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The relationship between divided attention and implicit memory: A meta-analysis

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ABSTRACT

This article reports a meta-analysis comparing the size of repetition priming in full and divided-attention (DA) conditions. The main analysis included 38 effect sizes (ES) extracted from 21 empirical studies, for a total of 2074 (full-attention) and 2148 (divided-attention) participants. The mean weighted ES was 0.357 (95% CI = 0.278–0.435), indicating that divided attention produced a small, but significant, negative effect on implicit memory. Overall, the distinction between identification and production priming provided the best fit to empirical data (with the effect of DA being greater for production tests), whereas there was no significant difference between perceptual and conceptual priming. A series of focused contrasts suggested that word-stem completion might be influenced by lexical–conceptual processes, and that perceptual identification might involve a productive component. Implications for current theories of implicit memory are discussed.

1. Introduction

A great research effort has been devoted to the study of the relationship between attention and implicit memory (see Mulligan & Brown, 2003; Rajaram, 2007, for reviews). Indirect memory tasks differ from explicit ones because they do not require intentional retrieval of the encoded information. Learning is typically demonstrated by an increase of the accuracy and/or speed of elaboration, identification and generation of studied vs. unstudied stimuli (Stone, Ladd, Vaidya & Gabrieli, 1998). Early studies suggested that divided attention (DA) at encoding had differential effects on implicit and explicit memory. This manipulation reduced performance in tasks of free recall and recognition (Craik, Govoni, Naveh-Benjamin, & Anderson, 1996), whereas it had no effects on implicit tests (Kellogg, Newcombe, Kammer, & Schmitt, 1996; Parkin, Reid, & Russo, 1990; Parkin & Russo, 1990; Russo & Parkin, 1993; Schmitter-Edgecombe, 1996; Szymanski & MacLeod, 1996). However, subsequent experiments found a number of exceptions (Gabrieli et al., 1999; Light & Prull, 1995; Mulligan & Hartman, 1996; Mulligan, 1997, 1998; Wolters & Prinsen, 1997). The present meta-analysis was specifically aimed at testing a number of different explanations about the effects of DA manipulations on implicit memory. In particular, the primary aim was to ascertain whether incongruent results could be reconciled by taking into account the nature of implicit tests (based on perceptual vs. conceptual or on identification vs. production processes) and the difficulty of interference tasks. These issues are briefly illustrated in the following paragraphs. In addition, two separate sections will be dedicated to the discussion of the problems concerning task classification and the use of different types of dependent variables.[1]

2. Perceptual vs. conceptual priming

The Transfer Appropriate Processing (TAP) theory proposes that memory performance will improve when the cognitive processes carried out during encoding are reengaged at test, and distinguishes between data-driven and conceptually-driven tasks (Blaxton, 1989; Roediger, Weldon, & Challis, 1989). Indirect tests based on conceptual processes, like category exemplar generation, require the analysis and retention of the meaning of the stimuli, whereas indirect tests based on perceptual processes, like word-fragment completion, imply the

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[1] Studies that made strong claims about the resource-demanding nature of implicit memory have often employed selective-attention paradigms (Berry, Henson, & Shanks, 2006; Crabb & Dark, 1999; Rajaram, Srinivas, & Travers, 2001; Stone, Ladd, & Gabrieli, 2000; Stone, Ladd, Vaidya, & Gabrieli, 1998), in which participants were instructed to direct their attention towards distractor stimuli spatially separated from the target ones (Mulligan, 2002; Mulligan & Peterson, 2008; Newell, Cavenett, & Andrews, 2008), or towards characteristics of the critical items different from their identity (for instance their colour in the Stroop task: Rajaram et al., 2001; Stone et al., 1998, 2000). These experiments were excluded from the present meta-analysis because selective-attention methods might prevent the conscious, unambiguous identification of the target stimuli — see Stone et al. (1998) and Soldan, Mangels, and Cooper (2008) for in-depth discussions. In addition, we limited our focus to long-term priming and eliminated all experiments that studied the effects of DA on implicit learning (Shanks, Rowland, & Ranger, 2005) and short-term semantic priming (Otsuka & Kawaguchi, 2007).

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analysis and retention of the surface properties of target items. The TAP theory predicts that DA at encoding should reduce performance in conceptual, but not in perceptual tests (both for explicit and implicit memory). In agreement with this hypothesis, Mulligan and Hartman (1996; see also Mulligan, 1998) found that DA significantly reduced repetition priming in the category exemplar generation task, whereas it had no effect in the word-fragment completion task. The same dissociation was not obtained on explicit memory, because DA affected both perceptual and conceptual explicit tasks.

Despite this early positive evidence, the distinction between perceptual and conceptual processes has now to face important empirical challenges. Significant effects of DA have been found in several implicit perceptual tasks — including word-fragment completion with unique solutions (Mulligan, Duke, & Cooper, 2007), word-stem completion (Clarys, Isingrini, & Haerty, 2000; Gabrieli et al., 1999; Horton, Wilson, Vonk, Kirby, & Nielsen, 2005; Mulligan et al., 2007; Wolters & Prinsen, 1997), perceptual identification (Mulligan, 2002, 2003; Mulligan & Hornstein, 2000; Mulligan et al., 2007), word naming (Light & Prull, 1995, Exp.1) and the possible–impossible object decision task (Ganor-Stern, Seamon, & Carrasco, 1998, Exp.2). On the other hand, the category-verification task, which is based on semantic processes, has demonstrated a strong resistance to the negative effects of DA at encoding (Light, Prull, & Kennison, 2000; Mulligan & Peterson, 2008). These problems led some authors to suggest a different distinction between identification and production processes.

3. Identification vs. production priming

On the basis of convergent behavioral and neuropsychological findings, Gabrieli et al. (1999) proposed to distinguish between identification and production forms of repetition priming. Identification tasks (like perceptual identification and lexical decision) require to identify target items or verify their attributes: in these conditions the test cues directly guide the retrieval processes toward unique appropriate responses. In contrast, the retrieval stimuli employed in production tasks (such as word-stem completion, category exemplar generation and word association) are more likely to begin a competition between numerous plausible solutions, involving the selection and production of one response from an array of multiple alternatives. Gabrieli et al. (1999; see also Fleischman et al., 2001) found that patients with Alzheimer's disease (AD) had normal priming on two identification tests (picture naming and category verification) but an impaired performance on two production tests (word-stem completion and category generation). Furthermore, they were able to demonstrate that this dissociation was caused by attentional factors, since division of study-phase attention in healthy young participants significantly reduced priming on the same two production tasks impaired in the AD sample, but had no effect on the two identification tests in which the AD performance was spared. A similar distinction between competitive and non-competitive forms of conceptual priming was previously advanced by Vaidya et al. (1997).

Both Vaidya et al. (1997) and Gabrieli et al. (1999) contended that implicit production tasks should be more demanding of attentional resources than identification tests, and hence more sensitive to the negative effects of DA, because they would imply higher levels of response competition at test. In other words, the probability of retrieving the studied items among multiple competitors would be directly proportional to the amount of attention directed toward the target stimuli during the encoding phase. Although such a distinction provides a useful framework to understand the mixed results obtained in literature, there still remain some inconsistent findings. For instance, it has been shown that, under appropriate conditions, DA at encoding can reduce performance on several identification tasks, like perceptual identification (Mulligan, 2002), word naming (Light & Prull, 1995, Exp.1) and word-fragment completion with unique solutions (Mulligan et al., 2007). In other studies DA failed to impair production tests like word-stem completion (Baques, Saiz, & Bowers, 2004; Schmitter-Edgecombe, 1999) and category exemplar generation (Baques et al., 2004; Isingrini, Vazou, & Leroy, 1995; Schmitter-Edgecombe, 1996).

4. Task classification

Both the dichotomies outlined in the previous sections are based on the classification of implicit tasks into separate categories. However, the criteria employed to make these distinctions are neither clear nor unambiguous, so that different researchers classify the same tasks into different classes. In particular, there has been considerable debate about the nature of the Word-Stem Completion (WSC) task. In their influential review, Roediger and McDermott (1993) included it in the perceptual category, because of its sensitivity to the negative effects of changes in the format or in the surface properties of target stimuli between study and test phases (Rajaram & Roediger, 1993; Roediger, Weldon, Stadler, & Riegler, 1992). However, following research demonstrated that a number of experimental manipulations had similar consequences on both WSC and conceptual implicit tasks. Like category exemplar generation, WSC priming is sometimes greater after conceptual than shallow processing (Fay, Isingrini, & Clarys, 2005; MacLeod & Masson, 1997; Richardson-Klavehn & Gardiner, 1998; but for different results see: Craik, Moscovitch, & McDowd, 1994; Graf & Mandler, 1984; Roediger et al., 1992) and is often impaired by DA at encoding (Clarys et al., 2000; Gabrieli et al., 1999; Horton et al., 2005; Mulligan et al., 2007). Furthermore, a neuro-imaging study by Desmond, Gabrieli, and Glover (1998; see also Schott et al., 2005) reported increased activation in the left middle frontal gyrus — a pattern very similar to that obtained with semantic indirect tests (see Henson, 2003, for a review). As a consequence, several authors suggested that WSC might be influenced by conceptual processes (Gabrieli, 1991; Keane, Gabrieli, Fennema, Growdon, & Corkin, 1991).

Perceptual identification (PI) is another test with an unclear classification. Even if priming in this task is generally decreased by changes in the modality of presentation of target items between study and test phases (Rajaram & Roediger, 1993), Mulligan and Peterson (2008) demonstrated that PI differs from other identification tests, like category verification and lexical decision, because it was negatively affected by DA manipulations (see also Mulligan, 2003; Mulligan & Hornstein, 2000). Mulligan and Peterson (2008) proposed that PI might not be an ideal identification task, because the target words are presented for brief intervals (16 or 32 ms) and participants are likely to perceive only some letters of the stimuli, which in turn would cause the activation of alternative responses. Therefore, perceptual identification might share some of the characteristics of production tests. Consistent with this suggestion, a number of theoretical models of PI are based on the assumption that briefly presented words would activate multiple solutions, resulting in response competition (Berry et al., 2006; Schooler, Shiffrin, & Raaijmakers, 2001).

5. Type of dependent variable

Fleischman et al. (2001) raised the possibility that the comparison between identification and production priming might be confounded by differences in the type of dependent variable employed (Light, Prull, La Voie, & Healy, 2000; Mulligan & Peterson, 2008; Prull, 2004). This happens because virtually all production tasks rely on accuracy measures (e.g., changes in the proportions of correct responses), whereas many identification tasks (lexical decision, category exemplar verification, semantic classification) are based on latency measures — e.g., changes in reaction times. Three studies compared the effect of these dependent variables in different experiments, although none has considered both variables in the same task. More specifically, Gabrieli