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Do conscious perception and unconscious processing rely on independent mechanisms? A meta-contrast study

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ABSTRACT

There is currently no consensus regarding what measures are most valid to demonstrate perceptual processing without awareness. Likewise, whether conscious perception and unconscious processing rely on independent mechanisms or lie on a continuum remains a matter of debate. Here, we addressed these issues by comparing the time courses of subjective reports, objective discrimination performance and response priming during meta-contrast masking, under similar attentional demands. We found these to be strikingly similar, suggesting that conscious perception and unconscious processing cannot be dissociated by their time course. Our results also demonstrate that unconscious processing, indexed by response priming, occurs, and that objective discrimination performance indexes the same conscious processes as subjective visibility reports. Finally, our results underscore the role of attention by showing that how much attention the stimulus receives relative to the mask, rather than whether processing is measured by conscious discrimination or by priming, determines the time course of meta-contrast masking.

1. Introduction

The recent surge of scientific interest in the phenomenon of conscious experience has led to the discovery that complex cognitive processes can unfold in the absence of consciousness (e.g., Dehaene & Naccache, 2001; Greenwald, Draine, & Abrams, 1996; Kunst-Wilson & Zajonc, 1980; Mudrik, Breska, Lamy, & Deouell, 2011; Sklar et al., 2012; van Opstal, Buc, Gevers, & Verguts, 2011) and to important progress in the search of the neural correlates of consciousness (NCC; e.g., Crick & Koch, 2003; Dehaene et al., 1998; Lamy, Salti, & Bar-Haim, 2009; Lau, 2011; Rees, 2011; Salti, Bar-Haim, & Lamy, 2012; Tononi & Koch, 2008). However, these breakthroughs still stand on shaky ground because the issue of what counts for conscious perception remains highly controversial (see Cardoso-Leite & Gorea, 2010; Holender & Duscherer, 2004; Marcel, 1983; Overgaard, Rote, Mouridsen, & Ramsøy, 2006; Sandberg, Timmermans, Overgaard, & Cleeremans, 2010; Schmidt, 2013). Obviously, if the measure used to establish that a stimulus is not perceived consciously is to be doubted, so should the alleged feats of the unconscious and neural substrates of conscious vision.

The traditional way of establishing unconscious processing has been to demonstrate that a stimulus affects behavior even though conscious perception of this stimulus is absent (e.g., Marcel, 1983). Such dissociations between conscious perception and unconscious processing have been reported either between two direct measures of perception, typically a subjective measure and an objective measure (e.g., subjective visibility of the critical stimulus and performance on forced-choice discrimination of one of its properties); or between two objective measures of perceptual processing, one direct and the other indirect (e.g., priming). The clash between these operational definitions has generated recurrent waves of heated debate

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(Draine & Greenwald, 1998; Erdelyi, 1986, 2004; Greenwald, Klinger & Schuh, 1995; Merikle & Reingold, 1991, 1998; Reingold & Merikle, 1990). In particular, whether objective forced-choice performance should serve as a measure of unconscious processing, or be favored over subjective report as a measure of conscious processing remains open. Despite promising recent methodological developments (Lau & Passingham, 2006; Overgaard et al., 2006; Persaud, McLeod, & Cowey, 2007; Sandberg et al., 2010; Snodgrass, 2004), a consensus seems still far from reach.

Several authors have rejected the classical dissociation procedure altogether and suggested alternative empirical strategies (Debner & Jacoby, 1994; Schmidt & Vorberg, 2006; Vorberg, Mattler, Heinecke, Schmidt, & Schwarzbach, 2003). They typically argued that simple dissociations provide inconclusive evidence for unconscious perceptual processing because the measure of consciousness used may not capture all aspects of conscious experience – a claim that has been referred to as the exhaustiveness problem (Reingold & Merikle, 1988, 1990; Vorberg et al., 2003). They suggested instead that if two processes are independent, then it should be possible to modulate them in qualitatively different ways. For instance, Vorberg et al. (2003) presented their participants with a brief arrow, the prime, followed after a variable stimulus-onset asynchrony (SOA) by a larger arrow that served as a type-B meta-contrast mask (see Breitmeyer (1984)). In one session, participants indicated whether the mask arrow pointed to the left or to the right, as fast as possible. The response times in this task served as an indirect measure of unconscious processing: response priming was calculated as the difference in response times when the mask followed a prime pointing in the same vs. in the opposite direction (e.g., Dehaene et al., 1998; Eimer & Schlaghecken, 1998; Klotz & Neumann, 1999; Mattler, 2003; Neumann & Klotz, 1994). In a different session, accuracy on non-speeded forced-choice discrimination of the prime arrow direction was assessed and served as a direct objective measure of conscious perception. The striking finding was that the direct measure followed the U-shape function that is characteristic of type-B meta-contrast masking, whereas response priming increased monotonically with prime-to-mask SOA. This is to date one of the most compelling demonstrations that separable mechanisms underlie conscious and unconscious information processing.

In the present study, we investigated whether conscious and unconscious vision indeed obey different temporal laws, with two important goals in mind. First, we used the temporal-dissociation rationale to compare the two competing measures of conscious perception (subjective report and forced-choice discrimination performance) in order to determine whether they index the same or different mechanisms. Second, we compared the time courses of conscious perception and unconscious processing measures *when these are sampled under the same experimental conditions*. This has not been done before. For instance, in Vorberg et al.'s (2003) study the dissociated reports were collected in different blocks of trials. It follows that while observers' attention was mainly allocated to the prime arrow in the direct task, it was mainly directed to the mask arrow in the indirect task. Differences in attention rather than in conscious perception may therefore account for the dissociated time courses.

2. Experiment 1

The stimuli were similar to Vorberg et al.'s (2003) except that both the prime and mask arrows pointed in one of four possible directions (upper right, upper left, lower right or lower left) instead of only two (left or right), as shown in Fig. 1. As a consequence, two of the 4 possible directions pointed to the left (upper left and lower left) and two pointed to the right (upper right and lower right). Likewise, classified in the vertical rather than on the horizontal axis, two of the 4 possible directions pointed upwards (upper left and upper right) and two pointed downwards (lower left and lower right). These conditions are illustrated in Fig. 1.

On each trial, participants performed a speeded forced-choice discrimination response to the direction of the mask arrow on one axis (e.g., horizontal, that is, left or right), followed by a non-speeded forced-choice discrimination response to the direction of the prime arrow on the other axis (e.g., vertical, that is, upwards or downwards). The purpose of using these arrows was to have the participants respond to the prime and mask arrows with different responses. Indeed, we suspected that responding to the same characteristics of the prime and mask (e.g., either left or right for both arrows) was most likely to create confusion and to induce contamination of the response to the prime by the response to the mask.

After the first two responses, participants reported the visibility of the prime using a sensitive scale ranging from 0 ("I saw nothing at all") to 3 ("I clearly saw the arrow"). This scale was similar to the Perceptual Awareness Scale (PAS; Ramsøy & Overgaard, 2004) except that report of "no experience" was labeled '0' instead of '1', in order to better convey total absence of perceptual experience. This procedure allowed us to extract the time courses of three indices of perceptual processing, simultaneously, using the same stimuli and under similar conditions: a sensitive index of subjective perception (visibility), a direct measure of objective performance (forced-choice discrimination of the prime arrow direction) and an indirect measure of visual processing (response priming, calculated from the responses to the masking arrow). We thereby sought to determine whether double-dissociations between the time courses of these measures could be observed when these are collected under similar conditions. We also examined the extent of prime processing when prime visibility was null, that is, whether simple dissociations could be observed: we probed whether objective discrimination of the prime arrow direction would be above chance and whether significant response priming could be observed, when subjects reported not seeing the prime at all.