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Target meta-awareness is a necessary condition for physiological responses to masked emotional faces: Evidence from combined skin conductance and heart rate assessment

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ABSTRACT

Much heated debate surrounds the extent to which we can process emotional stimuli without awareness. In particular the extent to which masked emotional faces can elicit changes in physiology measurements, such as heart rate and skin conductance responses, has produced controversial findings. In the present study, we aimed to determine whether briefly presented faces can elicit physiological changes and, specifically, whether this is due to unconscious processing. We measured and adjusted for individual differences in the detection threshold using both receiver operating characteristics and hit rates. For this we also used a strict Bayesian assessment of participant thresholds. We then measured physiological responses to threshold adjusted emotional faces and for hits, misses and post-binary subdivisions of target meta-awareness. Our findings based on receiver operating characteristics revealed that, when faces were successfully masked there were no significant physiological differences in response to stimuli with different emotional connotations. In contrast, when targets were masked based on hit rates we did find physiological responses to masked emotional faces. With further analysis we found that this effect was specific to correct detection of angry and fearful faces and that increases in experienced arousal were associated with higher confidence ratings for correct detection of these stimuli. Collectively, our results do not support the notion of unconscious processing when using markers of physiological processes. Rather they suggest that target meta-awareness is a necessary condition for – and possibly determined by – physiological changes in response to masked emotional faces.

1. Introduction

Can emotional responses be evoked without awareness? Is it possible that we can be scared, happy, sad, or simply aroused without being consciously aware of what has triggered this experience? These questions are as tantalizing in modern psychological research today (Pessoa, 2017) as they were in psychoanalytic theory almost one hundred years ago (Freud, 1923/1962). In the last thirty years, psychologists have devoted significant resources in providing an answer (Brooks et al., 2012). The method typically employed in the area (van der Ploeg, Brosschot, Versluis, & Verkuil, 2017) is to present very brief (6.25–83.33 ms) emotional stimuli preceded (forward masking) and/or followed (backward masking) by non-emotional stimuli used in order to mask - i.e., make *invisible* - the emotional targets (Bachmann & Francis, 2013). Neural, physiological or behavioural responses to these masked targets are suggested as evidence for unconscious processing (Pessoa & Adolphs, 2010).

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This field of research has produced extensive (Brooks et al., 2012), though theoretically controversial, findings (Pessoa, 2005; Pessoa, Japee, Sturman, & Ungerleider, 2005). For example, fMRI activation in emotion processing areas such as the amygdala has been reported in response to masked angry (Nomura et al., 2004), fearful (Liddell et al., 2005) and happy faces (Duan, Dai, Gong, & Chen, 2010) among other masked stimuli types (Brooks et al., 2012). Masked emotional faces have also been shown to elicit specific markers of bioelectric activity recorded from cortical brain regions (Lu, Zhang, Hu, & Luo, 2011). They have been shown to induce liking and dislike to subsequently presented targets (Winkielman & Berridge, 2004; Winkielman, Berridge, & Wilbarger, 2005; Lapate, Rokers, Li, & Davidson, 2014) and direct our attention as visual cues processed without explicit awareness (Yiend, 2010).

The biological preparedness model that has been put forth to explain these neural and behavioural responses suggests that unaware emotional targets can induce changes in physiological processes (van der Ploeg et al., 2017) that enable us to make automatic and involuntary responses to environmental stimuli (LeDoux, 2003). This model suggests that when stimuli confer survival value (Liddell et al., 2005) and social communication value (Hess & Fischer, 2013) and require an instant reaction they do not rely on slow-cortical pathways that enable awareness of the presented visual stimuli to produce a response. Instead they recruit a fast-subcortical pathway to the amygdala that disseminates automatic nervous system arousal and allows us to respond and adapt to our environment without conscious awareness (Pessoa & Adolphs, 2010).

When this theoretical notion was put to the test using physiological assessment such as sweating (skin conductance response) and cardiovascular changes (heart rate and blood pressure) there was evidence of an effect (van der Ploeg et al., 2017) such as higher physiological changes for masked fearful faces (Williams et al., 2004, 2006; Lapate et al., 2014) and threatening pictures (Najström & Jansson, 2007) compared to masked neutral stimuli. Nevertheless, the extent to which these findings represent unconscious processing has been extensively debated in the relevant literature. The main critical themes include the presentation of a set duration threshold for masked faces that is assumed "to remain consistently below the detection threshold on all trials and across all participants" (Lähteenmäki, Hyönä, Koivisto, & Nummenmaa, 2015; p. 341), the assessment of detection performance using hit rates (Pessoa, 2005; Pessoa et al., 2005) and the assertion of unawareness using non-significance (Dienes, 2015).

For example, previous studies presented masked emotional faces for durations spanning from 6.25 to 83.33 ms and compared the concomitant physiological effects to the effects caused by masked neutral faces (presented for the same duration). Signal detection research has suggested that masked emotional faces are more clearly detected than masked neutral faces for set durations (e.g. 16.67 ms) because they confer emotional incongruence with the neutral mask (Calvo & Lundqvist, 2008; Kim et al., 2010). Previous research has also suggested that some participants are able to reliably discriminate what kind of face was presented at 16.67 and 33.33 ms (Pessoa, 2005; Pessoa et al., 2005). This casts doubt on whether previous studies reported results that were indeed indicative of the response to unseen stimuli and suggest that the duration of the masked targets should be adjusted both for per participant and stimuli type differences to ensure truly unconscious presentation.

Hit rates and non-significance for differences to chance-level meta-awareness have also been used in previous studies to assess and assert target awareness respectively (van der Ploeg et al., 2017). In this context, the consensus in previous research has been that if correct detection rate as assessed usually in a post-experimental task (Lähteenmäki et al., 2015) is not significantly different from chance this is evidence that the participants were guessing and were unaware of the presented target (Stanislaw & Todorov, 1999). The first problem with this approach is that hit rates are a possibly biased measure. It allows participants to reply using different subjective criteria. For example, chance-level performance can be the outcome of conservative or liberal detection strategies such as replying seeing a masked face only when one is completely certain a face was presented or replying yes when one is quite unsure that a face was presented (Pessoa, 2005; Pessoa et al., 2005). The inclusion of unbiased signal detection measures such as d' and A' that produce a ratio between hits (correct answers) and false alarms (wrong answers) has been suggested as a more reliable alternative for assessing chance-level performance.

In respect to asserting chance-level awareness previous studies compared participant detection performance to absolute chance (e.g., 50%). If the analysis returned non-significant differences from chance the researchers claimed unconscious perception. The important problem with this approach is that "non-significantly different from chance" – lack of evidence for the alternative hypothesis - is misinterpreted as significantly at-chance and thus as evidence for the null (Overgaard et al., 2013). Previous research has suggested that instead of the traditional frequentist approach, Bayesian inference should be used to assert if performance is significantly at-chance ($B < 1/3$) and infer unconscious processing (Dienes, 2015).

These possible biases cast some doubt to the extent that emotional signals were adequately masked in previous studies. The primary aim of the current report was, therefore, to address these issues and provide necessary methodological conditions to answer whether we can evoke physiological changes in response to unconscious emotional faces. To achieve this goal, we pre-experimentally adjusted for per participant and stimuli type differences in detection performance using both hit rates and signal detection theory and we also assessed target meta-awareness using Bayesian significance for chance-level detection performance (Tsikandilakis & Chapman, 2017; in print); furthermore, we analysed separately correct and incorrect responses and target detection confidence responses to masked angry, fearful, sad and neutral faces using combined skin conductance and heart rate recordings.

2. Methods

2.1. Participants

Twenty-four volunteers (thirteen females) participated in the current study. The mean age for the participants was 33.2 years (S.D. = 8.98). The exclusion criteria for the current study were history of head trauma, current medical treatment, current or previous DSM Axis I or II diagnosis and current or previous alcohol/drug abuse - assessed through self-report. Participants were screened

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