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Inattentional blindness for ignored words: Comparison of explicit and implicit memory tasks

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ABSTRACT

Inattentional blindness is described as the failure to perceive a supra-threshold stimulus when attention is directed away from that stimulus. Based on performance on an explicit recognition memory test and concurrent functional imaging data Rees, Russell, Frith, and Driver [Rees, G., Russell, C., Frith, C. D., & Driver, J. (1999). Inattentional blindness versus inattentional amnesia for fixated but ignored words. *Science, 286,* 2504–2507] reported inattentional blindness for word stimuli that were fixated but ignored. The present study examined both explicit and implicit memory for fixated but ignored words using a selective-attention task in which overlapping picture/word stimuli were presented at fixation. No explicit awareness of the unattended words was apparent on a recognition memory test. Analysis of an implicit memory task, however, indicated that unattended words were perceived at a perceptual level. Thus, the selective-attention task did not result in perfect filtering as suggested by Rees et al. While there was no evidence of conscious perception, subjects were not blind to the implicit perceptual properties of fixated but ignored words.

1. Introduction

Inattentional blindness (IB) refers to the phenomenal experience of a visible stimulus not being perceived when attention is directed elsewhere (Rock, Linnett, Grant, & Mack, 1992). The discovery of IB led to the hypothesis that there is no conscious perception without attention and further, to the conclusion that when we perceive something this must be because it has at least momentarily captured attention (Mack & Rock, 1998).

Despite robust IB results stemming from years of exploration into the properties of a stimulus that attract attention and bring an object into conscious awareness (Mack & Rock, 1998; Mack, Tang, Tuma, Kahn, & Rock, 1992; Newby & Rock, 1998; Rock et al., 1992), there remained a question about whether true inattentional blindness would occur if the focus of attention and fixation were at the same spatial location as the presentation of the critical stimulus. This question was addressed using behavioral and fMRI measures by Rees, Russell, Frith, and Driver (1999). Under conditions where a selective-attention task and critical stimuli were simultaneously presented at fixation, the critical word stimuli that were not attended failed to be recognized in an explicit memory task (Rees et al., 1999).

Behavioral data reported by Rees et al. (1999) confirmed that explicit memory for attended words was better than for unattended words, which did not differ from the chance rate given by false-positive responses to never-seen foils. The poor recognition of unattended items could be due to either a failure of conscious perception (inattentional blindness) or forgetting prior to report of unattended items that were consciously perceived (inattentional amnesia). Therefore, fMRI data was

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analyzed to determine whether meaningful words produced differential brain activation compared to consonant strings under conditions of attention and inattention (Rees et al., 1999). The presumption was that poor recognition memory performance would be indicative of inattentional blindness if there was no activation of relevant left-hemisphere language areas during the presentation of unattended words. In contrast, activation of the brain regions of interest by unattended words would be indicative of inattentional amnesia on this task.

Rees et al. (1999) reported that robust left-hemisphere activation, similar to the simple effect of attending words (i.e., posterior basal temporal, parietal, and prefrontal cortex), was revealed by comparing activation to words and to consonant strings when the letter stream was attended. However, when the letter stream was unattended there was no significant activation (or deactivation) in these cortical areas. Contrary to previous claims of automatic word processing (Deutsch & Deutsch, 1963; Tipper & Driver, 1988), the results suggested that word processing was completely eliminated and not merely modulated under conditions of full inattention (Rees et al., 1999).

Rees et al.'s argument for the presence of inattentional blindness versus inattentional amnesia is weakened, however, by its dependence upon a null result from a single (psychophysically noisy) measure, especially when the relationship between "strength" of perception and level of fMRI activation, has not been assessed. For instance, visual inspection of the data representing the time course of BOLD activity to word and letter stimuli in the relevant left frontal and temporal cortices during attention to letter strings and attention to pictures (presented in Fig. 3 of Rees et al.) reveals an interesting dilemma. These data appear to show a very similar BOLD activation level and time course for *words* in both attention conditions (particularly in the temporal lobe), while it is an *increase* in activation for *letters* that results in no difference between activation to word and letter stimuli in the attend-pictures condition. Therefore, the critical interaction between attention and word identity highlighted in the fMRI activation map, and presented as support for a lack of perception of words during attention to pictures, appears to depend on increased activation for letters and NOT on decreased activation for words under conditions of inattention.

Furthermore, studies by Ruz and colleagues using event related potentials (ERPs) or fMRI analyses of the whole brain to examine word processing during the selective-attention task used by Rees et al., showed differential responding to ignored words and ignored non-words in brain areas not activated by attending words. They concluded that processing of fixated but unattended words occurred in different pathways than those responsive to attended words and at a level that was not accessible by explicit behavioral measures (Ruz, Wolmetz, Tudela, & McCandliss, 2005; Ruz, Worden, Tudela, & McCandliss, 2005). Thus, it is necessary to provide data using alternative methods, such as an implicit memory task, to determine the strength of perception of unattended words and to more fully assess the presence of inattentional blindness.

Whereas Mack and Rock (1998) suggest that words in general may be more easily accessed in memory than representations of objects and shapes, some equivocal results suggested that, based on the conditions of the task (e.g., mask versus no mask), a distinction between implicit and explicit memory/perception was required. It is widely accepted that explicit memory draws on conceptual processes such as elaboration, organization, and meaningful processing in addition to prior or parallel perceptual processes (Roediger & McDermott, 1993). Consequently, increased attention and higher-level processing during learning benefit explicit memory performance. In contrast, implicit memory can depend more strongly on either 'data-driven' perceptual processes (Blaxton, 1989), as tested in perceptual implicit memory tests, or on strictly conceptual/semantic processes, as tested in conceptual implicit memory tests (Roediger & McDermott, 1993; Schmitter-Edgecombe, 1999).

Priming (performance facilitation resulting from prior exposure) has been used extensively to study implicit memory (see Schacter, 1987 for a review) as well as implicit perception (perception without awareness). However, it is necessary to distinguish between perceptual and conceptual implicit memory tests used in priming experiments, as the transfer-appropriate processing view (TAP) (Roediger & McDermott, 1993) suggests that memory performance on these tests is a function of processing overlap between the study and test operations used. Perceptual implicit tests present studied and unstudied stimuli in a rapid or fragmented manner to one of the perceptual systems (usually vision). These tasks are affected by the perceptual similarity between the study and test items and draw primarily on perceptual processes used in word and object recognition (Roediger & McDermott, 1993). In contrast, in conceptual implicit tests the test cue is semantically related, rather than perceptually similar, to items in the prior study phase. Manipulations of meaning, rather than perceptual similarities, affect priming on conceptual tests (Roediger & McDermott, 1993).

Previous studies support the idea that perceptual priming is related to early, pre-semantic processes which do not require significant attentional resources for activation (Mack & Rock, 1998; Schmitter-Edgecombe, 1999; see Mulligan & Hornstein, 2000 for contrary results), while conceptual priming appears to benefit from deeper, semantic processing which is reduced, but apparently not obliterated, by dividing attention at encoding (Schmitter-Edgecombe, 1999). These conclusions indicate a need to explore not only explicit memory but perceptual and conceptual implicit memory processes in different inattentional blindness paradigms to determine the level of perception of items to which subjects are consciously unaware. A relevant question is whether fixated but ignored words, which are not explicitly recognized, are capable of semantic and/or perceptual priming when they are presented under inattention conditions. To investigate the claim by Rees et al. (1999) of perfect filtering on a high attentional load selective-attention task, the current study employed a paradigm modeled on their task, which controlled the distribution of attention to pictures and words presented at fixation in a serial dual-stimulus presentation. The effect of attentional focus on perception of words was assessed with an explicit memory task (recognition memory) as well as conceptual and perceptual implicit memory tasks (category association and perceptual identification). These tasks were used to determine whether evidence of semantic and perceptual priming would be present under conditions of inattention with high perceptual load.