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Substituted-letter and transposed-letter effects in a masked priming paradigm with French developing readers and dyslexics

Bernard Lété [a,*], Michel Fayol [b]

[a] Laboratoire d'Étude des Mécanismes Cognitifs (EMC), Université de Lyon 2, 69676 Bron cedex, France
[b] Laboratoire de Psychologie Sociale et Cognitive (LAPSCO), Université Blaise Pascal and CNRS, 63037 Clermont-Ferrand, France

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ABSTRACT

The aim of the study was to undertake a behavioral investigation of the development of automatic orthographic processing during reading acquisition in French. Following Castles and colleagues' 2007 study (*Journal of Experimental Child Psychology, 97,* 165–182) and their lexical tuning hypothesis framework, substituted-letter and transposed-letter primes were used in a masked priming paradigm with third graders, fifth graders, adults, and phonological dyslexics matched on reading level with the third graders. No priming effect was found in third graders. In adults, only a transposed-letter priming effect was found; there was no substituted-letter priming effect. Finally, fifth graders and dyslexics showed both substituted-letter and transposed-letter priming effects. Priming effects between the two groups were of the same magnitude after response time (RT) *z*-score transformation. Taken together, our results show that the pattern of priming effects found by Castles and colleagues in English normal readers emerges later in French normal readers. In other words, language orthographies seem to constrain the tuning of the orthographic system, with an opaque orthography producing faster tuning of orthographic processing than more transparent orthographies because of the high level of reliance on phonological decoding while learning to read.

* Corresponding author. Fax: +33 4 78 77 43 51.
E-mail address: bernard.lete@univ-lyon2.fr (B. Lété).

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Introduction

Automatic orthographic processing in visual word identification involves three basic processes (Davis, 2010). First, readers need to build an input code to access their lexicons in the form of a sensory representation that codes both the identity and the order of the letters within the letter string. Second, this input code must be matched against abstract long-term memory representations in order to activate lexical candidates. Third, a competitive selection process makes it possible to select the best matching candidate from among the tens of thousands of words in the reader's vocabulary. The issue of how these computations are performed in a way that creates meaningful strings is a fundamental question for any model of visual word recognition (e.g., Coltheart, Rastle, Perry, Langdon, & Ziegler, 2001; Forster, 1994; Grainger & Jacobs, 1994, 1996; Grainger & Ziegler, 2007; McClelland & Rumelhart, 1981; Perry, Ziegler, & Zorzi, 2007; Plaut, McClelland, Seidenberg, & Patterson, 1996).

Although a great deal of attention has been devoted to visual word processing in experienced readers, little is known about how automatic orthographic processing skills develop while learning to read (for reviews, see Castles & Nation, 2006; Metsala & Ehri, 1998; see also Dufau et al., 2010, and Glotin et al., 2010, for two recent theoretical investigations). Despite the fact that such information is not explicitly taught, children need to master orthographic processing skills if they are to be able to fluently identify approximately 250 words per minute at the end of fifth grade (Rayner, 1998). It seems likely that the execution of each of the three above-mentioned processes will develop as a function of a child's reading ability. The first process, letter identity and letter position coding, will be affected by the way the child analyzes the string of letters, from left-to-right scanning at the beginning of reading acquisition (especially if the children is learning in a transparent orthography) to whole-word processing by the end. Once the input code has been formed correctly, the matching process will be affected by the number of encounters with the word (with high-frequency words being matched faster than low-frequency words) and, finally, the competitive selection process will be affected by the size of the child's vocabulary.

The aim of the current study was to understand how the transition from a slow and effortful word recognition system to a rapid and automatic one takes place. Following Castles, Davis, Cavalot, and Forster's (2007) empirical investigation conducted with normally developing readers learning in the context of English orthography, we studied the tuning of automatic orthographic skills in French orthography, which constitutes a more regular system than English, by examining letter identity and letter position coding using a masked priming paradigm with substituted-letter and transposed-letter nonword primes. By replicating Castles and colleagues' study in another orthographic system, we wished to gain more in-depth knowledge of how orthographic transparency constrains basic processes such as letter identity and letter position coding during reading acquisition. Moreover, we extended Castles and colleagues' study by examining priming effects in a dyslexic population in order to gain a better understanding of normal orthographic processing through the study of what happens when certain key processes are not functioning well.

Development of automatic orthographic processing skills

How do developing readers build up their orthographic processing skills so that they can correctly code the identity and position of letters in a printed word while minimizing the importance of precise letter order information? Two basic effects relating to automatic orthographic processing in experienced readers have been observed in a masked priming paradigm (see Grainger, 2008, for a thorough review), namely the substituted-letter priming effect and the transposed-letter priming effect. These two priming effects can be used to evaluate the development of automatic orthographic processing skills because they must be gradually mastered by developing readers as they develop from a slow effortful word recognition system to a rapid automatic one.

The substituted-letter priming effect (the so-called "form priming effect" reported by Forster & Davis, 1984) occurs if target recognition is facilitated when a letter in a given prime is replaced by another letter that is not present in the target (with the letter position being respected in standard substituted-letter priming). Most studies have used single letter substitution priming, mainly in the