Language, Cognition and Neuroscience
Publication details, including instructions for authors and subscription information:
http://www.tandfonline.com/loi/plcp21

Effect of number of syllables in visual word recognition: new insights from the lexical decision task

F. Chetail[a]

[a] Laboratoire Cognition Langage Développement (LCLD) and Centre de Recherche Cognition et Neurosciences (CRCN), Université Libre de Bruxelles (ULB), Av. F. Roosevelt, 50/CP 191, 1050 Brussels, Belgium
Published online: 07 Jan 2014.

To cite this article: F. Chetail , Language, Cognition and Neuroscience (2014): Effect of number of syllables in visual word recognition: new insights from the lexical decision task, Language, Cognition and Neuroscience, DOI: 10.1080/23273798.2013.876504

To link to this article: http://dx.doi.org/10.1080/23273798.2013.876504

Language, Cognition and Neuroscience, 2014
http://dx.doi.org/10.1080/23273798.2013.876504

Effect of number of syllables in visual word recognition: new insights from the lexical decision task

F. Chetail*

Laboratoire Cognition Langage Développement (LCLD) and Centre de Recherche Cognition et Neurosciences (CRCN), Université Libre de Bruxelles (ULB), Av. F. Roosevelt, 50/CP 191, 1050 Brussels, Belgium

(*Received 10 May 2013; accepted 11 December 2013*)

A thorough knowledge regarding monosyllabic word reading has been accumulated over decades, which contrasts with our understanding of polysyllabic word processing. One reason why modelling of polysyllabic word reading is lagging behind might be related to the issue of orthographic segmentation, parsing requiring the integration of two types of information, the number of units to be extracted and boundaries between these units. In the present study, we focussed on the effect of number of syllables, and we compared lexical decision latencies in French words and pseudowords as a function of syllabic length (two vs. three graphosyllables). An effect was found in pseudowords, low-frequency words and high-frequency words, items with three syllables being processed more slowly than items with two syllables. We discuss what processes of current models of visual word recognition may underlie this effect, and based on previous studies and analyses on word mega corpus, we propose a new interpretation of the effect in terms of number of orthographic vowel-centred units.

Keywords: number of syllables; graphosyllable; vowel cluster; silent E; visual word recognition

The issue of word recognition has received considerable attention since the very beginnings of cognitive psychology. Substantial advances have been made on the subject, especially regarding monosyllabic words. The more recent and less numerous studies on polysyllabic word processing lean towards the idea that syllables are functional units of written word processing (e.g., Carreiras, Alvarez, & de Vega, 1993; Chetail & Mathey, 2009; Conrad, Stenneken, & Jacobs, 2006). According to this view, at an early stage of processing, polysyllabic words are decomposed into letter groups (hereafter, graphosyllables) that map onto spoken syllables. Examining the effect of number of syllables therefore enables one to investigate the processes by which words are parsed into letter clusters.

The effect of number of syllables has been examined since the 1970s, particularly in the naming task. In English, Eriksen, Pollack, and Montague (1970) reported that naming onset latencies were longer for trisyllabic words (e.g., *fantasy*) than monosyllabic ones (e.g., *fan*). When the number of letters was strictly controlled for, some studies replicated the effect (e.g., Klapp, Anderson, & Berrian, 1973; Mason, 1978) while others did not (e.g., Forster & Chambers, 1973; Frederiksen & Kroll, 1976; Richardson, 1976). Jared and Seidenberg (1990) demonstrated that such discrepancies could be explained by a confound with word frequency, the effect of number of syllables being observed for low-frequency words only.

To account for the effect, Jared and Seidenberg (1990) relied on the Parallel Distributed Processing (PDP) model that does not include syllabic representations (Seidenberg & McClelland, 1989), given that according to them the effect stems from the spelling-to-sound inconsistencies of English vowels rather than from syllabic units per se. Since each graphosyllable contains a vowel, increasing the number of graphosyllables also increases the probability of encountering inconsistent vowels – especially in low-frequency words – thus delaying pronunciation. However, follow-up results are hard to reconcile with this interpretation. First, an effect was found in orthographies with fewer vowel inconsistencies than English (Ferrand, 2000; Ferrand & New, 2003, in French; Stenneken, Conrad, & Jacobs, 2007, in German). Second, analyses on the English Lexicon Project (ELP) mega corpus (Balota et al., 2007) showed that the effect was present for both high- and low-frequency words – although larger for the latter – even after consistency measures were taken into account (Yap & Balota, 2009). The effect of number of syllables has therefore been taken as a genuine effect of number of units, explained in terms of sequential processing. As argued by Ferrand and New (2003), the Multiple-Trace Memory (MTM) model (Ans, Carbonnel, & Valdois, 1998) more successfully accounts for the effects in French than the PDP model (Seidenberg & McClelland, 1989) or the Dual Route Cascaded (DRC) model (Coltheart, Rastle, Perry, Langdon, & Ziegler, 2001); note that although there was initially no syllabic representations in the model, 'If graphemes – phonemes are replaced by graphemic syllables and phonemic syllables, DRC can assume a syllabic

*Email: fchetail@ulb.ac.be

decomposition instead of a grapheme – phoneme decomposition' (Ferrand & New, 2003, p. 170). The MTM model includes two procedures of reading: a global one and an analytic one. The global procedure is always activated first, and the analytic procedure – which involves the sequential activation of graphosyllabic units – proceeds only when the global one fails. The analytic procedure is assumed to generate the phonological code for pseudowords and most low-frequency words, lengthening naming latencies as a function of the number of syllables to process. On the contrary, high-frequency words would be read via the global procedure, so that syllabic length would not influence pronunciation onset.

To discard an interpretation of the effect of number of syllables in terms of phonological output, more recent studies used also the lexical decision task in addition to the naming task. As in naming, the MTM model (Ans et al., 1998) predicts no syllabic effect for high-frequency words in the lexical decision task due to the intervention of the global procedure, whereas low-frequency words would be processed via the sequential syllabic procedure. No effect is expected for pseudowords because negative decisions are performed without any involvement of the analytic procedure (Ferrand & New, 2003). Consistently with these predictions, Ferrand and New (2003) found an effect in French for low-frequency words, but not for high-frequency words, nor for pseudowords. In English on the contrary, regression analyses on lexical decision latencies provided in the ELP showed an effect of number of syllables for words (Muncer & Knight, 2012; New, Ferrand, Pallier, & Brysbaert, 2006) and for pseudowords that elicited long latencies (Muncer & Knight, 2012). Furthermore, Yap and Balota (2009) reported that the effect was present for both high- and low-frequency words, although it was larger for low-frequency words.

Taken together, the results in the lexical decision task are inconsistent across languages. Especially, the fact that the effect extends to more categories of items in English (high- and low-frequency words, pseudowords) than in French (low-frequency words only) is surprising because syllabic effects are assumed to be more prone to emerge in French or Spanish than in English due to less complex syllabic structures and clearer syllabic boundaries (e.g., Alvarez, Carreiras, & de Vega, 2000). Furthermore, the hypothesis of syllabic activation has been largely based on the syllable frequency effect in the lexical decision task (Carreiras et al., 1993) according to which words are recognised more slowly when they have a first syllable of high frequency than of low frequency, due to a stronger lexical competition between syllabic neighbours (i.e., words sharing the same first syllable). Chetail and Mathey (2011) recently showed that the number of syllables influences this competition in the lexical decision task, the strongest competitors being the neighbours with the same number of syllables. This suggests that letter strings are parsed at an early stage into graphosyllables and that a length-sensitive mechanism weights lexical representations according to their similarity with the target word in terms of number of graphosyllables. Given that syllabic neighbourhood competition effects were reported in French and Spanish for both high- and low-frequency words (e.g., Conrad et al., 2006; Mathey & Zagar, 2002; Perea & Carreiras, 1998) and for pseudowords (e.g., Alvarez, de Vega, & Carreiras, 1998; Conrad et al., 2006) in the lexical decision task, this length-sensitive mechanism may be at work for these items, and accordingly, effects of number of syllables should not be restricted to low-frequency words in French. Given that only one study on the effect of number of syllables in the lexical decision task was available in French, the aim here was to re-examine the effect, in both high-frequency words, low-frequency words and pseudowords.

Experiment 1

Method

Participants

Thirty native French speakers with normal or corrected-to-normal vision participated in this experiment for course credits.

Stimuli

Eighty words of six letters were selected in the French lexical database Brulex (Content, Mousty, & Radeau, 1990) according to the orthogonal combination of two factors: number of syllables (two, three) and word frequency (high, low). Forty words were of high frequency and 40 words were of low frequency. In each half, there were 20 bisyllabic and 20 trisyllabic words. Items were controlled for a number of variables and it was checked a posteriori that they were matched on lexical frequency provided in Lexique (New, Pallier, Brysbaert, & Ferrand, 2004), subjective frequency and age of acquisition (see Table 1). Eighty orthographically legal and pronounceable pseudowords were added, 40 being bisyllabic and 40 being trisyllabic (see Appendix).

Procedure

Participants performed a lexical decision task programmed with DMDX (Forster & Forster, 2003). After the presentation of a fixation point for 500 ms on the centre of the screen, a lowercase target item appeared, and participants had to decide as quickly and as accurately as possible whether the target was a French word or not, by pressing one of two buttons on a keyboard. Visual feedback was provided when they failed to respond or when 2500 ms had elapsed. All participants performed 12 practice trials before receiving the 160 trials in a different random order.

Table 1. Item characteristics in Experiment 1.

	Words				Pseudowords	
	High frequency		Low frequency			
	2 syll.	3 syll.	2 syll.	3 syll.	2 syll.	3 syll.
Objective word frequency						
Brulex	73.77	64.93	2.01	2.25	–	–
Lexique (books)	43.29	43.06	2.53	2.26	–	–
Lexique (films)	46.83	57.34	2.84	1.02	–	–
Subjective word frequency[a]	3.79	3.78	2.51	2.27	–	–
Age of acquisition[a]	2.44	2.65	3.30	3.65	–	–
Number of letters	6.00	6.00	6.00	6.00	6.00	6.00
Number of phonemes	5.40	5.55	5.40	5.60	5.40	5.58
Number of orthographic neighbours (*N*)	0.55	0.55	0.35	0.15	0.00	0.00
OLD20	1.80	2.13	1.94	2.17	2.26	2.38
Number of morphemes	1.10	1.05	1.05	1.25		
First syllable frequency	1277	1348	1531	1560	1347	1507
First bigram frequency	565	769	667	608	435	563
Summed bigram frequency	2081	2130	1912	1560	1817	1779
Percentage of concrete words	45	35	50	50	–	–

Note: Frequency measures are given in number of occurrences per million. First syllable frequency refers to the summed token frequency of words sharing the same first phonological syllable. All comparisons between bisyllabic and trisyllabic words yielded p values superior at .05.
[a]Collected on five-point Likert scales (see Alario & Ferrand, 1999; Morrison, Chappell, & Ellis, 1997) in participants not included in the experiment.

Results

The mean correct reaction times and error rates averaged over participants are presented in Table 2. Response times outside the range of two standard deviations from the individual mean of the participants were excluded (4.17% of the data). The data were submitted to separate analyses of variance on the participant means ($F1$) and on the item means ($F2$).

Words

Reaction time analyses showed a significant effect of word frequency, $F1(1, 29) = 166.05$, $p < .001$, $F2(1, 76) = 76.06$, $p < .001$. High-frequency words were recognised more rapidly than low-frequency words. There was also an effect of number of syllables, $F1(1, 29) = 30.12$, $p < .001$, $F2(1, 76) = 5.24$, $p < .05$, trisyllabic words being processed more slowly than bisyllabic ones. The interaction between the two variables was not significant, Fs < 1.

In the error analysis, the effect of word frequency was significant, $F1(1, 29) = 23.21$, $p < .001$ and $F2(1, 76) = 33.11$, $p < .001$, as well as the effect of number of syllables, $F1(1, 29) = 4.09$, $p = .05$ and $F2(1, 76) = 3.92$, $p = .05$. The interaction was significant in the participants analysis only, $F1(1, 29) = 4.55$, $p < .05$, $F2(1, 76) = 2.57$, $p = .11$, suggesting that the effect was present for low-frequency words only.

Pseudowords

There was a significant effect of number of syllables on reaction times, $F1(1, 29) = 7.61$, $p < .01$, $F2(1, 78) = 5.05$, $p < .05$, with trisyllabic items being recognised more slowly than bisyllabic ones. An effect was also found in the error rate analysis, $F1(1, 29) = 7.65$, $p < .01$, $F2(1, 78) = 4.07$, $p < .05$. Linear mixed effects analyses (binomial family) led to the same pattern of results, and the interaction between number of syllables and lexical frequency on error rates was not significant ($z < 1$).

Table 2. Mean reaction times and error rates (standard deviations are in parentheses) in Experiment 1.

	Reaction times (ms)			Error rates		
	2 syll.	3 syll.	Difference	2 syll.	3 syll.	Difference
High-frequency words	557 (64)	573 (65)	–16	0.3 (1.3)	0.7 (2.2)	–0.4
Low-frequency words	632 (83)	657 (84)	–25	4.0 (4.8)	7.1 (9.2)	–3.1
Pseudowords	884 (148)	903 (156)	–17	1.8 (2.3)	3.9 (3.7)	–2.1

Discussion

The comparison of lexical decision latencies for bi- and trisyllabic items showed an effect of number of syllables for both high-frequency words, low-frequency words and pseudowords in the reaction times. These findings extend the effect of number of syllables found in French for low-frequency words (Ferrand & New, 2003) to high-frequency words and pseudowords, but fail to support the prediction of the MTM model. Before re-examining the account of the effect, it is necessary to explain the discrepancy between our results and Ferrand and New's (2003) prior study in French.

An interesting difference is that in Ferrand and New's (2003) study, there was a high proportion of bisyllabic words with a final silent E (80% for high-frequency words, 75% for low-frequency words) compared to the trisyllabic words (15% for high-frequency words, 0% for low-frequency words), whereas in our study, the difference was much smaller (25% and 30% for high- and low-frequency bisyllabic words respectively vs. 0% for trisyllabic words). According to a recent hypothesis (Chetail & Content, 2012, 2013, in press), the organisation of consonant and vowel (CV) letters constrains the perceptual structure of letter strings, and the number of orthographic units within written words is determined by the number of vowel clusters (i.e., vowel letters or groups of adjacent vowel letters). Given that graphosyllables are centred on vocalic nuclei, their number generally coincides with the number of vowel clusters (e.g., *feeling*), but a mismatch occurs in words including a silent E (e.g., *trace*, one syllable but two vowel clusters). Accordingly, when readers had to highlight the graphosyllables in French written words, they based their judgement on vowel-centred units rather than graphosyllables, leading them to overestimate the number of units in silent E words (e.g., *biberon*, /bi-bʀõ/: categorised as three units instead of two, Chetail & Content, 2013). This suggests that three orthographic units are extracted and processed in bisyllabic items with a silent E (e.g., *va.li.se*, /va-liz/) as in trisyllabic words without silent E (e.g., *va.ni.té*, /va-ni-te/). A post-hoc analysis actually showed that the syllabic effect in Experiment 1 was not significant when comparing bi- and trisyllabic items with the same number of vowel clusters (e.g., *valise* vs. *vanité*), for both words (respectively, 599 vs. 606 ms, and 4.2 vs. 3.8%, all Fs < 1) and pseudowords (900 vs. 899 ms, 2.2 vs. 4.4%, all ps > .16). On the contrary, the effect was significant or marginally significant when the variation of the number of syllables and vowel cluster co-varied (e.g., *calcul* vs. *comité*), for both words (596 vs. 621 ms, $F1(1, 29) = 39.74$, $p < .001$, $F2(1, 52) = 2.91$, $p = .09$, and 2.0 vs. 4.8%, $F1(1, 29) = 7.57$, $p = .01$, $F2(1, 52) = 3.52$, $p = .06$) and pseudowords (877 vs. 901 ms, $F1(1, 29) = 6.89$, $p = .01$, $F2(1, 48) = 5.84$, $p = .02$, and 1.3 vs. 3.9%, $F1(1, 29) = 6.59$, $p = .02$, $F2(1, 48) = 3.56$, $p = .07$).

To confirm this interpretation, we conducted a second experiment. If written words are structured according to the number of vowel clusters, the time required to process words with the same number of graphosyllables should be longer for words including a silent E. We tested this hypothesis with the French Lexicon Project (FLP) mega corpus (Ferrand et al., 2010) which provides lexical decision latencies for a large set of words.

Experiment 2

Method

We selected 7428 monomorphemic words (word frequency > 0.5 occurrences per million) from the Lexique database (New et al., 2004) for which lexical decision latencies were available in the FLP (Ferrand et al., 2010) and which had at least 10 correct observations. Two categories of words were devised according to the presence of a silent E (final and/or internal E) or not. Roughly one third of French words include a silent E (Table 3). Given that there were very few words 5- or 6-syllable-long, we relied on one to four syllable-long words only ($N = 7359$; 2403 silent E words, 4956 non-silent E words).

Results

We conducted an analysis of covariance on reaction times (z-scores) according to the presence of a silent E, while controlling for word frequency (freqfilm2, log-transformed), number of letters, number of syllables, orthographic and phonological neighbourhood. A reliable silent E effect was found, $F(1, 7352) = 9.29$, $p < .01$, showing that words including a silent E were consistently processed more slowly than those without a silent E across all syllable length (Figure 1). To test the reliability of this effect, we performed multiple draws in the set of non-silent E words, which enabled us to ensure that the effect was not due to the unbalanced distribution of the two categories of words (2403 vs. 4956). The covariance analysis was conducted with 4806 observations (rather than 7359), half corresponding to the 2403 silent E words

Table 3. Distribution of French words according to silent E pattern and syllabic length.

	Number of graphosyllables					
	1	2	3	4	5	6
Without silent E	510	2264	1791	391	44	4
With silent E	508	1120	625	150	19	2
Internal	0	113	102	47	11	1
Final	508	1023	523	103	8	1

Note: Sixteen bisyllabic words had both an internal and a final schwa.

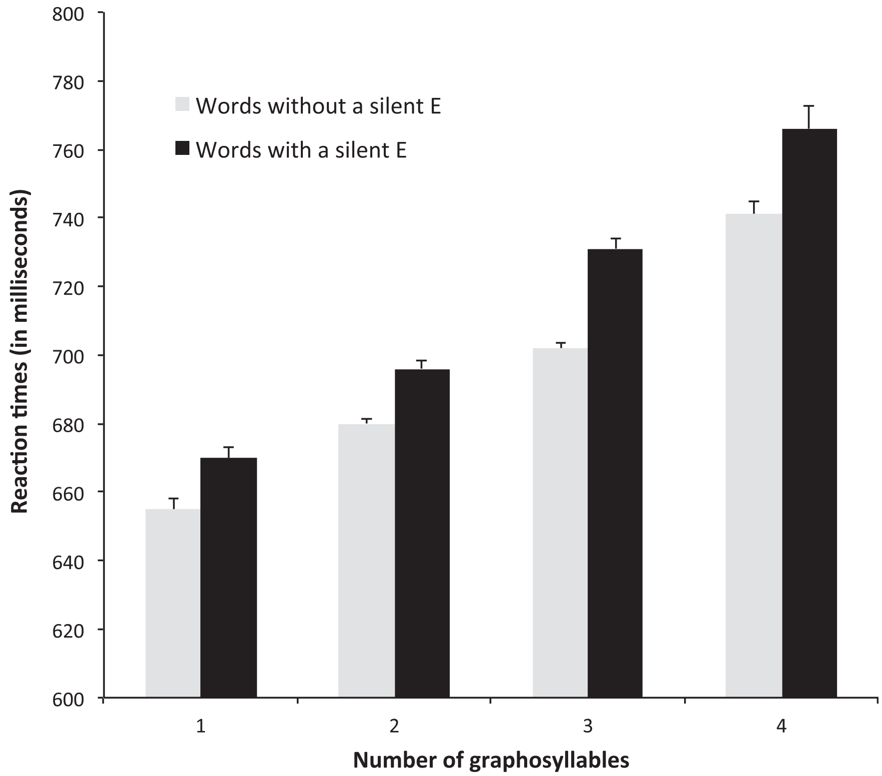

Figure 1. Silent E effect based on 7359 words as a function of number of graphosyllables in Experiment 2 (with standard error).

and the other half corresponding to 2403 non-silent E words randomly selected among the full set of 4956 words. We ran 1000 analyses, each with a different sample of control words. The silent E effect was significant in 977 draws with $p < .05$, and 777 draws with $p < .01$.

Consistently with the results of Experiment 1, there was no significant effect of number of syllables between bisyllabic words with a silent E and trisyllabic words without a silent E, $F(1, 2905) = 2.11$, $p = .15$. Accordingly, only 400 draws out of 1000 led to a significant effect of number of syllables with $p < .05$, and only 44 with $p < .01$. On the contrary, there was still a significant effect of number of syllables when three syllables words with a silent E were compared to four syllables words without a silent E, $F(1, 1010) = 11.72$, $p < .001$ (accordingly, 959 draws led to a significant effect with $p < .05$, and 594 with $p < .01$).

Discussion

Consistently with previous studies (e.g., Chetail & Content, 2013), this suggests that the presence of a silent E influences written word processing, silent E words entailing one orthographic unit more than non-silent E words despite an identical number of phonological syllables. Furthermore, this supports our interpretation of the discrepancy between Experiment 1 and the study of Ferrand and New (2003), at least for high-frequency words. The absence of difference between bisyllabic silent E words and trisyllabic non-silent E items in the latter study may be explained by the fact that both items had the same number of orthographic units. Additionally, Experiment 2 showed that for longer words (three/four syllables), there is still an effect of number of syllables when the presence of the silent E is controlled. This result is consistent with the study of Chetail and Content (2012) showing that the influence of the syllabic structure is stronger for longer words in the lexical decision task, due to the impact of assembly processes – and thus of the phonological word form – which is more important.

General discussion

We found an effect of number of syllables in French for low-frequency words, high-frequency words and pseudowords (Experiment 1). This is consistent with prior results in English (Muncer & Knight, 2012; Yap & Balota, 2009), and shows that the number of syllables influences written word recognition in French. In English, however, the effect was stronger in low- than high-frequency words (e.g., Yap & Balota, 2009), and present only for pseudowords with long decision latencies (Muncer & Knight, 2012). Furthermore, Experiment 2 suggests that the presence of a silent E in letter strings leads one to process one more orthographic unit than the number of syllables.

Among models of visual word recognition, the MTM model (Ans et al., 1998) seems particularly adapted to account for the present findings. Developed to simulate polysyllabic word recognition in French, the model incorporates two separate routes, one for global processing, the other one (including syllabic units) for analytic processing. The two routes are activated sequentially, the first one being always activated first. As it is, the model predicts an effect of number of syllables only for low-frequency words, because only these items are processed through the analytic route. In that case, the effect of number of syllables can be explained by the fact that syllabic units are processed sequentially (from left to right), implying that letter strings including more syllables need more sequential steps. Moreover, increasing the number of syllables leads to an increase in the number of potential ambiguities on graphosyllabic boundaries, especially for intervocalic consonants that can be assigned to the coda of the previous graphosyllable or to the onset of the next graphosyllable (e.g., *serm-on* vs. *ser-mon*). In that case, the ambiguity may also lengthen word processing (see Taft & Krebs-Lazendic, 2013). Thus, the effect found for low-frequency words in both our study and that of Ferrand and New (2003) may be due to the variation of number of syllables between the two relevant conditions of words.

The MTM model does not predict an effect for high-frequency words and for pseudowords because these stimuli are processed through the global processing route (Ferrand & New, 2003). However, recent studies (Chetail & Content, 2012, 2013, in press) and the results of Experiment 2 suggest that during early orthographic processing, letter strings are parsed into orthographic units based on the organisation of CV letters, each vowel cluster being the core of a unit. Modifying the global processing route of the MTM model to implement a sequential procedure based on vowel-centred units would account for a slower processing of high-frequency words and pseudowords with more orthographic units (e.g., *éclair* vs. *étaler*, as in Experiment 1), whereas items with the same number of orthographic units (e.g., *bataille* vs. *balancer*, as most of the items in Ferrand & New, 2003) would lead to similar processing times despite differing in their number of (phonological) syllables. This proposition is consistent with the evidence of sequential processing with frequent words in prior studies. For example, reliable syllable frequency and priming effects were observed only for the first syllable of items (e.g., Carreiras, Ferrand, Grainger, & Perea, 2005), leading to the conclusion that syllabic codes are computed sequentially during visual word recognition and that this process arises rapidly. The fact that the number of syllables and the number of vowel-centred units were identical in the stimuli of Carreiras et al. (2005) may have hidden that the sequential processing in frequent words primarily operates on orthographic units.

Cross-linguistic studies are now required to test whether a modified MTM-based model can account for the results obtained in different languages, and whether the hypothesis that the effect of number of syllables if partly driven by the number of vowel-centred units holds true in other languages than French.

Acknowledgements

The author thanks Ludovic Ferrand for comments on a previous version of the manuscript, and Alain Content for helpful discussions during drafting.

Funding

The present research was supported by a grant from the National Fund for Scientific Research (F.R.S.-FNRS, Belgium).

References

Alario, F.-X., & Ferrand, L. (1999). A set of 400 pictures standardized for French: Norms for name agreement, image agreement, familiarity, visual complexity, image variability, and age of acquisition. *Behavior Research Methods, Instruments, & Computers*, *31*, 531–552. doi:10.3758/BF03200732

Alvarez, C. J., Carreiras, M., & de Vega, M. (2000). Syllable-frequency effect in visual word recognition: Evidence of sequential-type processing. *Psicologica*, *21*, 341–374.

Alvarez, C. J., de Vega, M., & Carreiras, M. (1998). La sílaba como unidad de activación léxica en la lectura de palabras trisílabas [The syllable as a unit of lexical activation in trisyllabic word reading]. *Psicothema*, *10*, 371–386.

Ans, B., Carbonnel, S., & Valdois, S. (1998). A connectionist multiple-trace memory model for polysyllabic word reading. *Psychological Review*, *105*, 678–723. doi:10.1037/0033-295X.105.4.678-723

Balota, D. A., Yap, M. J., Hutchison, K. A., Cortese, M. J., Kessler, B., Loftis, B., … Treiman, R. (2007). The English Lexicon Project. *Behavior Research Methods*, *39*, 445–459. doi:10.3758/BF03193014

Carreiras, M., Alvarez, C. J., & de Vega, M. (1993). Syllable frequency and visual word recognition in Spanish. *Journal of Memory and Language*, *32*, 766–780. doi:10.1006/jmla.1993.1038

Carreiras, M., Ferrand, L., Grainger, J., & Perea, M. (2005). Sequential effects of phonological priming in visual word recognition. *Psychological Science*, *16*, 585–589. doi:10.1111/j.1467-9280.2006.01821.x

Chetail, F., & Content, A. (2012). The internal structure of chaos: Letter category determines visual word perceptual units. *Journal of Memory and Language*, *67*, 371–388. doi:10.1016/j.jml.2012.07.004

Chetail, F., & Content, A. (2013). Segmentation of written words in French. *Language and Speech*, *56*, 125–144. doi:10.1177/0023830912442919

Chetail, F., & Content, A. (in press). What is the difference between OASIS and OPERA? Roughly five pixel. Orthographic structure biases the perceived length of letter strings. *Psychological Science*. doi:10.1177/0956797613500508

Chetail, F., & Mathey, S. (2009). Syllabic priming in lexical decision and naming tasks: The syllable congruency effect re-examined in French. *Canadian Journal of Experimental Psychology*, *63*, 40–48. doi:10.1037/a0012944

Chetail, F., & Mathey, S. (2011). Effect of syllabic neighbourhood as a function of syllabic neighbour length.

Psychonomic Bulletin & Review, *18*, 1–7. doi:10.3758/s13423-011- 0138-1

Coltheart, M., Rastle, K., Perry, C., Langdon, R., & Ziegler, J. (2001). DRC: A dual route cascaded model of visual word recognition and reading aloud. *Psychological Review*, *108*, 204–256. doi:10.1037/0033-295X.108.1.204

Conrad, M., Stenneken, P., & Jacobs, A. M. (2006). Associated or dissociated effects of syllable frequency in lexical decision and naming. *Psychonomic Bulletin & Review*, *13*, 339–345. doi:10.3758/BF03193854

Content, A., Mousty, P., & Radeau, M. (1990). Brulex. Une base de données lexicales informatisée pour le français écrit et parlé [Bruxel. A lexical database for written and spoken French]. *L'année Psychologique*, *90*, 551–566. doi:10.3406/psy.1990.29428

Eriksen, C. W., Pollack, M. D., & Montague, W. E. (1970). Implicit speech: Mechanism in perceptual encoding? *Journal of Experimental Psychology*, *84*, 502–507. doi:10.1037/h0029274

Ferrand, L. (2000). Reading aloud polysyllabic words and nonwords: The syllabic length effect reexamined. *Psychonomic Bulletin & Review*, *7*, 142–148. doi:10.3758/BF03210733

Ferrand, L., & New, B. (2003). Syllabic length effects in visual word recognition and naming. *Acta Psychologica*, *113*, 167–183. doi:10.1016/S0001-6918(03)00031-3

Ferrand, L., New, B., Brysbaert, M., Keuleers, E., Bonin, P., Méot, A., … Pallier, C. (2010). The French Lexicon Project: Lexical decision data for 38,840 French words and 38,840 pseudowords. *Behavior Research Methods*, *42*, 488–496. doi:10.3758/BRM.42.2.488

Forster, K. I., & Chambers, S. M. (1973). Lexical access and naming time. *Journal of Verbal Learning and Verbal Behavior*, *12*, 627–635. doi:10.1016/S0022-5371(73)80042-8

Forster, K. I., & Forster, J. C. (2003). DMDX: A windows display program with millisecond accuracy. *Behavior Research Methods, Instruments, & Computers*, *35*, 116–124. doi:10.3758/BF03195503

Frederiksen, J. R., & Kroll, J. F. (1976). Spelling and sound: Approaches to the internal lexicon. *Journal of Experimental Psychology: Human Perception and Performance*, *2*, 361–379. doi:10.1037/0096-1523.2.3.361

Jared, D., & Seidenberg, M. S. (1990). Naming multisyllabic words. *Journal of Experimental Psychology: Human Perception and Performance*, *16*, 92–105. doi:10.1037/0096-1523.16.1.92

Klapp, S. T., Anderson, W. G., & Berrian, R. W. (1973). Implicit speech in reading: Reconsidered. *Journal of Experimental Psychology*, *100*, 368–374. doi:10.1037/h0035471

Mason, M. (1978). From print to sound in mature readers as a function of reader ability and two forms of orthographic regularity. *Memory & Cognition*, *6*, 568–581. doi:10.3758/BF03198246

Mathey, S., & Zagar, D. (2002). Lexical similarity in visual word recognition: The effect of syllabic neighbourhood in French. *Current Psychology Letters: Behaviour, Brain & Cognition*, *8*, 107–121.

Morrison, C. M., Chappell, T. D., & Ellis, A. W. (1997). Age of acquisition norms for a large set of object names and their relation to adult estimates and other variables. *Quarterly Journal of Experimental Psychology*, *50*, 528–559. doi:10.1080/027249897392017

Muncer, S. J., & Knight, D. C. (2012). The bigram trough hypothesis and the syllable number effect in lexical decision. *Quarterly Journal of Experimental Psychology*, *65*, 2221–2230. doi:10.1080/17470218.2012.697176

New, B., Ferrand, L., Pallier, C., & Brysbaert, M. (2006). Reexamining the word length effect in visual word recognition: New evidence from the English Lexicon Project. *Psychonomic Bulletin & Review*, *13*, 45–52. doi:10.3758/BF03193811

New, B., Pallier, C., Brysbaert, M., & Ferrand, L. (2004). Lexique 2: A new French lexical database. *Behavior Research Methods, Instruments, & Computers*, *36*, 516–524. doi:10.3758/BF03195598

Perea, M., & Carreiras, M. (1998). Effects of syllable frequency and syllable neighborhood frequency in visual word recognition. *Journal of Experimental Psychology: Human Perception and Performance*, *24*, 134–144. doi:10.1037/0096-1523.24.1.134

Richardson, J. T. (1976). The effects of stimulus attributes upon latency of word recognition. *British Journal of Psychology*, *67*, 315–325. doi:10.1111/j.2044-8295.1976.tb01518.x

Seidenberg, M. S., & McClelland, J. L. (1989). A distributed, developmental model of word recognition and naming. *Psychological Review*, *96*, 523–568. doi:10.1037/0033-295X.96.4.523

Stenneken, P., Conrad, M., & Jacobs, A. M. (2007). Processing of syllables in production and recognition tasks. *Journal of Psycholinguistic Research*, *36*, 65–78. doi:10.1007/s10936-006-9033-8

Taft, M., & Krebs-Lazendic, L. (2013). The role of orthographic syllable structure in assigning letters to their position in visual word recognition. *Journal of Memory and Language*, *68*, 85–97. doi:10.1016/j.jml.2012.10.004

Yap, M. J., & Balota, D. A. (2009). Visual word recognition of multisyllabic words. *Journal of Memory and Language*, *60*, 502–529. doi:10.1016/j.jml.2009.02.001

Appendix. List of the stimuli used in Experiment 1.

Bisyllabic	Trisyllabic	Bisyllabic	Trisyllabic
High-frequency words		*Low-frequency words*	
normal	numéro	manoir	mutilé
voyage	vérité	caviar	kimono
action	arrivé	astuce	assidu
hasard	arrêté	affect	anémie
désert	décidé	astral	avachi
direct	député	dosage	domino
étoile	éviter	escroc	erroné
éclair	étaler	impact	indigo
intact	infini	junior	jubilé
fierté	favori	castor	cagibi
canard	canapé	lacune	lavabo
croisé	coloré	limace	lycéen
calcul	comité	minime	mimosa
offrir	occupé	homard	otarie
public	paysan	pastis	parité
police	poésie	sacrer	saturé
relief	retiré	senior	séisme
régime	réussi	sénile	cécité
signal	cinéma	thorax	torero
valise	vanité	hublot	utopie
Pseudowords			
Bisyllabic	Trisyllabic	Bisyllabic	Trisyllabic
nurlir	codalé	moitar	moruvé
vorect	varumé	cadior	calovi
actove	arrolu	assior	assulo
astire	avouté	assiec	apolie
dénars	duropé	aspril	acolie
daltré	dimosé	donive	divabo
étroul	évolon	espoul	érasie
éclane	étomie	andict	invali
intric	indonu	juciur	varesé
fiedré	fosibé	caspir	casipé
capour	canocé	livute	varaci
cloivé	cosodi	licare	livéen
culval	curipé	misame	mitolé
ocrail	appali	ocrale	ovusie
piclac	réisté	pasmir	susacé
pusave	poélue	sudrin	siludé
rasief	rasodi	sarpir	séispé
révide	raléen	ralase	ruséen
sigrut	sinulo	sigrot	sinura
vadoce	varonu	vacole	varoli