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Early semantic activation in a semantic categorization task with masked primes: Cascaded or not?

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ABSTRACT

The assumption that activation is cascaded implies that the semantic properties of all neighbors of the input word are activated to varying degrees. This assumption is tested using masked priming in a semantic categorization experiment, where the prime belongs to the same category as the target (a congruent prime), or to a different category (an incongruent prime). In Experiment 1, the prime was a nonword neighbor of an exemplar or non-exemplar of the category, and a clear congruence effect was produced, even though the orthographic overlap was fairly low (e.g., *lucchibi-zucchini*). In Experiment 2, the prime was a word neighbor (e.g., *capable-cabbage*), which eliminates the possibility that the prime was simply interpreted as equivalent to the nearest task-relevant word, but a congruence effect was still obtained. Experiment 3 replicated this effect. Experiments 4–6 investigated the possible role of the category using a two-alternative forced choice discrimination task, where the task was simply to guess which of two subsequently presented words was more similar in meaning to the masked word. Despite better than chance performance when the masked word was related to one of the alternatives, performance was at chance when the masked word was a neighbor of a word that was related to one of the alternatives, indicating that semantic activation is not normally cascaded. It is concluded that the categorization task fundamentally alters the way in which a masked word is processed.

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Introduction

A fundamental distinction between different architectural models of visual word recognition is the contrast between staged models (also known as "form-first" models), and cascaded models (McClelland, 1979). In a staged model of lexical processing, it is assumed that the process of identifying a word (i.e., finding and confirming a match between the input and a lexical representation) must be completed before retrieving its semantic properties. This is true in serial models (Forster, 1976; Forster & Hector, 2002), where a search process must identify a lexical entry that is a perfect match for the input before any higher-level processing occurs. It is also true in parallel activation models such as the logogen model (Morton, 1969), where activation in a given logogen must reach threshold before semantic activation can occur. Such a restriction is explicitly rejected in parallel activation models based on the Interactive Activation Model (McClelland & Rumelhart, 1981). In this type of model, there is no threshold mechanism, and activation is continuously passed from one level to the next. A prominent example of such an approach is the Dual Route Cascaded model of word reading (DRC) proposed by Coltheart, Rastle, Perry, Langdon, and Ziegler (2001). In this model, activation is passed forward to a semantic level continuously. Because of the method by

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which activation is generated, all words that have any orthographic overlap with the input must receive some activation, and hence the semantic properties of these words must also be activated to varying degrees. This would result in a very complex pattern of activity at the semantic level, which would remain so until the competitive process between word units was resolved, and only one word unit remained active. The same conclusion applies in the case of connectionist models of word recognition (e.g., Harm & Seidenberg, 2004), where activation is immediately passed from orthographic units to both phonological and semantic units, with feedback from semantic units playing a role in eventually resolving the input.

Coltheart et al. (2001) justify the cascaded assumption on the following grounds. If the system is thresholded, then a nonword could never activate the properties of a word. However, as Glushko (1979) observed, the pronunciation of nonwords is influenced by their similarity to words. For example, Glushko showed that the pronunciation latencies of nonwords such as *heaf* that overlapped with an inconsistent word (*deaf*) were longer than the latencies of nonwords such as *hean* that overlapped with a consistent word (e.g., *bean*). The implication is that the phonology of *deaf* must have been activated by the nonword *heaf*, which would violate the assumptions of a thresholded model. Thus the phonological properties of all words that overlap orthographically with the input must be presumed to be activated. Thus cascaded activation allows for interaction between processing modules, in this case, both at the level of form. Whether the same applies to modules operating at different levels is another matter. Despite the importance of this issue for an understanding of the basic architectural features of information processing, relatively little effort has been devoted to demonstrating the existence of cascaded semantic activation.

One piece of evidence that is certainly consistent with cascaded activation is the so-called *turple* effect. Forster and Hector (2002) found that in a semantic categorization task, nonword neighbors of words were categorized more slowly than a nonword with no neighbors if the word neighbor was an exemplar of the category. This was not the case for nonword neighbors of non-exemplars. Thus, when the task was to detect animal names, a nonword such as *turple* (neighbor of *turtle*) was rejected more slowly than a nonword such as *firtan* (neighbor of no word), but a nonword such as *tabric* (neighbor of *fabric*) did not take any longer to reject than *firtan*, as it would have in a lexical decision task. This result supports cascaded activation in that it implies that semantic processing occurs early enough to interact with form processing. The specific nature of this interaction could include forcing a more careful examination of the spelling of the candidate, or extending the deadline for a "no" decision. Rodd (2004) extended this finding by performing a similar experiment but with word neighbors of animal exemplars (e.g. *leotard* for *leopard*) and of non-exemplars (e.g. *cellar* for *collar*). Animal neighbors were found to significantly increase reaction time when participants were monitoring the input for animal names, but not when they were monitoring for plant names. Rodd concluded that associative relations (e.g. *puppy* and *kitten*) were not the cause of the effect due to low association between adjacent items, but rather that the category at hand (*animal* vs. *plant*) was providing the semantic context for the difference. A participant looking for animals would inspect each word to be categorized in terms of members of the animal category, and a participant monitoring for plants would do so in terms of members of the plant category. However, Rodd concluded that the data do not distinguish between a staged or a cascaded account.

Bowers, Davis, and Hanley (2005) used a semantic categorization task in which some of the non-exemplar targets were orthographically related to an exemplar of the category, e.g., is *hatch* an item of clothing? Slower responses were obtained if the target letters contained an exemplar as a subset (*hatch-hat*) or if the target letters were a subset of an exemplar (*bee-beer*). Hino, Lupker, and Taylor (2012) obtained similar effects with a semantic relatedness task, showing that if the second member of a pair of unrelated words was orthographically similar to a word that was related to the first member (e.g., MISSILE-POCKET), responses were slower. No such effect was obtained when the target word was phonologically similar to the first word.

Pecher, Zeelenberg, and Wagenmakers (2005) examined long-lag repetition priming with a semantic categorization task (*animate* vs. *inanimate*), and showed that a word like *cat* would be responded to faster if the participant had previously seen *rat* than if she had seen *mat*. They further tested words with different neighborhood characteristics in terms of animacy, comparing reaction time and error rate in deciding the animacy of words with congruent neighbors like *fridge* (cf. *bridge* and *fringe*) with those of words like *cheek* (cf. *check* and *creek*), where congruence simply means belonging to the same semantic category. The category used in this experiment (animacy) was a much broader category than those used in previous studies. Their explanation of the data involves feature monitoring, in which semantic categorization is accomplished by means of selective monitoring of feature activation at the semantic level, with negative features such as "inanimate" activated by logically incompatible features such as "made of stone".

All of the studies reviewed above used experimental items that were consciously perceived and responded to. This leaves open the question of how early in lexical access the evidence for semantic categorization is gathered. In order to determine whether briefly and unconsciously perceived stimuli could influence semantic categorization, indicating early activation, the experiments described in this paper used masked primes (Forster & Davis, 1984). Masked primes, which are stimuli that are hidden from conscious perception by being presented briefly following a forward mask, are nevertheless capable of influencing the speed and accuracy of a person's response to stimuli that immediately follow them. By varying which target a given prime appears with, one can directly compare the differential effect of that prime on the response. Using this approach allows a more direct examination of the early stages of semantic categorization when the stimulus has not reached conscious identification.

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