.72	226
Feminine											
Low	.40	421	311	.53	174	255	.47	229	306	.53	230
High	.36	408	324	.40	158	267	.42	220	292	.58	228

The predictive value of word endings also exerted an influence on the probability of inspecting the article. As far as feminine items are concerned, this probability was lower in the high-PVE condition—that is, when the gender of the article was consistent with the gender predicted from the word ending. No such difference showed up for masculine items, however, which, again, can probably be attributable to the fact that the last letter was different from *e* for the high-PVE masculine condition. The processing of high-PVE masculine items apparently involved the inspection of both the word ending *and* the article, whereas fewer article-directed saccades were recorded for high-PVE feminine items. This difference between feminine and masculine items, in the high-PVE condition, can be interpreted in terms of last-letter predictability. More precisely, it can be argued that gender-to-orthography checking mechanisms were easier to achieve in the feminine condition. Predicting the presence of a specific letter (namely, *e*) in the feminine case was probably easier than predicting the absence of the letter *e* (any letter but *e*) in the masculine case.

GENERAL DISCUSSION

The main issue addressed in the experiments reported in this paper concerned the processing of gender during visual word recognition. This question was examined by looking at how regularities in the noun classification system of French affect lexical decision speed and accuracy and eye inspection strategies. The results, as a whole, revealed an effect of noun classification regularities during the processing of nouns with an arbitrary gender, even though the task requested of the subjects (lexical decision) did not require them to process this kind of information. For example, Experiment 1 revealed an interaction between the PVE and lexical frequency. For low-frequency items, lexical decision times were shorter when the word ending was a good predictor of its gender than when it was not (no significant difference in the case of high-frequency items). The gender information conveyed by a noun ending thus seems to have an impact on lexical access, at least as far as low-frequency words are concerned. This first result seems inconsistent with the hypothesis put forward by Desrochers et al. (1989; Desrochers & Paivio, 1990) and Bates et al. (1995) that gender information is processed only when the requested task focuses specifically on this kind of processing.

Experiment 1 also revealed an interaction between gender and PVE, with shorter lexical decision times for high-PVE masculine items than for the other three types of items. This pattern of results was interpreted as an indication that the last letter, rather than the whole ending (e.g., the last bigram), was possibly used as the cue to gender in Experiment 1, since the only condition in which the last letter was different from *e* was apparently granted an advantage. The importance of the last letter was confirmed by Experiment 2, in which all the items, either masculine or feminine and either high- or low-PVE, ended in the letter

e. The predictive value of word endings no longer had any effect when the identity of the last letter was maintained constant in this way. A main effect of gender was found instead, with shorter lexical decision times for feminine items than for masculine ones. The latter finding led us to suspect that the letter *e* could play a special role when located at the end of a feminine noun. Gender-related orthographic regularities can, in fact, be considered from two distinct points of view. A noun's ending can be used to predict its gender with more or less certainty (orthography-to-gender direction), and conversely, its gender can be used to predict its last letter (gender-to-orthography direction). This distinction is important because it can provide an insight into the time course of lexical access processes. Orthography-to-gender regularities are likely to operate at a moment at which gender is not yet determined (i.e., probably before identification is completed), whereas gender-to-orthography regularities can operate only once gender has been determined—that is, either after the word has been fully identified or during some late stage of the recognition process. By examining which of these two types of regularities underlies gender effects, it should thus be possible to shed some light regarding the moment at which gender is taken into account during word recognition. For example, in the framework of the activation-verification model (Paap et al., 1982), word recognition is viewed as the result of two successive stages—namely, an initial *activation* stage, during which a set of lexical candidates is activated on the basis of perceptual and contextual information, and a subsequent *selection* stage, during which the candidate that best matches the stimulus is eventually selected. Gender could theoretically enter into play at both of these stages. For example, it could be argued that the set of initial lexical candidates is restricted to a single gender, either feminine or masculine, as a function of orthographic and contextual information (e.g., gender information conveyed by the word ending and the preceding context, if any; see Bates et al., 1996, and Schriefers et al., 1998, for similar interpretations) and that the stimulus ending is subsequently checked for last-letter compatibility during the selection stage.

The locus of gender effects was further examined in an eye-tracking experiment. As in the two preceding experiments, high- and low-PVE feminine and masculine nouns were presented. Gender-to-last-letter predictability was maintained constant for feminine items (all feminine items ended in the highly predictive letter *e*) but was different for masculine items. Whereas low-PVE masculine items ended in the letter *e* (low last-letter predictability), high-PVE masculine items ended in a letter different from *e* (high last-letter predictability). Contextual gender information was provided by the presence of the definite article *la* (feminine) for feminine items or *le* (masculine) for masculine items. The first fixation was forced onto the blank between the article and the noun. The results indicated that this first fixation was relatively short and was immediately followed by a saccade that took the eye to a convenient viewing position within the noun. This enter-

ing saccade was typically followed by a second one, taking the eye to the noun ending, the noun beginning, or the article. The latency and location of this second saccade were affected by the stimulus properties manipulated in the experiment.

Most important, a main effect of PVE was found for the probability of making a refixation toward the word ending. When the noun-final bigram was predictive of gender, the probability that the eyes would move toward that ending, rather than toward the word beginning, was greater than when the final bigram was nonpredictive. The fact that a main PVE effect, rather than a gender $\times$ PVE interaction, was found suggests that the gender-related orthographic regularities manipulated in the experiment exerted their influence in the orthography-to-gender direction, rather than in the gender-to-orthography direction. The effect apparently was due to the possibility of predicting gender from word ending, a mechanism likely to operate at a moment when gender is not yet determined. If the determining factor was the predictability of the last letter, an interaction between gender and PVE would have been observed, since the last letter of feminine nouns was always predictable, whereas the last letter of masculine nouns was predictable only in the high-PVE condition. From this result, it could thus be tempting to conclude that the locus of the effect has to be looked for in an early stage of lexical access (e.g., the activation stage of the activation-verification model).

This conclusion must be considered with caution, however. First, it should be noted that the effect in question was found for a relatively late measure of visual inspection—namely, the probability of making a refixation toward the noun ending. There is, in fact, no direct evidence in the data that gender exerted any influence during the early stages of lexical access. Second, the above conclusion was based on the absence of a PVE $\times$ gender interaction, and it must be admitted that the data were not clear-cut from this point of view. Although no significant interaction was found, the PVE effect was, in fact, stronger for masculine than for feminine items. Moreover, a significant gender $\times$ PVE interaction was found for leftward saccades, directed either toward the noun beginning (longer latencies for high-PVE than for low-PVE masculine items, no difference for feminine items) or toward the article (lower probability for high-PVE than for low-PVE feminine items, no difference for masculine items). The finding that PVE played differently for feminine and masculine items, as far as leftward saccades are concerned, suggests that some kind of checking mechanism, probably triggered by the presence of the article, was involved in this case.

A similar checking mechanism possibly was responsible for the main effect of the PVE found for rightward refixations. For example, it could be argued that gender was initially determined on the basis of the article and that refixations were subsequently triggered in order to check the word ending for compatibility. Note that such an interpretation would not necessarily mean that gender information is of no use for lexical access. First of all, it should be noted

that the presence of determiners is mandatory in French. This means that native speakers of French are continuously confronted with many co-occurrences of a given noun and a given article, and it would not be surprising that stored associations between nouns and articles contribute to gender processing during reading. Desrochers et al. (1989; Desrochers & Brabant, 1995; Desrochers & Paivio, 1990) went even further, since they suggested that gender information is actually represented in the mental lexicon in the form of an association between nouns and determiners. In this view, checking the article and/or the word ending for gender compatibility can be considered as a normal processing step whenever an article + noun sequence is presented. In favor of their hypothesis, Desrochers et al. pointed out that native speakers of French usually have more trouble determining the gender of certain nouns that begin with a vowel and, thus, require a *neutral* determiner (e.g., *l'* or *mon* [*the* and *my*]), used before both masculine and feminine nouns) than for nouns that start with a consonant (Arrivé, Gadet, & Galmiche, 1985; Desrochers & Brabant, 1995; Desrochers & Paivio, 1990; Desrochers et al., 1989). Moreover, when asked to state gender by answering *un* or *une* (masculine and feminine forms of the indefinite article *a*), native French speakers always respond faster than when asked to choose between *masculine* and *feminine* (Desrochers & Brabant, 1995; Desrochers & Paivio, 1990; Desrochers et al., 1989).

In conclusion, although the noun classification system of French is described as arbitrary, it exhibits a number of regularities between noun endings and gender. The results obtained here suggest that French speakers are capable of detecting these regularities and putting them to work in recognizing nouns. Our results suggest that at least in the written language, French readers have acquired a body of multiply interconnected gender information encoded in the lexicon that involves different levels of language organization, including the sublexical level (which is the predictive value of the ending), the lexical level (the gender category), and the morphosyntactic level (the relationship between articles and nouns).

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APPENDIX A
Experiment 1: Materials

Low-Frequency Nouns	Word Frequency	PVE	Bigram Frequency	High-Frequency Nouns	Word Frequency	PVE	Bigram Frequency
Masculine							
Microbe	16.47	60	227	principe	420.99	45	227
Glaive	14.79	31	416	fleuve	151.18	31	31
Cloporte	2.83	63	4,682	miracle	162.99	52	4,682
Dialecte	3.40	63	4,682	exemple	676.47	52	4,442
Socle	11.92	52	4,442	texte	213.40	63	4,682
Saule	19.89	52	4,442	geste	647.91	63	4,682
Dédale	8.64	52	4,442	sable	171.18	52	4,442
Puzzle	2.83	52	4,442	style	186.20	52	4,442
Périple	3.18	52	4,442	siècle	538.26	52	4,442
Concile	7.27	52	4,442	article	245.24	52	4,442
Grade	17.83	31	1,591	monde	2,735.05	31	1,591
Cadran	13.07	99	371	roman	303.13	99	371
Bambou	7.62	97	251	genou	246.71	97	251
Calepin	4.76	99	1,312	portrait	171.52	100	447
Clavecin	6.47	99	1,312	chemin	565.91	99	1,312
Civet	2.83	100	917	jardin	400.40	99	1,312
Béret	13.53	100	917	objet	862.35	100	917
Galet	15.11	100	917	billet	114.30	100	917
Cornet	12.94	100	917	regret	147.51	100	917
Beignet	4.20	100	917	projet	295.75	100	917
Gobelet	9.44	100	917	paquet	116.23	100	917
Briquet	11.82	100	917	cabinet	124.54	100	917
Feminine							
Harpe	13.63	55	429	troupe	301.76	55	429
Ogive	7.38	69	416	preuve	220.21	69	416
Secte	16.71	37	4,682	carte	200.64	37	4,682
Comète	8.98	37	4,682	route	642.01	37	4,682
Fiole	11.36	48	4,442	école	277.99	48	4,442
Pilule	5.11	48	4,442	table	679.20	48	4,442
Cabale	5.32	48	4,442	étoile	246.26	48	4,442
Sandale	10	48	4,442	parole	777.59	48	4,442
Boussole	6.36	48	4,442	méthode	218.40	69	1,591
Horde	10.45	69	1,591	période	182.78	69	1,591
Tornade	7.16	69	1,591	attitude	315.78	69	1,591
Orgie	13.29	98	2,862	pluie	240.35	98	2,862
Toupie	6.71	98	2,862	série	133.88	98	2,862
Hostie	14.33	98	2,862	théorie	170.96	98	2,862
Poulie	8.53	98	2,862	énergie	204.06	98	2,862
Momie	8.53	98	2,862	industrie	115.67	98	2,862
Dièse	5.56	92	2,892	crise	200.70	92	2,892
Clause	12.49	92	2,892	chaise	218.40	92	2,982
Écluse	13.74	92	2,892	phrase	468.07	92	2,982
Punaise	8.64	92	2,892	chose	3,715.24	92	2,982
Ardoise	15	92	2,892	église	466.60	92	2,982
Ventouse	4.87	92	2,892	analyse	180.40	92	2,982

Note—PVE, predictive value of ending.

APPENDIX B
Experiment 2: Materials

Masculine Nouns	Word Frequency	PVE	Bigram Frequency	Feminine Nouns	Word Frequency	PVE	Bigram Frequency
Gnome	1.90	92	2,178	biscotte	1.50	96	4,682
Adage	2.30	94	2,580	cassette	2.40	96	4,682
Bocage	2.50	94	2,580	douille	2.60	83	4,442
Marasme	3.30	92	2,178	nacelle	3.80	90	4,442
Arôme	10.70	92	2,178	calorie	5.00	98	2,862
Potage	8.98	94	1,580	denrée	11.90	92	1,168
Diplôme	14.33	92	2,178	fusée	26.40	92	1,168
Fromage	36.00	94	2,580	écurie	31.60	98	2,862
Girofle	1.50	52	4,442	escalope	1.80	55	429
Poulpe	1.60	45	429	valve	1.90	69	416
Horoscope	2.80	45	429	belote	2.60	37	4,682
Dialecte	3.40	63	4,682	timbale	4.40	48	4,442
Trèfle	7.20	52	4,442	tulipe	8.70	55	429
Glaive	14.80	31	416	soucoupe	8.30	55	429
Microbe	16.50	60	227	secte	16.70	37	4,682
Pacte	31.15	63	4,682	épingle	37.30	48	4,442

Note—PVE, predictive value of ending.

APPENDIX C
Experiment 3: Materials

Masculine Nouns	Word Frequency	PVE	Bigram Frequency	Feminine Nouns	Word Frequency	PVE	Bigram Frequency
Globe	41.39	60	227	rubrique	7.38	45	3,628
Microbe	16.47	60	227	fresque	15.70	45	3,628
Proverbe	18.42	60	227	lessive	17.72	69	429
Groupe	373.88	45	429	digue	26.60	42	3,628
Fleuve	151.18	31	416	cravate	51.28	37	4,682
Tumulte	47.19	63	4,682	tempe	51.18	55	429
Peigne	16.26	39	3,651	grève	61.18	69	416
Masque	95.53	55	3,628	formule	171.18	48	4,442
Colloque	7.16	55	3,628	preuve	220.21	69	416
Miracle	162.99	52	4,442	faute	394.95	37	4,682
Boniment	10.21	99	3,249	faïence	13.64	85	2,440
Soutien	16.92	99	1,955	calomnie	16.26	98	2,862
Tilleul	25.35	99	145	cheville	23.42	90	4,442
Gilet	30.48	100	917	fusée	26.39	92	1,168
Coussin	35.43	99	1,312	marée	43.77	92	1,168
Ruban	55.27	99	371	bougie	47.75	98	2,862
Climat	66.66	99	147	galerie	62.61	98	2,862
Talent	103.61	99	3,249	paille	90.64	90	4,442
Quartier	224.10	100	6,602	bataille	242.51	90	4,442
Train	448.50	99	1,312	classe	246.15	85	2,892

Note—PVE, predictive value of ending.

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