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Does study duration have opposite effects on recognition and repetition priming?

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ABSTRACT

We investigated whether manipulating the duration for which an item is studied has opposite effects on recognition memory and repetition priming, as has been reported by Voss and Gonsalves (2010). Robust evidence of this would support the idea that distinct explicit and implicit memory systems drive recognition and priming, and would constitute evidence against a single-system model (Berry, Shanks, Speekenbrink, & Henson, 2012). Across seven experiments using study durations ranging from 40 ms to 2250 ms, and two different priming tasks (a classification task in Experiments 1a, 2a, 3a, and 4, and a continuous identification with recognition (CID-R) task in Experiments 1b, 2b, and 3b), we found that although a longer study duration improved subsequent recognition in each experiment, there was either no detectable effect on priming (Experiments 1a, 2a, and 4) or a similar effect to that on recognition, albeit smaller in magnitude (Experiments 1b, 2b, 3a, and 3b). Our findings (1) question whether study duration has opposite effects on recognition and priming, and (2) are robustly consistent with a single-system model of recognition and priming.

Introduction

Comparisons of recognition memory and long-term repetition priming have played a major role in the development of theories of the organization of memory (Squire & Dede, 2015; Tulving & Schacter, 1990). Recognition memory refers to the capacity to judge whether an item (e.g., a word or object) has been presented before in a particular context. Long-term repetition priming (henceforth priming) refers to a change in identification, detection, or production of an item, which occurs as a result of prior exposure to the same or a similar item. This change is often evident as an improvement in performance and can persist over minutes or longer (and so can be considered *long-term*). For example, identification latencies of objects that have been presented before in a study phase tend to be shorter than those of novel nonpresented items. Individuals with amnesia, arising from damage to the medial temporal lobes/hippocampus, show marked deficits in recognition memory, and yet their capacity to show priming can be left relatively intact, compared to normal adults (e.g., Hamann & Squire, 1997; Schacter, Chiu, & Ochsner, 1993). Various experimental manipulations have also been shown to differentially affect recognition and priming in healthy individuals and, together with the findings from amnesic individuals, have been used to support the now widely held *multiple-systems* view that recognition and priming are driven by functionally and neurally distinct explicit and implicit memory systems in the brain (Gabrieli, 1998; Squire, 2004; Squire & Dede, 2015; Tulving & Schacter, 1990).

Despite decades of research, the idea that there exists a sharp distinction between explicit and implicit memory systems is still disputed (see e.g., Addante, 2015; Berry, Shanks, Speekenbrink, & Henson, 2012; Dew & Cabeza, 2011; Hannula & Greene, 2012; Henke, 2010; Reder, Park, & Kieffaber, 2009; Shanks & Berry, 2012). Recognition memory and priming, in particular, may not be independent from one another as once thought. Many experimental factors that were initially believed to selectively affect either recognition or priming (providing evidence for a single dissociation) have since been shown to have similar effects on recognition and priming. This has been shown, for example, with the effects of normal aging (Ward, Berry, & Shanks, 2013a, 2013b), divisions of attention at encoding (Berry, Henson, & Shanks, 2006), retroactive interference (Eakin & Smith, 2012), changes in presentation modality between study and test phases (Craik, Moscovitch, & McDowd, 1994; Mulligan & Osborn, 2009), levels of processing (Brown & Mitchell, 1994), and also amnesia (Berry,

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Kessels, Wester, & Shanks, 2014; Ostergaard, 1999). This highlights a well-known limitation with the use of single dissociations (and Null Hypothesis Significance Testing) as evidence for multiple systems, which is that they rely on concluding that an effect of a variable on either recognition or priming is absent. Such a conclusion is problematic given that the variable may actually have an effect that, in reality, is relatively small and hard to detect, particularly if the sensitivity of the task is relatively low (Buchner & Wippich, 2000; Dunn, 2003). The same limitation applies when two single dissociations are used together to provide evidence of a double dissociation (see Dunn, 2003).

Stronger support for the notion that recognition and priming are driven by multiple systems would be a crossover dissociation, that is, a demonstration that an independent variable has opposite effects on recognition and priming. Such evidence, however, is rare. One classic example was reported by Jacoby (1983), who found that generating a target word from its antonym in the study phase (i.e., generate the word 'cold' from the cue 'hot-???') led to greater subsequent recognition of the target compared to when a target word had simply been read during study. In contrast, the same encoding manipulation produced less priming (in a perceptual identification task) for items that were generated rather than read. This pattern has been replicated by others (e.g., Blaxton, 1989; Masson & MacLeod, 1992) and has also been demonstrated with auditory stimuli (e.g., Dew & Mulligan, 2008), and suggests that recognition and priming rely on different sources of information. However, this dissociation can alternatively be interpreted in terms of the principle of transfer appropriate processing, whereby recognition and priming in the perceptual identification task differentially rely upon conceptual and perceptual processes, rather than distinct explicit and implicit memory systems (Blaxton, 1989; Jacoby, 1983). The idea is that generating a word evokes conceptual processing, which supports greater performance on a recognition task that draws heavily upon this type of processing. Conversely, reading a word evokes perceptual processing, supporting greater perceptual priming for the item. The production of a crossover dissociation using a read-generate manipulation at encoding also seems to critically depend upon words being generated from antonyms at encoding, since other methods of generating targets do not produce a reversal in the generation effect in priming (see Mulligan & Dew, 2009). On the whole, read-generate manipulations only produce a crossover dissociation between recognition and priming under very specific conditions, and, even when produced, may not necessarily reflect the operations of distinct explicit and implicit memory systems.

Other evidence for a crossover dissociation was more recently provided by Voss and Gonsalves (2010), who reported that study duration has opposite effects on recognition and priming. In the study phase of their experiment, participants classified pictures of objects presented for a brief (250 ms) or long duration (2000 ms) as natural or manmade. In the test phase, participants were presented with previously studied pictures of objects (half that were previously presented for a brief duration, and half for a long duration), and new objects for 500 ms, and once again were asked to classify the items as natural or manmade. The priming effect was calculated as the mean classification RT to new items minus the mean classification RT to old items (brief or long). After each classification, an old/new recognition judgment was made. Significant priming effects were found for both brief and long items, but, crucially, the mean priming effect was 19 ms (95% CI [6, 32], Cohen's d_z = 0.855, estimated from the results in Voss and Gonsalves) greater for brief items than for long items. The recognition results showed the opposite pattern: the proportion of long items correctly judged old (hits) was significantly greater than the proportion of brief items correctly judged old. (Both long and brief items were also judged old more often than new items.)

Voss and Gonsalves (2010) also measured event-related potential (ERP) responses during the test phase. The main findings here were that ERPs to objects that had been studied for a brief duration were more negative than those for new objects at parieto-occipital electrodes in the 200–400 ms interval after the stimulus onset at test, and this was not observed for long items. Instead, ERPs to objects that had been studied for a long duration were more positive in central-parietal electrodes in the 400–600 ms interval, relative to new objects, and this was not found for brief items. Given the behavioural differences between priming and recognition for brief and long conditions, the early negative repetition effects for brief items were attributed to priming, and the later positive effects were attributed to explicit remembering. The overall findings were taken as evidence against a single-system view of recognition and priming, and instead were taken to support a multiple systems view in which study duration differentially engages independent explicit and implicit memory systems at encoding.

Earlier studies looked at the effects of study duration on recognition and priming, but the majority used relatively long durations even in the brief condition (i.e., 1s or longer), and reported single dissociations in which longer durations improved recognition but had little or no effect on priming (e.g., comparing durations of 1s vs. 3s in Jacoby & Dallas, 1981; 1s vs. 10s in Musen, 1991; 1s, 3s, vs. 6.5s in Neill, Beck, Bottalico, & Molloy, 1990). von Hippel and Hawkins (1994) used study durations shorter than 1s, and found that performance in two explicit memory tasks (graphemic and semantic cued recall) and three implicit memory tasks (word fragment completion, perceptual identification and general knowledge) tended to be better as study duration increased from 50 ms to 2000 ms, and no dissociation was observed in their study. The authors did not include a recognition task, however, and recognition memory might reasonably be expected to increase across such brief durations. Indeed, Wichmann, Sharpe, and Gegenfurtner (2002) found that recognition memory (for scenes) increased reliably across study durations of 50–1067 ms, though this study did not include a priming measure.

Although a few studies have found that priming is not a monotonically increasing function of study duration (e.g., Miyoshi & Ashida, 2014; Miyoshi, Kimura, & Ashida, 2015; Zago, Fenske, Aminoff, & Bar, 2005), these studies either did not additionally examine recognition (Miyoshi et al., 2015; Zago et al., 2005), or, if recognition was also examined, found no evidence of a dissociation (Miyoshi & Ashida, 2014; though this study was particularly focused on recognition accuracy for guesses). These studies are discussed further in the *General Discussion*. The study by Voss and Gonsalves (2010) is, to our knowledge, the first to demonstrate that study duration produces a crossover dissociation between recognition and priming when the encoding conditions are identical for both tasks. We regard such demonstrations as more compelling than comparisons of individual priming or recognition conditions from different studies because they help to limit the range of alternative explanations of the dissociation (see also Ryan & Cohen, 2003).

Why might a brief study duration cause greater priming than a long one? Voss and Gonsalves (2010) offered two potential explanations. A study duration of approximately 250 ms might be optimal if priming is driven by neural "sharpening" and "selection" processes. Indeed Zago et al. (2005) observed a duration-dependent rise and fall of cortical brain deactivation in a functional magnetic resonance imaging (fMRI) study of priming. An alternative transfer-appropriate processing hypothesis is that the rapid perceptual processing required to identify a briefly-presented study item, as compared to a long-duration study item, transfers better to the test phase, which also requires rapid identification.

If study duration has opposite effects on recognition and priming then this would pose a serious challenge for single-system theories