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Repetition priming and hyperpriming in semantic dementia

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Abstract

Evidence from neurologically normal subjects suggests that repetition priming (RP) is independent of semantic processing. Therefore, we may expect patients with a selective deficit to conceptual knowledge to exhibit RP for words regardless of the integrity of their semantic representations. We tested six patients with semantic dementia (SD) on a lexical decision task that incorporated four different lags between first (baseline) and second (primed) presentation of repeated words. The patients exhibited significant RP that was greater for words that were categorised as semantically 'degraded' than for words categorised as 'known.' This RP advantage for semantically degraded words declined as lag increased. The patients also demonstrated hyperpriming, and a significant correlation was identified between baseline response time and RP in SD but not in controls. These findings indicate that level of semantic knowledge about a word influences both baseline lexical decision performance and RP of that word. The observed hyperpriming can be parsimoniously explained by a cognitive slowing account.

Keywords: Semantic knowledge; Lexical decision; Cognitive slowing; Implicit memory

1. Introduction

Recall and recognition tests of memory typically make explicit reference to, and require conscious recollection of, a specific learning episode. Memory can also be revealed, however, by a facilitation or change in performance in which information that was encoded during a previous specific episode is expressed without conscious recollection of that episode. These two types of memory were first referred to as *explicit* and *implicit* by McDougall (1924) and the same labels were adopted by Graf and Schacter (1985, 1987) and Schacter and Graf (1986). A well-established technique used to assess memory is repetition priming (RP): processing of a stimulus is facilitated as a result of a recent encounter with the same stimulus. In RP paradigms where no explicit reference is made to the initial study episode, priming effects have been interpreted as a measure of implicit memory (see Roediger & McDermott, 1993; Schacter, 1987 for reviews). When the prime and target stimuli are printed words, it is generally accepted that RP is mediated by the form-based orthographic representation of the word. Evidence that word meaning plays a role in RP has generally been restricted to priming tasks that require explicit memory (e.g., Jacoby & Dallas, 1981; Schacter & Church, 1992).

Studies from both the neuropsychological and normal literature support the view that conceptual knowledge has little or no impact on implicit RP (Moscovitch, 1992; Moscovitch & Umilta, 1990, 1991; Schacter, 1992; Tulving & Schacter, 1990). Whereas explicit tasks are strongly affected by the extent of semantic elaboration at encoding, implicit tasks are generally not affected by level-of-processing manipulations (Craik, Moscovitch, & McDowd, 1994; Graf & Mandler, 1984; Jacoby & Dallas, 1981). In contrast, change in perceptual features of the stimulus between encoding and retrieval has little impact on explicit tasks but attenuates RP effects (see Roediger & Blaxton, 1987 for a review). While visual word processing has received the most attention, the differential impact of perceptual and conceptual factors has also been noted in other domains. Using an auditory identification task, Schacter and Church found that semantic manipu-

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lation in the study phase and change in speaker's voice between study and test produced differential effects on explicit recognition and RP (Church & Schacter, 1994; Schacter & Church, 1992). In object perception, the same dissociation has been reported using different levels of elaboration at encoding and changes in view between study and test (Schacter, Cooper, & Delaney, 1990; Srinivas, 1995).

The observed dissociations between explicit and implicit memory were encompassed in Schacter's (1990, 1992) perceptual representation system (PRS) account. He argued that RP is highly dependent on structural processing of surface features and need not entail semantic processing. For objects, RP is founded on specific visual features rather than abstract or semantic properties. Similarly, auditory word RP relies on the phonological word form and even its specific acoustic properties, such as the characteristics of the voice in which the word is spoken, rather than conceptual knowledge about the word. Likewise, one of the subsystems that is proposed as part of the pre-semantic PRS is the visual word form system, which supports representation and retrieval of information about the structure of written words, but not their meanings or associative properties. In Schacter's view, RP of words occurs through the activation of word form representations and this is very different to the way in which episodic representations enable memory for particular episodes.

Despite this strong view, there is some evidence that semantic factors can influence RP. Bassili, Smith, and MacLeod (1989) tested word-stem completion of targets that were either seen or inferred at encoding and revealed significant RP for actually seen words and smaller but still reliable priming for inferred words. This result implies that there is a conceptually driven contribution to RP plus an additional contribution of perceptual processing when surface form is the same at study and test. Brown and Mitchell (1994), in a review and meta-analysis of 166 outcomes from 38 studies, demonstrated that RP was greater following semantic processing than non-semantic processing in 79% of cases. In a smaller review of only perceptual tests, RP was numerically greater in the semantic processing condition in 33 of the 35 cases (Challis & Brodbeck, 1992). It appears, therefore, that semantic factors do influence RP, but this influence can be difficult to detect in individual studies, especially when mixed rather than blocked or between-subject designs are used.

Direct evidence for a semantic influence on implicit memory has been presented by Dehaene and colleagues. They demonstrated that, despite not being consciously aware of a briefly presented and masked prime (a number word, e.g., 'NINE'), subjects exhibited inhibition or facilitation, respectively, when asked to categorise the target (a numeral, e.g., '6') as either smaller than or larger than 5 (Dehaene et al., 1998). The fact that the priming occurred at a notation-independent level of representation and depended on semantic similarity (larger or smaller than 5) rather than a simple repetition effect prompted the conclusion that semantic processes can influence non-conscious RP. This conclusion was strengthened by a subsequent imaging study that located repetition suppression (the functional-activation correlate of RP) in parts of the parietal cortex that are known to be activated when people manipulate numbers, but not in phonological or lexical tasks (Naccache & Dehaene, 2001).

Findings that semantic factors can influence RP suggest (a) that any meaningful stimulus automatically activates semantic information, which then (b) feeds activation back to more perceptual/structural levels of representation which—should that stimulus happen to occur in the near future—will (c) result in facilitation of its processing on this second occurrence. Any framework that embodies these ideas can in principle account for this pattern of results, but this set of assumptions is perhaps most explicit in the parallel distributed processing (PDP) framework (e.g., Plaut, McClelland, Seidenberg, & Patterson, 1996; Seidenberg & McClelland, 1989). In PDP models, word knowledge is distributed over processing units in three separate but highly interactive domains: orthographic, phonological, and semantic. This approach questions the assumption of many models (e.g., Coltheart, 2004) that a word-recognition task like lexical decision typically relies on activation of an orthographic or phonological lexicon, with semantic representations exerting little or no influence.

The word-recognition performance of patients with semantic dementia (SD) might be useful in assessing whether semantic processing impacts upon implicit memory. SD is a neurodegenerative condition that involves progressive and eventually severe bilateral but asymmetrical atrophy of the temporal pole, amygdala, parahippocampal gyrus (including the entorhinal cortex), anterior fusiform gyrus, and the inferior and middle temporal gyri (Galton et al., 2001), and is characterised by a relatively pure deterioration of semantic memory. SD patients, therefore, perform poorly on tasks that are dependent on semantic memory, such as picture naming, generation of definitions from a picture or name, generation of exemplars from a category, associative matching of either pictures or words, and other comprehension and general knowledge tasks. Performance in other cognitive domains is relatively unaffected, at least until late stages of the disease, with sparing of phonological and syntactic aspects of language, executive function, visuo-spatial skill, non-verbal problem solving, and at least some aspects of episodic memory (Graham, Patterson, & Hodges, 2000; Hodges, Graham, & Patterson, 1995; Hodges, Patterson, Oxbury, & Funnell, 1992; Hodges, Patterson, & Tyler, 1994; Saffran & Schwartz, 1994; Snowden, Goulding, & Neary, 1989; Warrington, 1975).

Recent research into SD suggests that deterioration in conceptual knowledge can have an impact on lower level orthographic and phonological processes. For example, it has been demonstrated that degraded semantics can affect the integrity of phonological word forms in the context of a verbal immediate serial recall task (Jefferies, Patterson, Jones, Bateman, & Lambon Ralph, 2004; Knott, Patterson, & Hodges, 1997; Patterson, Graham, & Hodges, 1994). The