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Unconscious task set priming with phonological and semantic tasks

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ABSTRACT

Whether unconscious stimuli can modulate the preparation of a cognitive task is still controversial. Using a backward masking paradigm, we investigated whether the modulation could be observed even if the prime was made unconscious in 100% of the trials. In two behavioral experiments, subjects were instructed to initiate a phonological or semantic task on an upcoming word, following an explicit instruction and an unconscious prime. When the SOA between prime and instruction was sufficiently long (84 ms), primes congruent with the task set instruction led to speedier responses than incongruent primes. In the other condition (36 ms), no task set priming was observed. Repetition priming had the opposite tendency, suggesting the observed task set facilitation cannot be ascribed solely to perceptual repetition priming. Our results therefore confirm that unconscious information can modulate cognitive control for currently active task sets, providing sufficient time is available before the conscious decision.

1. Introduction

It is widely acknowledged that information not consciously perceived can influence our perception and behavior, and subliminal priming has been demonstrated at visual, semantic and motor levels (for a recent review, see Dehaene & Changeux, 2011). Non-conscious information can modulate performance in many cognitive tasks, e.g. object recognition (Stoerig & Cowey, 1997), extraction of the meaning of words (Gaillard et al., 2006; Naccache & Dehaene, 2001; Van den Bussche, Notebaert, & Reynvoet, 2009), categorization (Van den Bussche & Reynvoet, 2007), emotional processing (Whalen et al., 1998), action planning and execution (Binsted, Brownell, Vorontsova, Heath, & Saucier, 2007). Recently, it has been reported that monetary rewards affected subjects' motivation in a force task (Pessiglione et al., 2007), a finger-tapping task (Bijleveld, Custers, & Aarts, 2010, 2012) and a switch task (Capa, Bouquet, Dreher, & Dufour, 2012) even though participants were unaware of the reward.

However, the extent to which non-conscious stimuli influence high-order control functions remains controversial in cognitive psychology. Cognitive control processes have traditionally been considered to be based on voluntary control and to depend on conscious decision-making and awareness. As such, they have been contrasted with unconscious, automatic information activation. According to the global neuronal workspace framework (Dehaene, Changeux, Naccache, Sackur, & Sergent, 2006), top-down strategic processes can influence unconscious processing (Merikle, Joordens, & Stolz, 1995;

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Naccache, Blandin, & Dehaene, 2002; Van den Bussche, Segers, & Reynvoet, 2008), but the possibility of an effect of non-conscious stimuli on cognitive control processes is not explicitly included in the model (Dehaene & Naccache, 2001).[1]

Recent findings suggest subliminal stimuli can affect high-order cognitive processes such as inhibitory control or task-setting. In a go/no go task, for instance, non-conscious "stop" signals slow down motor responses. This inhibitory control, which occurs unbeknown to the subject, is associated with a frontal activity typically related to response inhibition in both electroencephalographic (Hughes, Velmans, & Fockert, 2009; Van Gaal, Ridderinkhof, Fahrenfort, Scholte, & Lamme, 2008) and functional magnetic resonance imaging (fMRI) (Van Gaal, Ridderinkhof, Scholte, & Lamme, 2010) studies. These findings are evidence that inhibitory control can be triggered unconsciously.

Another set of studies has addressed the activation of task sets by masked stimuli that do not reach consciousness (Lau & Passingham, 2007; Mattler, 2003; Reuss, Kiesel, Kunde, & Hommel, 2011). The concept of task set assumes we can adopt a particular configuration of our cognitive system to perform a given task (Rogers & Monsell, 1995). Mattler et al. instructed participants to indicate either a sound's timbre (piano versus marimba) or its pitch (high versus low). A shape (task cue) indicated which task they were to perform, with diamonds denoting the pitch task and squares the timbre task. Before the fully visible task cue was presented, there was a prime in the shape of either a diamond or square. The task cue acted as a metacontrast for the prime so that the latter was either visible or invisible depending on the delay between prime and task cue onsets. The results signaled a congruency effect for subliminal primes: participants responded faster when the shapes of the prime and cue were the same than when they were different. These findings suggested that subliminal primes triggered the establishment of a cognitive task set which shortened the preparation time for the task when the visible cue occurred.

Using a similar paradigm in a fMRI study, Lau and Passingham (2007) reported that, relative to congruent trials, in incongruent trials increased activity was observed in brain regions associated with the task cued by the subliminal prime, whereas reduced activity was reported in brain regions associated with the task cued by the visible instruction. These results demonstrated that the task-related network can be modulated by subliminal information.

There are methodological concerns surrounding these important studies which could undermine their conclusions. Firstly, in all of them the absence of awareness of masked primes cannot be taken for granted in all subjects. In the Mattler study (2003), for example, participants' performance when they had to identify the shapes of the subliminal primes was at best only marginally different from chance, around 55% ($d' = 0.28$), and in the worst case, close to 60% (i.e. above-chance). In the Lau and Passingham study (2007), discriminability in the low-visibility condition was lower ($d' = 0.05$), but the difference in relation to the conscious condition was quite small ($d' = 0.26$), with the latter result equivalent to the Mattler unconscious condition. It is possible these results are due to the choice of masking by metacontrast. Secondly, the presence of conscious primes in the same block as masked primes might have had an effect on the visibility of the prime, by creating an expectation of a stimulus, which has been shown to speed information processing (Vangkilde, Coull, & Bundesen, 2012), and might have facilitated the priming effect (Naccache et al., 2002). All in all, it still seems necessary to check whether task-set priming effects can be replicated in strict conditions where subjects are unaware of the primes. To that end, we used a backward masking paradigm in which a single letter displayed only briefly was followed 24 ms later by a mask consisting of letters surrounding the previous letter location (Del Cul, Baillet, & Dehaene, 2007; Del Cul, Dehaene, & Leboyer, 2006). It has previously been shown that both objective measures (proportion of primes correctly identified) and the subjective visibility of the primes reported by participants indicated they were not aware of the presentation of the primes under these experimental conditions. Furthermore, unlike all previous studies, which combined trials with conscious primes with trials with masked primes, we did not include any trials with conscious primes.

Another methodological issue concerns the double dissociation between priming effect and visibility reported in the study by Lau and Passingham (2007): the priming effect was maximal when the prime visibility was minimal but disappeared when participants consciously perceived the prime (see also Schmidt & Vorberg, 2006). The absence of an effect of a visible prime on the task set selection could be due to an excessively too short delay between the prime and the task cue in the conscious condition (16 ms) compared with the subliminal condition (83 ms). It has already been shown that the efficiency of visible primes generally increases as a function of the prime-target delay (Kouider & Dehaene, 2007). Two factors were therefore confounded: the visibility of the prime and the delay between prime and instruction. The confound is due to the use of metacontrast masking characterized by a U-shaped visibility curve as the delay between prime and instruction increases. In the present study we examine the impact of this delay manipulation while keeping constant the SOA between prime and mask.

The purpose of the present study was to provide more evidence proving that a subliminal prime could initiate a task set. We designed a different masking procedure to overcome the methodological issues raised by the study by Lau and Passingham (2007). First of all, we were intent on making sure the participants really were unaware of the prime. Even if it is difficult to demonstrate statistically that visibility is exactly zero, it is known that metacontrast masking rarely produces complete masking at any level of SOA (Francis, 1997). Here, we used backward masking which allows no visibility of the prime, as previously shown by objective performance and subjective ratings (Del Cul et al., 2007, 2006). Secondly, primes

[1] Although the formulation in Dehaene and Naccache (2001) is ambiguous, the workspace model does not preclude rule out the possibility that automatic bottom-up effects of an unconscious stimulus T1 may bias the choice of a cognitive strategy applied, in turn, to a second target T2. What is ruled out is that an unconscious stimulus T1 changes the strategy applied to itself, as this would imply a closed bottom-up and top-down loop, which, in the global neuronal workspace model, is deemed to imply reverberating ignition and therefore conscious perception. Thus, the present data do not strictly imply rejection of the global workspace model.