British Journal of Developmental Psychology (2009), 27, 761–766

The British Psychological Society

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Brief report

Morphological effects in children word reading: A priming study in fourth graders

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A growing corpus of evidence suggests that morphology could play a role in reading acquisition, and that young readers could be sensitive to the morphemic structure of written words. In the present experiment, we examined whether and when morphological information is activated in word recognition. French fourth graders made visual lexical decisions to derived words preceded by primes sharing either a morphological or an orthographic relationship with the target. Results showed significant and equivalent facilitation priming effects in cases of morphologically and orthographically related primes at the shortest prime duration, and a significant facilitation priming effect in the case of only morphologically related primes at the longer prime duration. Thus, these results strongly suggest that a morphological level is involved in children's visual word recognition, although it is not distinct from the formal one at an early stage of word processing.

Recent developmental studies conducted on alphabetical scripts have evidenced morphological effects on word reading in child readers, suggesting that, beyond the alphabetical principle, morphological units may participate in written word processing. Although such effects have mostly been obtained in English child readers, extension to other languages, such as French, still requires examination.

In English-speaking children, derived words (e.g. *dancer*) have been shown to be read more accurately than pseudo-derived words, i.e. monomorphemic words ending with a morpheme-like unit (e.g. *dinner*) as early as 7 years (Laxon, Rickard, & Coltheart, 1992)

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DOI:10.1348/026151008X389575

and grade 2 (Carlisle & Stone, 2003). In French, while pseudo-words have been shown to be read more accurately when they are made up of morphemes, no impact has been found on word reading in first and second graders (Marec Breton, Gombert, & Colé, 2005). The fact that English has a deep orthography, entailing a weaker reliance on sole grapheme–phoneme correspondences for word decoding, could explain this discrepancy. Taking morphemes into account could assist word reading. Indeed, Carlisle and Stone (2003) found that English-speaking third graders read less accurately derived words that were phonologically changed – i.e. with a phonological change of the stem in the derived form (e.g. nature – natural) – than phonologically stable words without phonological change. This indicates that morphology could assist word decoding in English readers. An influence of morphological information has also been shown in English-speaking fourth and sixth graders, whose reading performance has been found to be influenced by both the family size (number of word family members) and the base word frequency (Carlisle & Katz, 2006). Whether children from grade three and above do process morphology while reading words in more transparent languages remains unclear. In Italian, a more transparent language than French, Burani, Marcolini, and Stella (2002) have reported that third to fifth graders named faster and more accurately pseudo-words made up of morphemes than control ones. Those pseudo-words tended to be more frequently accepted as words in the lexical decision task. Such a pattern is interpreted as reflecting morpho-lexical processing: morphemes are processed as wholes, thus speeding the decoding process. To date, however, there is no evidence that morphological information is processed during word reading in languages such as French. It has been suggested that large units may be activated during less frequent word processing. According to Ehri (1999), these units may or may not coincide with morphemes. It is inversely possible that specific processing takes place for morpheme units (Burani *et al.*, 2002).

The priming paradigm offers a powerful tool in investigating whether – and when – the morphological level is involved in visual word recognition. In priming studies, the impact of prime duration is examined together with the effect of the nature of the prime, allowing the 'tracking' of the temporal course of both morphological and orthographic information. In the adult literature, morphological priming has been shown to differ from both orthographic and semantic priming, with a greater facilitation effect for morphological priming, particularly at longer prime durations (Feldman, 2000). Whether morphological priming effects differ from orthographic ones according to prime duration suggests that distinct levels of representation are involved in word processing. In addition, such a paradigm allows us to examine whether morphological effects occur early or late in the processing.

To date, no morphological priming study has been conducted on child word recognition. The aim of the present study was to examine whether morphological priming may be observed in French fourth grade readers, that is among developing readers with reading experience, and to examine to what extent it differs from orthographic priming. In order to track the time course of these effects, two prime durations were used: a relatively short duration (75 ms) and a longer one (250 ms). Given that morphological effects have been found with short stimulus onset asynchronies (SOAs) of 42 ms in expert readers, we lengthened this short duration to 75 ms to ensure that the children could process the prime. The 250 ms SOA was designed to provide a contrasted longer SOA. Therefore, we examined how the prior presentation of a prime word affects lexical decisions on target items as a function of: (a) the nature of the relationship between primes and targets and (b) the prime duration (75 ms vs. 250 ms).

Method

Participants

Fifty-three fourth graders, all French native speakers, participated in the experiment. They all were students at an elementary school located in Calais, in northern France. All participants reported normal or corrected-to-normal vision. They were divided into two groups: 26 children (mean age: 9 years 8 months) and 27 children (mean age: 9 years 8 months) performed the experiment respectively with the 75 ms and with the 250 ms prime duration.

Several pre-tests measures were collected. First, no child had significant delay in reading as assessed with the 'Alouette test' (Lefavrais, 1974). In this test, children had to read aloud a text and the score takes into account both accuracy and speed (mean for 75 ms group = 9 years 8 months; mean for 250 ms group = 9 years 7 months, ns). Second, as assessed with the Raven progressives matrices (Raven, 1976; Cronbach's $\alpha = .94$) – in which children are asked to select the missing segment required to complete a larger pattern from six possible options – no significant delay in non-verbal abilities was found. Third, groups were matched on vocabulary, as assessed by the EVIP test (Dunn, Thiérault, & Dunn, 1993; Cronbach's $\alpha = .81$) in which children are asked to select the picture that corresponds to the word said by the experimenter from four possible options. In addition, morphological awareness was assessed with the sentence completion task (from Casalis, Colé, & Sopo, 2004; Cronbach's $\alpha = .79$): children had to complete a sentence with a derived word, given a base (e.g. the man who lies is a . . . liar). Groups were matched on this measure.

Design and stimuli

Thirteen suffixed words were selected as targets (see Appendix). Each target word was tested in the three priming conditions: (1) morphological priming (e.g. *LAVEUR-lavage – CLEANER-cleaning*), (2) orthographic priming (e.g. *LAVANDE-lavage – LAVENDER-cleaning*), and (3) unrelated priming (e.g. *MOUTARDE-lavage – MUSTARD-cleaning*). All words had regular grapheme-phoneme correspondences. Three different lists were built. Each target was thus presented three times, once in each list, with a different prime condition in each list. The three categories of primes were equally present in each list. Each child was administered all three lists in three different sessions, so each child was presented with all priming conditions for each target word. A repeated measures paradigm was chosen because of the risk of high variability among children in lexical decision latencies. To limit inherent effects in repetition such as impact of an episodic memory trace, each test session was separated by one week. In addition, 11 words were added as fillers. Fillers were close to unrelated primes, except that they were not specifically matched in length and frequency to other primes. Twenty-four prime-pseudo-word pairs were constructed for the purpose of the lexical decision task. Each pseudo-word was preceded by a real word – matched on length and frequency with primes of target words. Pseudo-words were constructed by changing one or two letters from a word. Endings of pseudo-words were matched to endings of words. In all, each participant had 144 lexical decisions, split into three lists, to perform. There were eight practice trials in each session. The experiment manipulated the priming condition (morphological vs. orthographical vs. unrelated), and the prime duration (75 ms vs. 250 ms) in a 3×2 factorial design. Order of list administration was randomized. In order to examine the possible effect of repetition, the order of list administration was entered into the analysis.

Procedure

Items were presented on a high resolution VGA colour screen on a DELL portable computer using a DOTNET program. Items were typed in 24-point Times font. Participants were placed about 40 cm from the screen. Children were asked to decide whether the letter sequence was a word or not. They indicated their decisions by pressing one of the two responses buttons. 'Yes' was given with the dominant hand. At the beginning of each trial, participants had to focus on the fixation cross-displayed in the middle of the screen without moving their eyes. Then, 100 ms later, a forward mask (a string of hash marks) appeared centered on the screen for 500 ms. Then, a prime word was presented. There were two prime durations: 75 and 250 ms.

Primes in uppercase were immediately replaced by the target in lowercase. Lowercase was chosen since it is more familiar to children. In addition, accents, which are present in lowercase and not in uppercase, are very informative in French. The target remained until the child response. No feedback was provided.

Results

Response latencies were analyzed on correct responses only (1.20% errors). Latencies longer than 4,000 ms were not taken into account (outliers accounted for less than 1% of the responses). Data were first analyzed in a mixed-design analysis of variance with one between-subject factor (prime duration: 75 and 250 ms) and two within subject-factor priming factors (condition: morphological, orthographic, and unrelated; and list order: 1,2, and 3). List order had no main effect ($F < 1$) and did not interact with prime duration ($F < 1$) or condition ($F < 1$). Thus, this factor was not considered further.

There was no difference between prime duration groups (mean for the 75 ms prime duration group = 1139 ms, mean for the 250 ms prime duration group = 1175 ms, $F < 1$). There was a main effect of condition ($F(2, 102) = 6.75$, $MSE = 12385$, $p < .01$), which interacted with prime duration ($F(2, 102) = 4.90$, $MSE = 12385$, $p < .05$). Thus response latencies were sensitive to priming condition depending on the prime duration. In order to examine the priming effects in more detail, separate analyses were conducted for each group. Data are presented Table 1.

Table 1. Mean lexical decision latencies for correct responses (percentage of errors) and priming effects

	Prime duration	
	75 ms	250 ms
Unrelated	1200 (2.18)	1195 (1.01)
Morphological	1132 (1.45)	1123 (0.67)
Orthographic	1133 (1.45)	1236 (1.35)
Effect (U–M)	68**	72*
Effect (U–O)	67**	− 41
Effect (O–M)	1	113**

Note. U, unrelated; M, morphological; O, orthographic conditions.
*$p < .05$; **$p < .01$.

Prime duration 75 ms

There was a main effect of priming condition ($F(2, 50) = 4.01$, $MSE = 10107$, $p < .05$). Newmann–Keuls comparisons revealed that both the orthographic and morphological

conditions differed from the unrelated one ($p < .01$) and did not differ from each other. Additionally, priming facilitation was similar in the orthographic (67 ms) and morphological (68 ms) conditions.

Prime duration 250 ms

There was a main effect of priming conditions ($F(2, 52) = 7.2$, $MSE = 14576$, $p < .01$). Pairwise comparisons (Newmann–Keuls) revealed that the morphological condition differed from both the orthographic ($p < .01$) and unrelated ($p < .05$, with facilitation effect = 72 ms) conditions. The difference between the orthographic and unrelated conditions did not reach significance ($p = .10$).

Discussion

Priming in visual word recognition was evidenced in French fourth grade readers for orthographic and morphological conditions and the pattern of priming differed across prime duration conditions. Words are recognized more quickly when they are preceded by a morphological or an orthographic related word than preceded by an unrelated word. At 75 ms, there was a significant facilitation priming for both orthographic and morphological conditions, with effects of very close amplitude. At 250 ms, only the morphological condition produced facilitation. Thus, while significant priming was observed, the time course of orthographic and morphological priming differs, suggesting distinct levels of representation. Morphological priming differs from orthographic priming only at the long prime duration (250 ms), although it is not distinguishable from orthographic activation at the very early stage of processing. These patterns of activation indicate a morphological activation during word recognition in French fourth graders with distinct orthographic and morphological information. It is important to underline that these data have been obtained in the French language – a more transparent orthography than English – suggesting that morphological processing is not only involved in assisting irregular grapheme–phoneme correspondences in developing readers. This can be taken as further evidence that morphological information facilitates word recognition in a silent reading task. At an empirical level, our findings help demonstrate that the priming paradigm is particularly relevant to examining the extent to which orthographic and morphological activation may be distinguished in the course of word processing. Further studies are needed to examine whether this morphological activation participates in word processing early or late in the reading acquisition course.

Acknowledgements

This research was supported by the French Agence Nationale de la Recherche (ANR) grant, program 'Apprentissage, Connaissances et Société', project LECT MORPHO ANR-06-APPR-06 (award to S. Casalis).

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Received 13 May 2008; revised version received 6 November 2008

Appendix. Stimuli used in the experiment

	Target	Morphological prime	Orthographic prime	Unrelated prime
	Arrosoir	Arrosage	Arrondi	Fanfare
	Baignoire	Baigneur	Baisse	Gravier
	Balançoire	Balancier	Baladeur	Confetti
	Bavoir	Bavure	Bavard	Guidon
	Berceau	Bercer	Berger	Citron
	Bougie	Bougeoir	Bouger	Testament
	Bricolage	Bricoleur	Brigadier	Orphelin
	Fermier	Fermette	Fermer	Marteau
	Lavage	Laveur	Lavande	Moutarde
	Mariage	Marier	Marine	Climat
	Menteur	Mensonge	Menthe	Chandail
	Plongeoir	Plongeur	Plombier	Réussite
Mean frequency (per million)	12.6	2.81	14.16	9.19

Mean frequency: from the Manulex database (Lété, Sprenger-Charolles, & Colé, 2004).