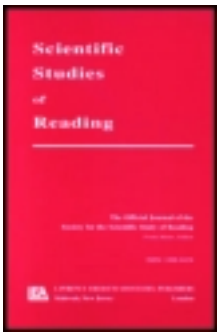

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Effect of Syllable Congruency in Sixth Graders in the Lexical Decision Task With Masked Priming

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The aim of this study was to investigate the role of the syllable in visual recognition of French words in Grade 6. To do so, the syllabic congruency effect was examined in the lexical decision task combined with masked priming. Target words were preceded by pseudoword primes sharing the first letters that either corresponded to the syllable (congruent condition) or not (incongruent condition). A reliable syllable congruency was found. Children were faster to recognize words when the prime matched for the first syllable. These results are discussed in interactive activation models including syllables and in the dual-route approach.

In alphabetic writing systems, learning to read requires understanding that a string of letters code for speech utterances and that the written symbols represent sounds of speech in an indirect and abstract way. The processes underlying reading acquisition have been widely investigated with regards to the dual-route hypothesis (e.g., Coltheart, Rastle, Perry, Langdon, & Ziegler, 2001; see Morais, 2003, for a review). In this framework, phonological recoding would be the primary procedure used by beginning readers and would be fundamental for the establishment of the orthographic lexicon. Grapheme-to-phoneme conversion rules make

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it possible to convert a given grapheme into the corresponding phoneme. When the string of phonemes is assembled, the word representation is contacted in the phonological lexicon and the word meaning is retrieved. Reading progress is characterized by the use of an additional procedure, whereby letter strings are processed without any phonological recoding. By using this lexical procedure, word representations are directly activated in the orthographic lexicon via the letter representations.

Together with the idea according to which phonemes are central units of reading acquisition, several studies showed that syllables are easier to process by children in speech processing than phonemes (e.g., Courcy, Béland, & Pitchford, 2000; Liberman, Shankweiler, Fischer, & Carter, 1974). Actually, syllables would be less abstract and more intuitive units than phonemes, that is, more accessible and more easily isolable than phonemes, even for skilled readers (see Bastien-Toniazzo, Magnan, & Bouchafa, 1999). This would occur especially in syllable-timed languages such as French. French has rather clear syllabic boundaries (see Goslin & Floccia, 2007), and the most frequent syllabic structure in both orthographic and phonological forms of written words is the consonant–vowel (CV) syllable. In addition, roughly 53% of orthographic syllables have a simple syllabic structure of two or three letters long (Chetail & Mathey, 2010). Given these properties, the syllable has become of particular interest in French, explaining why most of the studies with children were carried out in this language and why syllables have been considered the potential preferred units of phonological recoding in young readers in French.

A key effect to examine the role of syllables in word processing is the syllable congruency effect. The effect was initially developed in the auditory modality in adults to test to what extent syllables could be functional units of spoken word recognition. In a seminal study, Mehler, Dommergues, Frauenfelder, and Segui (1981) used pairs of French words matched for the first three phonemes but not for the first syllable (*pa.lace*/*pal.mier*).[1] The word *pa.lace* has a CV first syllable (hereafter, CV word), whereas the word *pal.mier* has a CVC syllable (CVC word). The task was to detect segments like /pa/ (CV segment) and /pal/ (CVC segment) in spoken words. These segments were either matched with the first syllable of target words (e.g., /pa/ in *pa.lace*, /pal/ in *pal.mier*) or not (/pal/ in *pa.lace*, /pa/ in *pal.mier*). A syllable congruency effect was found, showing that segment detection was faster when it exactly matched the first syllable of the word. However, the effect was not fully replicated in follow-up studies (e.g., Cutler, Mehler, Norris, & Segui, 1986; Tabossi, Collina, Mazzetti, & Zoppello, 2000). In particular, Content, Meunier, Kearns, and Frauenfelder (2001) showed that syllable congruency effects in French emerged only under restrictive conditions, namely, for target words including a liquid pivotal consonant (e.g., *bal.con*).

[1]The dots mark syllable boundaries, though the items presented did not contain the dots.

Despite this questioning of the effect in the auditory modality, the syllable congruency effect has received much attention, and the procedure has been adapted to the visual modality. In children, this procedure was used specifically to investigate their sensitivity to syllable units in written words. The results obtained with tasks requiring the detection of letters, bigrams, or trigrams suggest that the syllables are perceptual units of reading (e.g., Colé, Magnan, & Grainger, 1999, visual segment monitoring task; Doignon & Zagar, 2006, illusory conjunction task), although these tasks did not provide direct information about word reading given that lexical access was not mandatory (Doignon & Zagar, 2006). Surprisingly, very few studies have been conducted specifically in reading tasks requiring lexical access.

In beginning readers (first, second graders), two variants of the lexical decision task were used to examine syllable congruency effects during lexical access (Chetail & Mathey, 2009a; Katz & Baldasare, 1983). Words were either segmented or colored while participants had to read items and judge their lexicality. More precisely, in the segmented lexical decision task, words are segmented by slashes or spaces so that the segmented parts are either congruent with syllables (e.g., *pa/per*) or not (e.g., *p/aper*). In English, Katz and Baldasare (1983) reported that second graders made fewer errors in recognizing congruent words than for incongruent words, but this effect was present only in poor readers. According to the authors, the use of syllables to recognize words can be understood as the use of phonological recoding, necessary in reading acquisition. This explanation can be related to the proposition according to which syllable units would be functional units on the indirect route of phonological recoding (e.g., Colé et al., 1999). Given that phonological recoding becomes inefficient with reading experience, such a framework predicts that syllable congruency effects would disappear in more advanced readers who would mainly rely on the lexical procedure.

Using the colored lexical decision task, Chetail and Mathey (2009a) also reported an effect of syllable congruency varying with reading level in Grade 2. When words were displayed in two colors, poor readers were faster to recognize words when the colors matched for the syllabic segmentation (e.g., *CA.rotte*, *CAR.ton*) rather than not (e.g., *CA.Rotte*, *CAr.ton*).[2] On the contrary, an inhibitory effect was found for good readers: Word identification was slower for syllable congruent words (e.g., *CA.rotte*, *CAR.ton*) than for syllable incongruent ones (e.g., *CA.Rotte*, *CAr.ton*). To account for such findings, the authors relied on the hypothesis of dual syllabic activation initially developed in adults in interactive activation models (McClelland & Rumelhart, 1981) including syllables (e.g., Carreiras, Alvarez, & de Vega, 1993; Conrad, Carreiras, Tamm, & Jacobs,

[2]Uppercase letters and lowercase letters represent two different colors, though the items were entirely presented in lowercase.

2009; Mathey, Zagar, Doignon, & Seigneuric, 2006). According to this hypothesis, prelexical facilitation and lexical inhibition both contribute to the emergence of syllable effects. When a letter string is displayed, activation from the letters spreads to the corresponding syllables. Syllable activation then spreads to the word level via direct connections, activating both the word representation and the syllabic neighbor representations (i.e., words sharing the first syllable). Lexical competition occurs between the activated neighbors by means of a lexical inhibition mechanism, which delays the stimulus recognition. The respective weight of prelexical facilitation and lexical inhibition determines the direction of syllabic effects. In the syllable congruency conditions, Chetail and Mathey (2009a) assumed that lexical inhibition had time to develop in good readers in Grade 2 but not in poor ones.

Contrary to beginning readers, the syllable congruency effect has not been examined in advanced young readers (fifth, sixth graders) with tasks involving lexical access. To our knowledge, only tasks such as visual segment monitoring were used in few studies (e.g., Colé et al., 1999; Maïonchi-Pino, Magnan, & Ecalle, 2009, in French), and results were not fully consistent. For example, Colé et al. (1999) did not report syllable congruency effects in fifth-grade readers, whereas Maïonchi-Pino et al. (2009) did. This lack of studies in advanced young readers—specifically with lexical access tasks—may obstruct integrative accounts of processes underlying syllabic activation during visual word recognition. Thus, examining the syllable congruency effect in advanced young readers would be a first step to fill the empirical gap between beginning readers and adults. Similarly, it is necessary to link theoretical frameworks developed to accommodate syllabic effects in children with those developed in adults. Syllabic effects have been mainly explained in terms of phonological recoding processes in children, and very few links have been developed with frameworks proposed in skilled readers, as interactive activation-based models. This might be partly due to the fact that syllabic effects have been mainly investigated in children in first and second graders and not in more advanced readers. Another reason may be that, as presented next, syllable congruency effects in adults were examined with paradigms that differ from those used in children. Thus, assessing in advanced graders (sixth graders in the present study) the syllable congruency effect similarly to what was previously done in skilled readers may be a first empirical attempt toward a theoretical connection between developing and skilled reader accounts of syllabic effects in reading.

In adults, the syllable congruency effect was investigated in the lexical decision task combined with the masked priming paradigm (see Ferrand, Segui, & Grainger, 1996, for the first adaptation to visual modality). In this situation, primes are briefly displayed so that they are not perceived by readers and then replaced by target words for which participants have to perform a lexical decision. In the congruent condition, primes share the first letters and the first syllable

with the targets (e.g., *pa&&&& - PA.LACE*, in French), whereas in the incongruent condition they share the first letters but not the syllable (e.g., *pal&&& - PA.LACE*). The prime can be a partial prime, a word, or a pseudoword containing the segment (respectively, *pa&&&&*, *pa.nier*, *pa.suve*). Besides avoiding strategic processes from participants (Forster, 1998), the masked priming paradigm enables syllabic effects to be dissociated from overlap effects (e.g., Alvarez, Carreiras, & Perea, 2004; Chetail & Mathey, 2009b). For example, the processing of French target words such as *BA.LANCE* is compared when they are preceded by pseudoword primes, which are either syllabically congruent (e.g., *ba.lieux*) or incongruent (e.g., *bal.veux*). In this design, syllabic primes are matched for both the first syllable (/ba/) and the first two letters (*ba*), whereas control primes are matched only for the first letters (*ba*, but /ba/ vs. /bal/). Hence, if a priming effect is obtained, it would reflect syllabic activation and not ortho-phonological overlap between primes and targets (referred to as segmental overlap; see Schiller, 1998). Given that the masked priming technique ensures that syllabic effects are genuine effects, it has become a method of choice to examine processes underlying syllabic activation in adults, especially in naming and lexical decision tasks.

In word naming, data remain unclear because syllable congruency effects were reported at a 29-ms prime duration (Ferrand et al., 1996, in French; Ferrand, Segui, & Humphreys, 1997, in English), but these effects failed to be replicated several times (Brand, Peereman, & Rey, 2003, in French; Schiller, 1998, in Dutch; Schiller, 1999, 2000, in English), even with longer prime durations (Brand et al., 2003). On the contrary, the initial failure to report a syllable congruency effect in the lexical decision task (Ferrand et al., 1996; Ferrand et al., 1997) was explained by the use of too-short prime duration (29 ms), which may not be sufficient to trigger significant activation of prelexical syllable units (Chetail & Mathey, 2009b; Ferrand et al., 1996). Accordingly, the syllable congruency effect was found with prime durations higher than 60 ms when partial primes (Carreiras & Perea, 2002, in Spanish) and nonword primes (Alvarez et al., 2004, in Spanish; Chetail & Mathey, 2009b, in French) were used. Such facilitatory syllabic effects in the lexical decision task were accounted for by preactivation of syllabic units at a sublexical level. For example, when the pseudoword prime *ba.lieux* is briefly displayed, this might preactivate the syllable /ba/ at the syllabic level. When the target word *BA.LANCE* is then displayed, its recognition is speeded up because of the preactivation of its first syllable by the prime.

The masked priming paradigm being particularly relevant to examining syllable congruency effects during visual word recognition in adults, this paradigm was used in the present study to investigate the syllable congruency effect in sixth graders. The aim was twofold. First, we assessed syllable congruency effects in advanced young readers so that data will be available to fill the gap between

beginning readers and adults. Second, we compared data with previous empirical results in adults in order to connect the different theoretical frameworks of syllabic effects proposed in children and adults.

METHOD

Participants

Forty-five sixth graders (*M* age = 11 years 9 months, *SD* = 5 months) participated in this research. All children were native French speakers. They had corrected-to-normal vision, and none of them had any particular reading difficulties or sensory impairment. Their reading level evaluated with a standardized reading test (L'Alouette; Lefavrais, 1967) was 11 years 10 months (*SD* = 1 year 7 months).

Materials

The French lexical database Manulex (Lété, Sprenger-Charolles, & Colé, 2004) was used to select target words. Eighty bisyllabic words were selected into pairs so that one word had a CV structure in the first syllable (CV target, e.g., *VO.LUME*) and the other word had a CVC structure (CVC target, e.g., *VOL.CAN*). The words were of medium to high frequency (number of adjusted occurrences = 33.89, standard frequency index = 53.24), and they were matched for their lexical frequency in each pair. As expected in the French language, the first syllable of CV targets was much more frequent than that of CVC targets (2,904 vs. 1,443 occurrences per million respectively, taken from Manulex-Infra; Peereman, Lété, & Sprenger-Charolles, 2007), whereas the number of higher frequency syllabic neighbors of the selected words was rather low (2.8 and 6.3, respectively, computed on Manulex; Lété et al., 2004). Two pseudoword primes were created for each target word, both primes sharing the three initial letters with the target. One of the primes had a CV structure in the first syllable (CV prime, e.g., *vo.liar*), whereas the other prime had a CVC structure (CVC prime, e.g., *vol.cer*). Thus, four experimental conditions were created, two exhibiting a syllable congruency pattern (e.g., *vo.liar-VO.LUME*, *vol.tie-VOL.CAN*) and the others not (e.g., *vol.cer-VO.LUME*, *vo.lode-VOL.CAN*). For the task requirements, 80 legal and pronounceable pseudowords were added. Though the experiment did not aim at testing the effects on pseudoword targets, they were constructed similarly to words to avoid response bias based on the materials. Hence, both CV and CVC pseudowords were included and either CV or CVC pseudoword primes preceded them. Two lists of 160 trials were created so that all the items were presented in each list but with a different prime. Hence, no participant was presented with the same item more than once.

Procedure

The participants were tested individually in a single session. First, they performed the reading level test. Second, the primed lexical decision task was run on a laptop computer using the DMDX software (Forster & Forster, 2003). Each trial began by presenting a forward mask (row of hash marks matched for length with the prime) for 500 ms on the centre of the screen, which was replaced by a prime for 67 ms. The prime was immediately replaced by a target, which remained on the screen until the participants responded. A 67-ms-prime duration was used because previous studies using the lexical decision task showed that syllable priming effects were obtained only for stimulus onset asynchronies (SOAs) longer than 60 ms (see Chetail & Mathey, 2009b). Primes were presented in lowercase letters and targets in uppercase letters to ensure that priming effects were not due to overlap of visual features (see Evett & Humphreys, 1981). Participants had to decide as quickly and as accurately as possible whether or not the target was a French word by pressing one of two buttons on the keyboard. Visual feedback was provided when they failed to respond. Reaction times (in milliseconds) were measured from target onset until response. The participants were randomly assigned to one of the two lists of materials, and they performed 14 practice trials before receiving the 160 trials in a different random order.

RESULTS

In the lexical decision task, response times outside the range of 2 standard deviations from the individual mean of the participants were excluded (4.14 % of the data). Mean correct reaction time was 847 ms ($SD = 124$ ms), and mean error rate was 6.92 % ($SD = 4.33$). The data were submitted to separate analyses of variance (ANOVAs) on the participant means ($F1$) and on the item means ($F2$) with target type (CV, CVC) and prime type (CV, CVC) as main factors. The mean correct reaction times averaged over participants for words according to target type and to prime type are presented in Figure 1.

In the reaction time analysis, the main effect of target type was significant in the participant analysis, $F1(1, 44) = 5.79$, $p = .02$, $F2 < 1$. CV words were responded to faster (840 ms) than CVC words (854 ms). The main effect of prime type was not significant, $Fs < 1$. The interaction between prime type and target type was significant, $F1(1, 44) = 9.04$, $p = .004$, $F2(1, 78) = 11.12$, $p = .001$. This interaction was due to the fact that CV targets were recognized more rapidly when they were preceded by a CV prime (828 ms) than by a CVC prime (851 ms), $F1(1, 44) = 8.02$, $p = .007$, $F2(1, 78) = 8.02$, $p = .006$, and because CVC targets were recognized more rapidly when they were preceded by a CVC prime (846 ms) than by a CV prime (862 ms), $F1(1, 44) = 4.86$, $p = .03$, but $F2(1, 78) = 3.55$, $p = .06$. In the error rate analysis, there was no significant effect (all $ps > .28$).

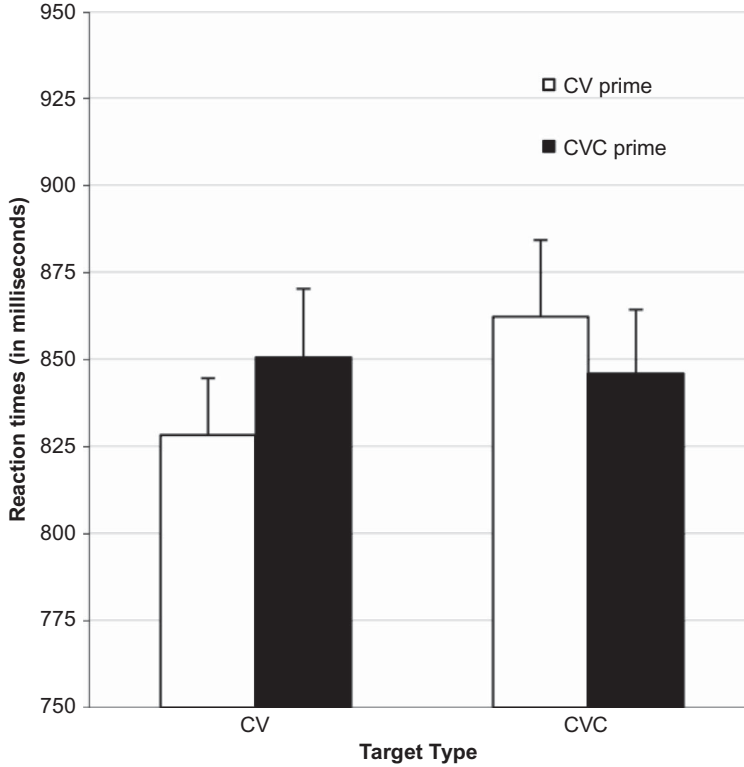

FIGURE 1 Mean reaction times (+SE) in sixth graders as a function of target type and prime type. *Note.* C = consonant; V = vowel.

DISCUSSION

The aim of the study was to investigate the syllable congruency effect in the primed lexical decision task in sixth graders. A facilitatory syllabic priming effect was found, indicating that words were recognized faster when they were preceded by a congruent prime (e.g., *vo.liar-VO.LUME*, *vol.tie-VOL.CAN*) rather than by an incongruent prime (e.g., *vol.cer-VO.LUME*, *vo.lode-VOL.CAN*).

The present study reports successfully for the first time a syllable congruency effect in the primed lexical decision task in children. The fact that the effect was found while both congruent and incongruent primes shared the same number of letters with the target rules out a segmental interpretation (e.g., for both *vo.liar-VO.LUME* and *vol.tie-VO.LUME* there is a three-letter overlap, but a priming effect was found for the former condition only). On the contrary, this supports

the hypothesis according to which written syllables of words have a functional role during reading in children. Given that in the present study, spelling of syllables in primes matched spelling of syllables in congruent targets (i.e., identical orthographic syllables), the current data do not enable one to decide between a phonological or an orthographic account of the syllabic priming effects (see Alvarez et al., 2004). This first evidence for syllabic priming effects in children should be the starting point to further the investigation on the nature of syllabic priming effects, as previously done in skilled readers. In this perspective, it should be noted that some neuropsychological studies in adults provided support for an orthographic locus of syllabic effects (see Caramazza & Miceli, 1990; Stenneken, Conrad, Goldenberg, & Jacobs, 2003). Though syllables are phonological units in essence, syllabic effects in written word processing may be driven by orthographic features of syllables.

Given that the syllable congruency effect was found in sixth graders—who cannot be considered beginning readers—and that the effect was similar to the effect previously obtained in skilled readers with SOAs longer than 60 ms (e.g., Carreiras & Perea, 2002; Chetail & Mathey, 2009b), this rules out the hypothesis according to which syllabic effects are merely phonological recoding effects (Colé et al., 1999; Katz & Baldasare, 1983). Hence, as children become more proficient readers, the involvement of syllable units in reading experience would change from units of phonological recoding to automatically activated orthographic syllables, suggesting that syllables are functional units of lexical access even when phonological recoding is not the dominant reading procedure.

At a theoretical level, the present findings support the relevance of integrating accounts of syllabic effects in children in more general frameworks developed in adults. Thus, the data can be explained in terms of preactivation of syllabic units at a sublexical level within an interactive activation framework including syllables such as those proposed in adults (e.g., Conrad et al., 2009; Mathey et al., 2006). In the congruent condition, strong activation might be sent from the letter to the syllable level and then from the syllable to the lexical level, compared to the incongruent or control conditions. When the target word is displayed, its lexical representation is therefore already activated. Thus, the processing of the target is facilitated in the syllable congruent condition compared to the other prime conditions.

The results can also be discussed in light of the recent dual-route approach to orthographic processing proposed by Grainger and Ziegler (2011). In this framework, two orthographic codes are assumed to map orthographic strings to meaning, namely, a coarse-grained orthographic code and a fine-grained orthographic code. Each code would reflect different types of constraints that arise during reading acquisition and entails the development of different sublexical orthographic representations. Especially, the fine-grained orthographic route is assumed to code for multiletter graphemes and enables sublexical orthographic

information to match for preexisting sublexical phonological representations. Our data, added to those of previous studies on syllabic activation, suggest that orthographic counterparts of phonological syllables need to be included in the sublexical level of the fine-grained orthography route in addition to morpheme and grapheme representations. More generally, this prompts a precise examination of what relationships exist between these different types of sublexical units and how orthographic clusters are extracted from written words, processes, and cues determining orthographic grouping remaining far from clear currently. According to Grainger and Ziegler (2011), sublexical orthographic representations are constructed during learning to read via exposure to frequently co-occurring letter combinations. In addition, they proposed that the CV distinction could be a sizeable cue for orthographic chunking of letter strings. This point is particularly relevant for the issue of syllabic parsing and syllabic activation in the written modality: The first syllable-sized unit in the word *balai* is *ba* because the consonant *l* is followed by a vowel, whereas the first syllable-sized unit in *balcon* is *bal* because the consonant *l* is followed by another consonant. Therefore, the alternation of consonants and vowels within words may be a promising hypothesis to explain how graphosyllables are perceived and extracted from written words.

To conclude, the present study reports a reliable facilitatory effect of syllable congruency in the primed lexical decision task in Grade 6. These results provide new data favoring the genuineness of this effect in French and confirming therefore that syllables are salient units of reading. Concerning reading acquisition and instruction, the fact that syllable-sized units are relevant units of word processing in developing readers—even those who cannot be considered as beginning readers—supports phonics reading instruction based on syllables. In addition, this argues for using and developing computer-assisted training and remedial reading programs focused on syllabic units in order to improve reading efficiency in children (see Ecalle, Magnan, & Calmus, 2008). Finally, in a more methodological perspective, this study shows that masked priming is a relevant method to investigate syllabic effects in children, which should allow direct comparisons with the various syllabic priming effects found in adults.

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APPENDIX

Target Words and Corresponding Primes

	CV Words			*CVC Words*		
Pair No.	*Target*	*CV Prime*	*CVC Prime*	*Target*	*CV Prime*	*CVC Prime*
1	BALANCE	balieur	balveux	BALCON	baluve	balnat
2	BANAL	banoi	banti	BANQUISE	bannieux	bancheux
3	BANANE	baneil	bantil	BANDIT	baniée	bancée
4	BONNET	bonoin	bonvio	BONBON	bonnul	bonqué
5	CANON	canui	canca	CANTINE	canioux	cangoux
6	CAROTTE	caruirs	carduis	CARTON	carrul	carmue
7	CARREAU	caranne	cardane	CARNET	careul	cartuc
8	CERISE	ceroul	cermal	CERCLE	ceriet	cerdet
9	COMIQUE	comeurs	compurs	COMPOTE	commuis	combeux
10	COMMANDE	comaurts	compreux	COMBAT	comior	compor
11	CONNU	conaf	conri	CONCOURS	connisse	convisse
12	CORAIL	coruve	cortof	CORDON	corèce	corvic
13	DURÉE	durio	durmo	DURCIR	durian	durdan
14	FACILE	facron	facton	FACTEUR	facoint	facsain
15	FANER	fania	fanfa	FANFARE	fanouir	fantian
16	GARAGE	gareul	garnel	GARDIEN	garoule	garcole
17	GENOU	genié	genvé	GENTIL	genian	gendan
18	GORILLE	goraint	gormint	GORGÉE	goruis	gorvus
19	MALADE	mallui	malgui	MALGRÉ	malour	malsor
20	MANÈGE	maneau	manlar	MANTEAU	manance	manlace
21	MANIÈRE	mancial	manqual	MANQUER	manisse	mancran
22	MANUEL	manise	mansié	MANGEUR	manaive	mantive
23	MARIAGE	mareuil	marchil	MARMOTTE	marrieux	marchoux
24	MARRON	marace	marpal	MARMITE	marioul	marsaid
25	MENACE	meniul	mentut	MENSONGE	menieurs	mencioux
26	MENER	menoc	menco	MENTON	menoux	mencut
27	MORAL	morio	mormo	MORSURE	morroin	morboin
28	NOMMER	nomail	nombin	NOMBREUX	nomaiche	nompache
29	PALAIS	palite	palmot	PALMIER	palouve	palcove
30	PANIQUE	panourt	pansort	PANTIN	paneux	pancel
31	PANNEAU	panoise	pansibe	PANTHÈRE	pannieux	panqueux
32	PAREIL	paroux	parfou	PARFUM	parioc	parmor
33	PAROLE	pareuc	parcus	PARTOUT	paromme	parcive
34	REMÈDE	remoif	rempif	REMPLI	remoce	remboc
35	SOLIDE	soluir	solmié	SOLDAT	solèce	solcée
36	SONNETTE	soniaurs	songreil	SONGEUR	sonoise	sonvise
37	TOMATE	tomiur	tombru	TOMBÉE	tomair	tompul
38	TORRENT	toriole	torcile	TORDU	torré	torgé
39	VENUE	venoi	vensi	VENDEUR	venoule	ventule
40	VOLUME	voliar	volcer	VOLCAN	volode	voltie

Note. C = consonant; V = vowel.