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Research Report

An ERP investigation of orthographic priming with superset primes ☆

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ABSTRACT

Prime stimuli formed by inserting unrelated letters in a given target word (called "superset" primes) provide a means to modify the relative positions of the letters shared by prime and target. Here we examined the time-course of superset priming effects in an ERP study using the sandwich-priming paradigm. We compared the effects of superset primes formed by the insertion of unrelated letters (e.g., maurkdet–MARKET), or by the insertion of hyphens (e.g., ma-rk-et–MARKET), with identity priming (e.g., market–MARKET), all measured relative to unrelated control primes. Behavioral data revealed significantly greater priming in the hyphen-insert condition compared with the letter-insert condition. In the ERP signal, letter-insert priming emerged later than hyphen-insert priming and produced a reversed priming effect in the N400 time-window compared with the more typical N400 priming effects seen for both hyphen-insert priming and identity priming. The different pattern of priming effects seen for letter-insert primes and hyphen-insert primes suggests that compared with identity priming, letter superset priming reflects the joint influence of: (1) a disruption in letter position information, and (2) an inhibitory influence of mismatching letters.

1. Introduction

Relative-position priming has played a key role in the investigation of orthographic processing, providing important insights on how letter position information is represented and processed during the early phases of visual word recognition. In relative-position priming, primes and targets share a set of letters that respect their relative but not absolute, length-dependent position in prime and target. In the majority of prior experiments, relative-position primes were formed by the removal of letters from the target word while preserving the correct letter order (so-called subset primes; e.g., slene–SILENCE). When a subset prime immediately precedes a word target it facilitates target word recognition compared with an orthographically unrelated prime (e.g., Humphreys et al., 1990; Peressotti and Grainger, 1999;

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Grainger et al., 2006). This finding is one of the main pieces of evidence demonstrating the flexibility with which letter identities are associated with a given position in a word (see Grainger, 2008 for a review). It demonstrates that letter positions are not rigidly encoded as in standard slot-based coding schemes, such as implemented in the Interactive Activation (McClelland and Rumelhart, 1981) and the Dual Route Cascaded (DRC) models of word reading (Coltheart et al., 2001). This has given rise to several new models of letter position coding that appeal to positional noise (Gomez et al., 2008; Norris et al., 2010), spatial coding (Davis, 2010), or open-bigram coding (Grainger and Van Heuven, 2003; Whitney, 2001) as a means to accommodate these and other findings.

The present work focuses on a different form of relative-position priming, namely superset priming. In superset priming, orthographically related nonword primes are formed by inserting unrelated letters in target words while preserving the correct order of the shared letters (e.g., sile**d**n**h**ce–SILENCE). Superset priming thus allows one to examine the effects of unrelated letters on orthographic priming, in combination with the effects of relative-position priming. While prior research, to be summarized below, has provided behavioural demonstrations of superset priming, this is the first study to combine superset priming with the recording of event-related potentials (ERPs) in order to investigate the time-course of such priming effects.

In a masked priming study, Van Assche and Grainger (2006) were the first to provide evidence for superset priming. They found that superset primes formed by 1-letter and 2-letter insertions facilitated target word recognition to a similar extent as identity primes, compared with unrelated nonword primes that shared no letters with the target words. They further showed that even superset primes made of three-letter insertions produced significant priming compared with unrelated primes, albeit significantly less than identity primes. Welvaert et al. (2008) extended this work, and provided evidence for robust superset priming that varied as a function of the number of inserted letters. Importantly, in a meta-analysis of superset priming effects they found graded effects of number of inserted letters, with a small processing cost associated with each additional letter. The processing cost associated with unrelated letters in superset priming could be due to at least two factors: (1) each unrelated letter provides additional negative evidence with respect to target word identity; and (2) adding unrelated letters increases the mismatch in positional information concerning letters shared by prime and target. In the present study we compare inserted letter superset primes (e.g., maurkdet for the target MARKET) with hyphenated superset primes (e.g., ma-rk-et–MARKET) in order to examine the relative contribution of these two factors. Hyphenated primes are expected to be just as disruptive with respect to positional information, but much less disruptive in terms of negative evidence. Evidence in line with this possibility was provided by Peressotti and Grainger (1999), who found behavioural facilitation with primes formed by replacing the two central letters of 4-letter target words with a plus sign (e.g., F++R–FOUR) compared with different letter substitutions (e.g., FNBR—FOUR). Furthermore, the recording of ERPs will provide important additional constraints on possible interpretations of these priming effects, given existing knowledge of the time-course of relative-position priming.

Prior research investigating relative-position priming effects using ERPs and subset primes (Carreiras et al., 2009; Grainger and Holcomb, 2009a; Ktori et al., 2012) has shown early priming effects on the N250 ERP component. Most important, with respect to the present study, is that priming effects with hyphenated subset primes (e.g., c-lle-t–COLLECT) emerged during the early part of the N250 ERP component (200–250 ms post-target onset), whereas priming effects with concatenated subset primes (e.g., cllet–COLLECT) emerged during the later part of the N250 component (250–300 ms post-target onset). Furthermore, it was found that displacing prime stimuli horizontally with respect to target stimuli wiped-out the earlier hyphenated priming effects but did not affect the later concatenated priming effects (Ktori et al., 2012). Hyphenated and concatenated subset primes, however, were found to produce a similar pattern of priming effects in the N400 time-window (300–500 ms post-target onset), in line with the behavioural evidence for no difference between these priming conditions (Grainger et al., 2006; Peressotti and Grainger, 1999). These results suggest that hyphens indeed provide positional information that leads to greater subset priming in the early phase of orthographic processing, when letter positions are coded using gaze-centered coordinates (Grainger and Van Heuven, 2003)[1]. They also suggest that the hyphens are not generating significant interference in later phases of orthographic processing, when letter positions are coded using length-independent word-centered coordinates. The hyphenated superset priming condition to be tested in the present study should therefore provide a baseline with which the effects of unrelated letters can be evaluated. Any difference between the hyphenated and inserted letter conditions will provide evidence that the unrelated letters are doing more than just disrupting positional information.

2. Results

2.1. *Behavioral data*

All correct lexical decisions less than 1500 ms post-target onset (92.1% of all data) and response error rate were included in the behavioral analyses. 3 (Prime Type) × 2 (Relatedness) within-groups ANOVAs were conducted separately on the mean RTs and percentage of errors per experimental condition for word and nonword stimuli, with participants (F_1) and items (F_2) as random variables. Mean RTs and % Errors to words and nonwords for each type of prime (identity, hyphen-insert, letter-insert) across related and unrelated conditions are presented in Table 1.

For words, analyses on mean RT revealed that the main effect of Prime Type ($F_1(2, 38)=13.46$, $p<.001$; $F_2(2, 472)=6.98$,

[1]More precisely, the early phase of the N250 has been linked with the mapping of location-specific letter representations onto location-invariant sublexical representations, while the later phase of the N250 has been associated with the mapping of location invariant sublexical orthographic representations onto whole-word representations (Grainger and Holcomb, 2009b).