



Review

Unconscious vision and executive control: How unconscious processing and conscious action control interact



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ARTICLE INFO

Article history:

Received 1 February 2014

Keywords:

Subliminal priming
Masked priming
Executive functions

ABSTRACT

Research on unconscious or unaware vision has demonstrated that unconscious processing can be flexibly adapted to the current goals of human agents. The present review focuses on one area of research, masked visual priming. This method uses visual stimuli presented in a temporal sequence to lower the visibility of one of these stimuli. In this way, a stimulus can be masked and even rendered invisible. Despite its invisibility, a masked stimulus if used as a prime can influence a variety of executive functions, such as response activation, semantic processing, or attention shifting. There are also limitations on the processing of masked primes. While masked priming research demonstrates the top-down dependent usage of unconscious vision during task-set execution it also highlights that the set-up of a new task-set depends on conscious vision as its input. This basic distinction captures a major qualitative difference between conscious and unconscious vision.

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1. Introduction

Since long it has been argued that not all visual processing is conscious (Münsterberg, 1910), but especially the recent decades have seen a tremendous number of articles concerning the capabilities of unconscious vision (for topical reviews, see Ansorge, Horstmann, & Scharlau, 2011; Dehaene, Changeux, Naccache, Sackur, & Sergent, 2006; Dehaene & Naccache, 2001; Kiefer, Adams, & Zovko, 2012; Kunde, Reuss, & Kiesel, 2012; Lamme, 2003). The current article focuses on one very fruitful method in the area of unconscious vision, namely masked priming (Greenwald, Draine, & Abrams, 1996; Marcel, 1983). There are other methods to study unconscious vision, like investigating visual capabilities after brain lesions (Goodale, Milner, Jakobson, & Carey, 1991) or priming during continuous flash suppression (Almeida, Mahon, Nakayama, & Caramazza, 2008; Tsuchiya & Koch, 2005). In comparison to brain lesion studies, however, masked priming allows studying unconscious processing also in healthy participants, therefore avoiding interpretational difficulties due to neuro-plastic changes of processing after brain damage. Furthermore, masked priming has been applied in a greater variety of studies compared with the more recent method of continuous flash suppression. Finally, methods in which attention is directed away from a stimulus or in which binocular rivalry is used to lower conscious perception of a stimulus are not entirely convincing in terms of the claimed invisibility of the stimuli (Blake, 1998; Holender, 1986), and therefore are also only occasionally discussed in the present review. As masked priming research provides an important window on unconscious vision for several decades, our portrait therefore almost naturally relies mostly on research in this area, although we will sometimes refer to related findings with other methods as well.

The focus of the current review is on the connection between unconscious vision and executive functions. These functions encompass the setting up and representation of goals and the operations needed to achieve these goals (Baddeley & Hitch, 1974; Miller & Cohen, 2001; Miyake et al., 2000). In this context, task-control representations, sometimes simply called ‘task sets’, denote representations specifying preceding conditions that have to be met for the execution of an action (e.g., ‘It turns dark, so I should switch on the light.’) or an operation (e.g., ‘I have to get out of the airport, so I should search for an exit sign.’) the corresponding action (e.g., ‘Switch on the light.’) or operation (e.g., ‘Attend to the signs under the ceiling.’) itself, as well as optional intended consequences of these actions, such as outcomes (e.g., ‘Light is on.’, or ‘There is an exit sign.’). Finally, executive control includes the processes necessary for securing the success of the actions and operations. Among these supporting processes are the shielding of goal representations against conflicting goals, the monitoring of the outcomes of actions and operations, and the registration and correction of errors during the execution of the operations (Norman & Shallice, 1986). The latter are typically involved when an operation is repeatedly performed, as in a computer experiment consisting of many trials.

Intuitively, there seems to be a tight connection between the activity of executive functions and consciousness or awareness. For example, when I decide to buy an apartment because I do no longer want to pay the rent, I have the strong intuition that I am fully aware of setting up the task set representation of how I go about buying an apartment, including the visual information that I have taken into account while deciding. Accordingly, early theories equated conscious vision with top-down controlled processing and unconscious vision with so-called automatic processing (Norman & Shallice, 1986; Posner & Snyder, 1975). In this context, automatic processing means that unconscious vision would run off independently of an agent’s own intentions, being entirely stimulus triggered, and being even uncontrollable – that is, not modifiable by a currently opposing intention or task set. In fact, until today, many theories take this stance on unconscious vision (Mulckhuysse & Theeuwes, 2010).

As we will delineate, however, much research on masked priming supported a different view (Ansorge & Neumann, 2005; Dehaene & Naccache, 2001; Kiefer & Martens, 2010; Neumann, 1990). Specifically, our review has three aims. First, we look at the most important strands of research that led to the conclusion that unconscious vision depends on top-down control. This will be done in part 2. Second, we will review different theories of masked priming and point out some surprising commonalities between these theories (mostly in part 2), as well as the differences between them (in parts 2, 3, and 4). Finally, we will detail the limits of top-down control of unconscious vision in part 3, and the limits of unconscious vision in general in part 4. The latter concerns the very limited power of unconscious vision to modify or set up task sets in the first place.

1.1. Masked priming

In masked priming, a visual prime is presented followed by a visual mask at the same position or surrounding the same position. Typically, the interval between prime and mask is short (about a few tens of milliseconds). This procedure is called ‘backward masking’ because the mask follows the prime (Breitmeyer, 1984). Backward masking can lead to the complete

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