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Anger superiority effect for change detection and change blindness

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ABSTRACT

In visual search, an angry face in a crowd "pops out" unlike a happy or a neutral face. This "anger superiority effect" conflicts with views of visual perception holding that complex stimulus contents cannot be detected without focused top-down attention. Implicit visual processing of threatening changes was studied by recording event-related potentials (ERPs) using facial stimuli using the change blindness paradigm, in which conscious change detection is eliminated by presenting a blank screen before the changes. Already before their conscious detection, angry faces modulated relatively early emotion sensitive ERPs when appearing among happy and neutral faces, but happy faces only among neutral, not angry faces. Conscious change detection was more efficient for angry than happy faces regardless of background. These findings indicate that the brain can implicitly extract complex emotional information from facial stimuli, and the biological relevance of threatening contents can speed up their break up into visual consciousness.

1. Introduction

Emotionally significant, especially threatening, stimuli occupy perhaps the most privileged place in the processing stream of visual information in humans. Behaviorally, they capture and hold attention automatically (Anderson, 2005), amplify perceptual processes (Fox et al., 2000; Öhman, Flykt, & Esteves, 2001), facilitate learning (Öhman & Soares, 1998) and initiate physiological fight or flight responses (LeDoux, 1996). At the level of the brain, the processing of threatening stimuli is faster and more distributed than the processing of neutral stimuli, thanks to the dedicated neural systems evolved to process threatening stimuli, even outside of attention and awareness (LeDoux, 1996; Öhman, 2009). It has been proposed that, in the human brain, at least two systems for perceiving naturally threatening stimuli have been evolved: one related to detection of predators of primates, such as snakes, and another related to detection of dominance-submissiveness for which visual analysis of faces expressing threat is especially relevant (Öhman, 1986).

In a number of studies, faces expressing anger have been shown to pop out more easily when presented simultaneously among neutral or happy faces than the other way around (Hansen & Hansen, 1988). This phenomenon has been dubbed the "anger superiority effect", and it has been proposed as one example of the workings of the dominance-submissiveness system in the visual system (Öhman, 2009). Some controversy has been raised about the reliability of the phenomenon (Becker, Anderson, Mortensen, Neufeld, & Neel, 2011), but it has been convincingly shown, at least with faces of males (Becker,

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Kenrick, Neuberg, Blackwell, & Smith, 2007), schematic faces (Öhman, Lundqvist, & Esteves, 2001), and facial expressions of prototypical emotions (Pinkham, Griffin, Baron, Sasson, & Gur, 2010) as stimuli. Hansen and Hansen (1988) already noted that the phenomenon is hard to explain without some kind of implicit preattentive processing of the angry faces. They suggested a parallel, high capacity search mechanism for the detection of angry faces which enables only facial expressions expressing threat to capture attention and pop out.

Face perception and perception of emotional expressions have been shown to occur outside of attention, as shown by distractor effects on the primary task at the behavioral level (e.g., Eastwood, Smilek, & Merikle, 2003). Also cortical and subcortical, especially the colliculo-pulvino-amygdalar pathway, is activated in response to implicitly presented facial expressions in cortically blind (Morris, DeGelder, Weiskrantz, & Dolan, 2001), and in intact observers by using visual masking (Morris, Öhman, & Dolan, 1999). Relatively early face-specific electrophysiological responses, such as the P1 response (e.g., Eimer & Holmes, 2002), N170 response (Blau, Maurer, Tottenham, & McCandliss, 2007; Leppänen, Kauppinen, Peltola, & Hietanen, 2007; Wronka & Walentowska, 2011), responses sensitive to emotional saliency, like the 'early posterior negativity' (EPN) (Jiang et al., 2009; Schupp et al., 2004), and the visual mismatch negativity (vMMN) response related to the perception of regularities in the emotional content of stimuli (Astikainen & Hietanen, 2009; Stefanics, Csukly, Komlosi, Czobor, & Czigler, 2012) have been observed to be preattentively modulated by facial emotional expressions.

One effective method to study implicit perception is the change blindness paradigm. In change blindness, viewers have difficulties in spotting differences between two consecutive images owing to interruption of the stimulation or presentation of global distracting stimuli simultaneously with the change (Rensink, 2002; Simons & Rensink, 2005). The difference can go unnoticed for considerable periods of time, even if the changes would otherwise be detected immediately. Because of this, the period of change blindness offers an opportunity to investigate the implicit processing of sensory stimuli by behavioral and neural measures.

The change blindness phenomenon has spurred the view that outside focal attention, visual representation is sparse, and that focal attention is needed for representation of the changed features, and especially so for combinations of those features (O'Regan and Noe, 2001; Treisman, 1998). According to a more moderate view, "proto-objects", preliminary coarse representations of objects of the visual scene can be formed outside the sphere of focal attention (Rensink, 2002). Both these views hold that information carried by complexes of features nevertheless cannot exert a bottom-up effect on change detection, which relies solely on top-down attentional search.

Implicitly presented changes have been shown in a number of studies to affect electrophysiological and behavioral measures already during change blindness (Beck, Rees, Frith, & Lavie, 2001; Eimer & Mazza, 2005; Fernandez-Duque, Grossi, Thornton, & Neville, 2003; Huettel, Guzeldere, & McCarthy, 2001; Khittl, Bauer, & Walla, 2009; Kimura, Katayama, & Ohira, 2008; Lyyra, Wikgren, & Astikainen, 2010; Lyyra, Wikgren, Ruusuvirta, & Astikainen, 2012; Pessoa & Ungerleider, 2004; Schankin & Wascher, 2007; Schankin & Wascher, 2008). To date, only one study has investigated implicit processing of emotionally significant changes by electrophysiological measures in the change blindness paradigm (Lyyra, Mäkelä, Hietanen, & Astikainen, 2014). However, this study focused only on face perception in the change blindness paradigm in general by comparing change blindness-related ERPs to faces and scrambled faces, and the effect of emotional content was not controlled for. Therefore, it is an open question whether in addition to general facial configural information, specific information about the emotional content of the facial configuration could be extracted, and whether the anger superiority effect could carry over to change detection.

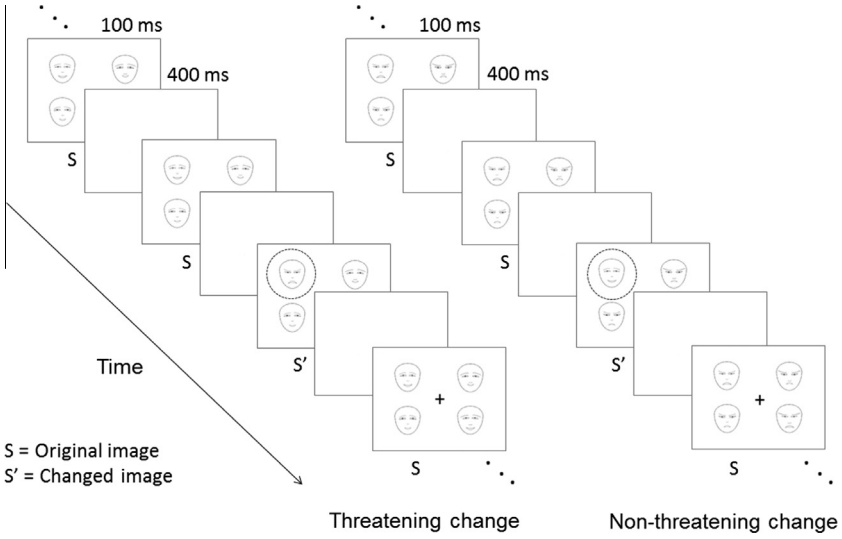

Fig. 1. An illustration of the stimulus displays and sequences with changed expressions indicated by dotted circles in the threatening and non-threatening change conditions in Experiment 1.