Consciousness and Cognition 20 (2011) 1793–1800

Contents lists available at ScienceDirect

Consciousness and Cognition

journal homepage: www.elsevier.com/locate/concog

Short Communication

Immediate and long-term priming effects are independent of prime awareness

Jolien C. Francken [a], Simon van Gaal [b], Floris P. de Lange [a,*]

[a] Radboud University Nijmegen, Donders Institute for Brain, Cognition and Behavior, The Netherlands
[b] INSERM/CEA Cognitive Neuroimaging Unit, Gif-sur-Yvette, France

ARTICLE INFO

Article history:
Received 22 December 2010
Available online 7 May 2011

Keywords:
Perceptual awareness
Vision
Metacontrast masking
Response conflict
Consciousness
Priming
Conflict adaptation

ABSTRACT

Subliminal primes are assumed to produce weaker and short-lived effects on subsequent behavior compared to clearly visible primes. However, this difference in priming effect may be due to differences in signal strength, rather than level of awareness. In the present study we manipulated prime discriminability by using metacontrast masks and pseudo-masks, while keeping the prime strength equal. This manipulation resulted in large differences in discriminability of the primes. However, both immediate response priming and long-term response priming (measured with conflict adaptation) was equal for the poorly discriminable and well discriminable primes, and equal for groups that differed markedly in terms of how well they could discriminate the primes. Our findings imply that discriminability of information is independent of both the immediate and long-term effects that information can have on behavior.

1. Introduction

Many studies have shown how a masked (subliminal) visual stimulus can nevertheless influence processing of a subsequent stimulus, putatively by activating visual, semantic and/or response attributes related to the stimulus (Dehaene et al., 1998; Greenwald, Draine, & Abrams, 1996; Naccache & Dehaene, 2001). While subliminal primes can elicit reliable priming effects, the size of the priming effect is almost always markedly smaller than for supraliminal (perceived) primes (Greenwald et al., 1996; Kouider, Dehaene, Jobert, & Le Bihan, 2007; Merikle & Joordens, 1997; van Gaal, Lamme, & Ridderinkhof, 2010). Also, longer-lasting priming effects like conflict adaptation are typically abolished (Ansorge, Fuchs, Khalid, & Kunde, 2010; Frings & Wentura, 2008; Greenwald et al., 1996; Kunde, 2003) or greatly reduced (Bodner & Mulji, 2010; van Gaal et al., 2010).

Why do subliminal primes have weaker and only short-lived effects on behavior, compared to supraliminal primes? One common explanation is that the reduced priming effect is a direct result of the reduced (or abolished) perceptual awareness of subliminal primes. Neurophysiological (Lamme & Roelfsema, 2000) and neuroimaging (Dehaene et al., 2001; Haynes, Driver, & Rees, 2005) studies have showed that subliminal primes are associated with a lack of neural amplification (possibly resulting in weaker priming) and lack of neural reverberation (possibly resulting in more short-lived priming) (Dehaene, Changeux, Naccache, Sackur, & Sergent, 2006).

* Corresponding author. Address: Radboud University Nijmegen, Donders Institute for Brain, Cognition and Behavior, P.O. Box 9101, 6500 HB, Nijmegen, The Netherlands. Fax: +31 24 36 10652.
E-mail address: floris.delange@donders.ru.nl (F.P. de Lange).

1053-8100/$ - see front matter © 2011 Elsevier Inc. All rights reserved.
doi:10.1016/j.concog.2011.04.005

However, subliminal primes usually differ not only in terms of perceptual visibility but also in terms of 'signal strength' (Lau & Passingham, 2006). Namely, in order to render primes invisible, subliminal primes are typically displayed for a shorter duration or followed after a shorter delay by the mask than supraliminal primes, reducing the time that the prime can have an impact on processing (Ansorge et al., 2010; Kunde, 2003; van Gaal et al., 2010; Vorberg, Mattler, Heinecke, Schmidt, & Schwarzbach, 2003). Therefore, the weaker and fleeting nature of invisible primes could be simply due to differences in prime strength (see also Schlaghecken, Blagrove, & Maylor, 2008). In line with this 'signal strength' interpretation, Vorberg et al. (2003) observed an increase in response priming as a function of prime-mask interval for primes that were all equally invisible, suggesting a dissociation between priming and awareness (see Mattler (2003) for similar results). In a similar vein, differences in prime strength may also underlie the attenuation or absence of long-term priming effects such as conflict adaptation (Egner, 2007; Kunde, 2003; van Gaal et al., 2010).

In this study, we compared immediate and long-term priming effects of well discriminable and poorly discriminable primes, while keeping prime duration, mask duration and prime-mask interval equal. In line with a 'signal-strength' account of priming, we observed identical priming of well and poorly discriminable primes, despite large differences in discriminability between them. These results imply that the discriminability of information is independent from the effects the information can have on behavior, at both short and longer time scales.

2. Method

2.1. Participants

Fourteen volunteers (8 females; age range: 22–33 years; 13 right handed) with normal or corrected-to-normal vision participated in a prime recognition and a response priming paradigm, measured on separate days. All subjects started with the response priming paradigm. The study was approved by the regional ethics committee, and a written informed consent was obtained from the subjects according to the Declaration of Helsinki.

2.2. Stimuli

Stimuli were presented using a PC running Presentation software (Neurobehavioral systems, Albany, USA) on a 60-Hz Samsung SyncMaster 940BF monitor placed at a viewing distance of 75 cm. We used a chin and forehead rest to restrain head and eye position. Stimuli were presented in black (<1 cd/m^2) on a light-gray background (59 cd/m^2). Primes consisted of a left or right pointing arrow (width 1.36°, height 0.59°). The mask stimuli (width 2.72°, height 0.86°) were constructed such that the outer contours of the primes either touched the inner contours of the mask stimuli (metacontrast mask) or were rectangularly shaped (pseudomask), leading to poorly discriminable and well discriminable primes respectively. Metacontrast masks and pseudomasks were equal in terms of overall luminance. The shape of the mask could be a left/right pointing arrow. In the prime recognition task, we additionally used square-shaped masks (see Fig. 1).

2.3. Prime recognition task

During the prime recognition task, subjects had to decide on the identity of the prime stimuli. Each trial started with a central fixation cross (duration between 1250 and 1750 ms). Then, a prime was briefly flashed (duration 17 ms), followed by a blank interval (duration 33 ms), after which a mask was presented (duration 150 ms). Participants decided on the orientation of the prime by pressing a left or right button with their right hand, while ignoring the masks. To prevent direct priming effects on recognition, subjects were cued to respond at least ~600 ms after the mask, when the fixation cross reappeared (Vorberg et al., 2003). After the response, subjects received feedback (indicated by a green or a red fixation cross for correct and incorrect responses, respectively) which was displayed for 500 ms. In addition to arrow-shaped masks, we used rectangular masks to assess the effects of mask identity on prime recognition. The prime recognition task consisted of twenty blocks of 60 trials (leading to a total of 1200 trials). Trials were presented in a random order each block. Before the experiment, participants practiced 24 trials. Summary feedback was given after each block (number of correct and incorrect trials).

2.4. Response priming task

During the response priming task, subjects had to decide on the identity of the mask stimuli. Each trial started with a central fixation cross (duration between 1250 and 1750 ms). Then, a prime was briefly flashed (17 ms), followed by a blank interval (duration 33 ms), after which a mask was presented (duration 150 ms). Participants decided as quickly and accurately as possible on the orientation of the mask by pressing a left or right button with their right hand, while ignoring the primes. After they responded, the fixation cross was presented for 500 ms. The task consisted of twenty blocks, each containing 80 trials (leading to a total of 1600 trials). Trials were presented in a random order each block. Before the experiment, participants practiced 24 trials. Performance feedback was given after each block (in terms of average response time and number of correct/incorrect trials).