Consciousness and Cognition 42 (2016) 162–180

Contents lists available at ScienceDirect

Consciousness and Cognition

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

Individually different weighting of multiple processes underlies effects of metacontrast masking

Thorsten Albrecht *, Uwe Mattler

Georg-Elias-Müller-Institute of Psychology, Georg-August University Göttingen, Germany

A R T I C L E I N F O

Article history:
Received 10 December 2015
Revised 3 March 2016
Accepted 5 March 2016

Keywords:
Individual differences in metacontrast masking
Consciousness
Criterion content
Cue weighting
Two-process models

A B S T R A C T

Metacontrast masking occurs when a mask follows a target stimulus in close spatial proximity. Target visibility varies with stimulus onset asynchrony (SOA) between target and mask in individually different ways leading to different masking functions with corresponding phenomenological reports. We used individual differences to determine the processes that underlie metacontrast masking. We assessed individual masking functions in a masked target discrimination task using different masking conditions and applied factor-analytical techniques on measures of sensitivity. Results yielded two latent variables that (1) contribute to performance with short and long SOA, respectively, (2) relate to specific stimulus features, and (3) differentially correlate with specific subjective percepts. We propose that each latent variable reflects a specific process. Two additional processes may contribute to performance with short and long SOAs, respectively. Discrimination performance in metacontrast masking results from individually different weightings of two to four processes, each of which contributes to specific subjective percepts.

1. Introduction

Visual backward masking techniques are widely used in vision science to limit the sensory input to the visual system and to examine stimulation parameters that determine participants' performance in perceptual tasks (e.g., Bachmann, 1984, 1994; Breitmeyer & Ögmen, 2006; Turvey, 1973). The technique of metacontrast masking has frequently been applied in priming studies to render stimuli invisible and to investigate the effect of unconscious stimuli on information processing and behavior (e.g., Eimer & Schlaghecken, 1998; Fehrer & Raab, 1962; Mattler, 2003, 2005, 2006; Neumann & Klotz, 1994; Schmidt, 2000, 2002; Vorberg, Mattler, Heinecke, Schmidt, & Schwarzbach, 2003).

Metacontrast masking occurs when a masking stimulus follows a target stimulus and the contours of the mask are in close contiguity to the contours of the target stimulus. A broad range of stimuli with specific geometric configurations has been employed to produce metacontrast masking including flanking bars (e.g., Ramachandran & Cobb, 1995), circular shape displays (e.g., Cohen, van Gaal, Ridderinkhof, & Lamme, 2009; Fehrer & Raab, 1962; Schmidt, 2002), squares and diamonds (e.g., Ansorge, Becker, & Breitmeyer, 2009; Ansorge, Breitmeyer, & Becker, 2007; Breitmeyer & Hanif, 2008; Breitmeyer, Ogmen, & Chen, 2004; Lau & Passingham, 2007; Mattler, 2003; Neumann & Klotz, 1994; Tapia, Breitmeyer, & Shooner, 2010) or arrow stimuli (e.g., Kiesel et al., 2006; Mattler & Palmer, 2012; Tapia & Breitmeyer, 2011; Van Gaal, Scholte, Lamme, Fahrenfort, & Ridderinkhof, 2011; Vorberg et al., 2003; Wenke, Fleming, & Haggard, 2010). Across all

* Corresponding author at: Georg-Elias-Müller Institute of Psychology, Georg-August University Göttingen, Gosslerstr. 14, 37073 Göttingen, Germany.
E-mail address: thorsten.albrecht@biologie.uni-goettingen.de (T. Albrecht).

http://dx.doi.org/10.1016/j.concog.2016.03.006
1053-8100/

displays, metacontrast is characterized by the phenomenon that the visibility of the target is a function of stimulus onset asynchrony (SOA) between target and mask. In addition to SOA, target visibility is a function of the specific stimulation parameters (e.g. the energy ratio between target and mask) leading either to increasing visibility with increasing SOA (type-A masking) or to an u-shaped function with poorest visibility at intermediate SOAs (type-B masking; Kolers, 1962). Although the most prominent effect is a reduction in the perceived contrast of the target by the mask (e.g. Werner, 1935), metacontrast masking is a multidimensional phenomenon that also affects several other perceptual dimensions of the target stimulus including perceived onset time and spatial position (e.g. Didner & Sperling, 1980; Sigman, Sackur, Del Cul, & Dehaene, 2008). Moreover, there is evidence that each of these dimensions may depend on SOA in a specific way. Breitmeyer et al. (2006), for instance, reported that the maximum of masking occurred with shorter SOAs for processing of contours than for processing of brightness information. This multidimensionality of metacontrast masking is closely linked to the concept of "criterion content" – the stimulus attribute, psychological dimension, or perceptual cue a judgment is based on Kahnemann (1968) and Ventura (1980). Along this line, masking effects depend on the task that is performed on the target stimulus (Breitmeyer et al., 2006; see also Ansorge et al., 2007, 2009) because different tasks require the use of different criterion contents. For instance, rating the brightness of a stimulus requires processing of surface information, whereas a speeded simple detection task does not. Type-B masking functions are usually obtained with brightness rating tasks or discrimination tasks, whereas type-A masking functions usually occur with simple detection or speeded response time tasks (for a review see Breitmeyer & Ögmen, 2006).

1.1. Individual differences as a tool to study metacontrast masking

Although research on visual perception traditionally focuses on general principles that apply to the majority of participants, recent studies have shown stable individual differences in metacontrast masking (Albrecht, Klapötke, & Mattler, 2010; Albrecht & Mattler, 2012a, 2012b). Albrecht and colleagues used a metacontrast masking paradigm with square and diamond shaped target and mask stimuli (Fig. 1A). This stimulus configuration has frequently been used in priming experiments (e.g. Lau & Passingham, 2007; Mattler, 2003; Neumann & Klotz, 1994) and in studies on metacontrast masking (e.g. Ansorge et al., 2009; Ansorge et al., 2007).

Individual differences have been found on the following three different measures: First, the initial study of Albrecht et al. (2010) reported qualitative individual differences in *metacontrast masking performance*. When participants performed a stimulus discrimination task with varying SOAs, individuals exhibited either type-A or type-B masking functions.

Second, individual differences in discrimination performance were associated with differences in the reported *phenomenology and cue use* (Albrecht & Mattler, 2012b). Participants with type-A masking functions spontaneously reported to perceive apparent motion when they observed the target–mask sequences. In particular, they reported to perceive rotational motion on trials with different shapes of mask and target. In the literature metacontrast masking has previously been associated with apparent motion: Wertheimer (1912) noted that metacontrast can produce the perception of apparent motion, and there has been a long debate about whether apparent motion and metacontrast share underlying mechanisms (for a review see Breitmeyer & Ögmen, 2006). On the other hand, participants with type-B masking functions reported to perceive a kind of target afterimage, which seemed to occur simultaneously with the masking stimulus on part of the trials. Werner (1935) already reported the occurrence of bright or light gray afterimages in metacontrast masking and more recently, a related phenomenon has been reported that was termed "brightness reversals" (Purcell & Dember, 1968; Stewart, Purcell, & Pinkham, 2011): At very short SOAs a dark target on light background appeared to be brighter than the background. In sum, the data suggest that the use of motion and afterimage cues distinguishes type-A and type-B observers.

Third, individual differences in discrimination sensitivity and reported percepts correspond to individually different *response bias patterns* (Albrecht & Mattler, 2012a, 2012b). Type-A observers but not type-B observers exhibited a clear response bias towards the shape of the mask with short SOAs and this bias decreased with increasing SOA. This response pattern may reflect a response strategy that depends on the shape of the mask: When observers see rotational motion in the target–mask stimulus sequence, they report that the shape of the target was opposite to the shape of the mask. However, when they see no such rotational motion they report that the target had the same shape as the mask. This strategy might lead to high levels of target discrimination performance with long SOA most likely, because rotational motion cues are more reliable with long SOA. With short SOAs, however, this strategy produces a response bias towards the mask because the motion percept is missing (see Albrecht & Mattler, 2012a). This view is consistent with the finding that motion percepts occur only in specific spatial and temporal conditions (e.g. Wertheimer, 1912).

Whereas our initial study yielded two distinct groups of observers, follow up studies suggest that at least some participants can use both the motion cue and the afterimage cue. First, in Albrecht and Mattler (2012b) some participants performed very well across all SOAs (which we called "overachiever") and some participants performed near chance across all SOAs (which we called "underachiever") indicating that the former use both cues while the latter use neither. Second, when directly asked about the occurrence of either percept, most type-A observers and overachievers reported to see both perceptual cues, afterimages and rotation, simultaneously.

These findings suggested to us that individual differences might be used as a new approach to examine the number of processes that are involved in metacontrast masking. The characteristics of individual differences suggest that the observed masking function is the result of two processes that are related to the motion cue and the afterimage cue, respectively. If