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Raising the alarm: Individual differences in the perceptual awareness of masked facial expressions

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ABSTRACT

A theoretical concern in addressing the unconscious perception of emotion is the extent to which participants can access experiential properties of masked facial stimuli. Performance on a two alternative forced choice (2AFC) task as a measure of objective awareness was compared with a new measure developed to access experiential phenomena of the target-mask transition, the perceptual contrast-change sensitivity (PCCS) measure in a backward-masking paradigm with angry, happy and neutral facial expressions. Whilst 2AFC performance indicated that the targets were successfully masked, PCCS values were significantly higher in the happy-neutral face condition than in the angry-neutral face and the neutral-neutral face conditions (Experiment 1). Furthermore, objective measures of awareness were more readily displayed by individuals with high trait anxiety, whereas individuals with low trait anxiety showed greater access to the experiential quality of happy faces (Experiment 2). These findings provide important insights into the methodological considerations involved in the study of non-conscious processing of emotions, both with respect to individual differences in anxiety and the extent to which certain expressions can be successfully masked relative to others. Furthermore, our results may be informative to work investigating the neural correlates of conscious versus unconscious perception of emotion.

1. Introduction

Ubiquitous in our daily lives, emotional experiences are ingrained in the evolutionary process (Al-Shawaf, Conroy-Beam, Asao, & Buss, 2016; Ekman, 1992; Ekman & Cordaro, 2011; Nesse & Ellsworth, 2009; Öhman, 2006). Thus firmly established in our neurobiological system, emotions are perceived automatically and unconsciously (Dimberg, Thunberg, & Elmehed, 2000; Dimberg, Thunberg, & Grunedal, 2002; Tamietto & de Gelder, 2010; Tracy & Robins, 2008). According to Tamietto and de Gelder (2010), the unconscious perception of emotion has been implicated in a multitude of subcortical brain regions, which can broadly be divided into a network involved in the visual processing of emotional cues and a network centered on non-visual emotion-oriented processes. The former network, as the authors note, includes the substantia innominate, the superior colliculus, the nucleus accumbens, the pulvinar and the amygdala, whereas the latter network involves the basal ganglia, the locus coeruleus, the hypothalamus, the periaqueductal grey, the hippocampus and the nucleus basalis of Meynert. Conscious perception of emotional cues, in turn, usually also extends across the cingulate, occipitotemporal and frontal areas, although such activity can sometimes be found in studies rendering emotional cues unconscious as well, possibly due to direct and indirect links between cortical and subcortical structures (Brooks et al., 2012; Tamietto & de Gelder, 2010). Not surprisingly then, there has been an avid debate concerned with the extent to which brain activation during conscious versus unconscious perception of emotion relies on common or distinct neural substrates (Balconi & Bortolotti, 2013; Jiang & He, 2006; Phillips et al., 2004; Tamietto & de Gelder, 2010; Tamietto et al., 2015; Yang, Cao, Xu, & Chen, 2012). Part of this debate rests on the crucial assumption that the paradigms used to test unconscious perception of emotion uniquely measure unconscious, but not conscious, perception of emotion.

1.1. The backward-masking paradigm in perceiving emotional expressions

One of the principal paradigms for the study of unconscious emotions in healthy individuals is the backward-masking procedure (Tamietto & de Gelder, 2010). The backward-masking

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procedure has made a significant contribution to the amygdala's status as the brain's silent 'alarm' system, alerting us to impending dangers, such as fearful and angry facial expressions, often with relatively little conscious appraisal on our part (Liddell et al., 2005; Öhman & Mineka, 2001). Procedurally, it entails the brief presentation of a visual stimulus, referred to as the *target*, followed by the subsequent presentation of another visual stimulus, in the same (or nearby) spatial location, referred to as the *mask*. Presentation rates of the target stimulus, which is usually a picture of an emotional face such as an angry or fearful expression, are very brief, usually in the order of 30msec or less. The masking stimulus, usually a picture of a neutral face has a slightly longer duration, typically 100msec or more. Whilst participants are often able to report the presence of the mask, they are unable to identify or even detect the presence of the target. Thus, the participant is deemed to be *unaware* of the target, even though the physiological and neuroimaging changes are observed in the participant during the target's presentation in the backward-masking task (e.g., Dimberg et al., 2000; Whalen et al., 2004). Furthermore, manipulating the temporal interval between the presentation of the target and mask, most commonly expressed in terms of stimulus onset asynchrony (SOA), appears to play a key role in influencing the detection of emotional targets, with longer SOAs facilitating target detection performance (e.g., Esteves & Öhman, 1993).

1.2. Emotion perception without awareness: The role of objective and subjective criteria

Outside of the neuroscientific investigation of the threat detecting capacities of the amygdala, cognitive psychologists have been concerned for quite some time as to whether participants are truly unaware of the masked threatening emotional expression (Maxwell & Davidson, 2004; Milders, Sahraie, & Logan, 2008; Pessoa, 2005; Pessoa, Japee, & Ungerleider, 2005). A particular problem in classifying whether or not a participant is unaware of the masked emotional expression partially derives from the criteria used in defining subjective vs objective levels of awareness. According to subjective criteria, awareness is assessed on the basis of participants' self-reports of their conscious experiences; if participants can report that they have 'seen' the target, it is assumed that the item was perceived with awareness, and if the participants report that they have not 'seen' the target, it is assumed that they are unaware of the critical (i.e., masked) item (e.g.,Dimberg, Thunberg & Elmehed, 2000; Morris, Öhman, & Dolan, 1998; Merikle, 1992; Tsuchiya & Adolphs, 2007). A more sensitive approach over such binary responses (e.g., seen vs. not seen) involves the additional use of confidence ratings (e.g., Esteves & Öhman, 1993; Phillips et al., 2004) during the target/-mask pairings to establish when participants become fully conscious or aware of the presence of the target (i.e., 'extremely confident').

According to objective criteria, awareness is assessed on the basis of setting performance thresholds, typically measured in a forced-choice decision task. Participants are deemed unaware of the target if they cannot discriminate the presence or absence of a stimulus or categorize the emotionality of the target (e.g., fear vs disgust) with above-chance accuracy (e.g., Liddell et al., 2005; Merikle, Smilek, & Eastwood, 2001; Phillips et al., 2004). Objective perception of the target face is assessed using a signal detection framework in which the detection threshold of $d' = 0$ or its nonparametric analogue, $A' = 0.50$ is used as a measure of chance performance (e.g., Hanley & McNeil, 1982; Liddell et al., 2005; Macmillan & Creelman, 1991; Maxwell & Davidson, 2004; Milders et al., 2008; Szczepanowski & Pessoa, 2007). Studies that have utilized A' measures have reported above-chance detection even at 17msec target presentation times (e.g., Pessoa et al., 2005) thus contrasting with previous findings with longer, yet seemingly 'unconscious' thresholds (e.g., Morris et al., 1998; Whalen et al., 1998).

Self-report methodologies that focus on binary 'seen/unseen' responses or confidence ratings may not sensitively capture all relevant aspects of participants' conscious experiences of the backward-masking methodology (e.g., Maxwell & Davidson, 2004; Merikle et al., 2001). Usually, these experiences stem from the perceptual changes during the transition between target and mask, resulting in apparent motion phenomena which are likely to be intensified in some emotional expressions on account of the perceptual discrepancy in the localized facial features. For instance, happy facial expressions are reliably identified from neutral faces (i.e., 70% of raters agree) on the basis of the presence of the bags under eyes, cheeks raised, upper lip raised and exposure of the upper teeth, whilst angry facial expressions are reliably identified by the presence of a pronounced frown (Calvo & Marrero, 2008). Asking participants to explicitly report their experience of such phenomena through questionnaire formats and/or funnel interview techniques can yield important individual differences in detecting the emotionality of masked faces. For example, Maxwell and Davidson (2004) divided their participant pool into those participants who could verbally report the presence of apparent motion (e.g., flickering and movement) in the backward-masking task (explicitly aware) and those who maintained, despite persistent prompting, not to have experienced any apparent motion phenomena (explicitly unaware). The two groups differed in performance in a target identification forced choice procedure, such that the explicitly aware group performed better than the unaware group in identifying happy and neutral targets, whereas the unaware group outperformed their explicitly aware counterparts in the identification of anger. Thus, the contrasting effects in setting subjective vs objective measures of awareness indicates how facial expressions of emotion perceived without awareness can both bias which stimuli are perceived with awareness and influence how stimuli are consciously experienced (e.g., Maxwell & Davidson, 2004).

1.3. The role of self-reported anxiety in emotion perception

The perceptual awareness of emotional stimuli may be further modulated by individual differences in trait levels of self-reported anxiety, which can affect an individual's response to impending situational (i.e., state anxiety) stressors (Eysenck, 1992; Eysenck, Derakshan, Santos, & Calvo, 2007; Spielberger, Gorsuch, Lushene, Vagg, & Jacobs, 1983). Above threshold presentation of facial stimuli tends to trigger greater levels of visual spatial attention towards threatening facial expressions in individuals with high trait anxiety (Byrne & Eysenck, 1995; Mogg & Bradley, 1999). Anxiety-related difficulties also emerge when it comes to disengaging attention away from threat-relevant facial stimuli (Fox, Russo, Bowles, & Dutton, 2001; Georgiou et al., 2005) and can also interfere in the processing of task-irrelevant threat distracters (e.g., Damjanovic, Pinkham, Clarke, & Phillips, 2014).

Recent investigations with backwardly masked emotional expressions are also consistent with the view of a finely tuned threat detection mechanism in anxiety, such that high performing participants on fear detection trials are likely to belong to the high end of the trait anxiety continuum (Japee, Crocker, Carver, Pessoa, & Ungerleider, 2009). This bias can emerge as early as 115–145 ms post-stimulus (Li, Zinbarg, Boehm, & Paller, 2008), whilst spatial markers show increases in right amygdala activation which correlates strongly with symptom severity in individuals with generalized anxiety disorder (Monk et al., 2008).

1.4. Aims of the current study

Successful masking of facial expressions poses a complex challenge for researchers. The aim of the current study is to provide a detailed comparison between traditional approaches in determin-