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Emotional facial activation induced by unconsciously perceived dynamic facial expressions

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ABSTRACT

Do facial expressions of emotion influence us when not consciously perceived? Methods to investigate this question have typically relied on brief presentation of static images. In contrast, real facial expressions are dynamic and unfold over several seconds. Recent studies demonstrate that gaze contingent crowding (GCC) can block awareness of dynamic expressions while still inducing behavioural priming effects. The current experiment tested for the first time whether dynamic facial expressions presented using this method can induce unconscious facial activation. Videos of dynamic happy and angry expressions were presented outside participants' conscious awareness while EMG measurements captured activation of the zygomaticus major (active when smiling) and the corrugator supercilii (active when frowning). Forced-choice classification of expressions confirmed they were not consciously perceived, while EMG revealed significant differential activation of facial muscles consistent with the expressions presented. This successful demonstration opens new avenues for research examining the unconscious emotional influences of facial expressions.

1. Introduction

Facial expressions of emotion are an important part of human social interaction – so important that human beings have evolved the ability to process such expressions both extremely quickly and automatically. It is now generally accepted that an emotional face can impact an observer even when he or she is not aware of its presence (e.g. Tamietto and de Gelder, 2010). For example, previous studies have found that even in the absence of conscious recognition, emotional expressions influence participants' evaluative decisions (e.g. Almeida, Pajtas, Mahon, Nakayama, and Caramazza, 2013; Murphy and Zajonc, 1993), activate affect-related brain regions such as the amygdala (Whalen et al., 1998) and lead to emotion-congruent reactions in participants' own facial muscles (Dimberg, Thunberg, and Elmehed, 2000). Overall, measuring the impact that unconsciously perceived facial expressions have on an observer can help to elucidate the automatic aspects of face processing and disentangle such effects from more conscious, strategic reactions towards others' expressions. While several approaches for blocking visual awareness exist, they all constrain the type of stimuli that can be employed (for a review of several techniques see Kim and Blake, 2005). To date, the most commonly utilized method for blocking awareness of facial stimuli has been visual backward masking. Here, the presentation of an emotional face is immediately followed by a non-emotional picture (e.g. a photo of a neutral expression) which helps to block the awareness of the main stimulus of interest (see Kouider and Dehaene, 2007). Crucially, preventing awareness in this way is only possible if the emotional face is presented for a very short time, usually 10 to 30 milliseconds. This constraint on the duration of exposure usually limits experimental studies of nonconscious face processing to the use of static facial images.

In contrast to the static images used in back-masking studies the facial expressions we experience in everyday life are dynamic, i.e. we usually encounter movements of facial muscles that can unfold and change over several seconds. Importantly, a growing body of evidence suggests that the movement and timing of an expression might play a role in how we process it in both quantitative and qualitative terms. Quantitatively, previous studies have found that consciously viewed dynamic facial expressions, as compared to their static counterparts, are rated as more intense (Biele and Grabowska, 2006), create stronger activation in brain regions associated with the processing of socially relevant stimuli (Arsalidou, Morris, and Taylor, 2011), and lead to stronger facial reactions in the observer (Sato, Fujimura, and Suzuki, 2008). Qualitatively, some experimental evidence suggests that people rely on the timing of an expression to interpret its meaning (Ambadar, Schooler, and Cohn, 2005), for example when distinguishing between authentic and posed displays of emotion (Sato & Yoshikawa, 2004; Krumhuber and Kappas, 2005). This raises the question as to whether the influences of dynamic aspects of expressions are dependent on their conscious appreciation or can also result from nonconscious processing. A paradigm permitting effective nonconscious processing of dynamic expressions would help to increase the ecological validity of future experimental findings (Krumhuber, Kappas, and Manstead, 2013). Additionally, it would open new research avenues such as exploring the unconscious

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influence of changes in expression, for example from an expression indicating happiness to one of anger or disgust.

Sato, Kubota, and Toichi (2014) presented an approach to address this limitation within the backward masking paradigm by showing three photos in quick succession (presenting an expression at its onset, its midlevel, and its peak), which were then masked by a neutral stimulus. This effectively results in a short backward masked stop-motion animation. While this presents an improvement in terms of being able to employ dynamic face stimuli in unconscious presentations, the reliance on backward masking here still limits the possible face animation duration (~30 ms in Sato et al., 2014). The resulting need to rely on a stop motion animation of only three pictures produces stimuli that are still arguably different in richness to a natural, dynamic display of emotions.

A recent alternative approach to presenting facial expressions outside of awareness has been described by Kouider, Berthet, and Faivre (2011), who used the gaze contingent crowding paradigm (GCC) to prevent the awareness of videos of facial expressions. In their study dynamic happy and angry faces were shown parafoveally, i.e. in the periphery of people's viewing field, in such a way that participants were not able to focus on the videos directly. These expressions were surrounded by unrelated objects ('flankers') at close proximity giving rise to the so-called crowding effect – the phenomenon that objects close to each other in peripheral vision are perceived as blurring together, making the identification of the crucial face stimuli substantially harder (Levi, 2008). The advantage of preventing awareness using this method is that it is not directly dependent on the duration of the target stimulus; it thus permits the presentation of naturally unfolding dynamic expressions over several seconds. It was found that, despite being unable to consciously identify the expressions being presented, participants rated Chinese characters presented after happy faces as more positive than after angry ones. While these previous studies found evidence that crowded nonconscious presentation can elicit behavioural priming, the current experiment tested for the first time if this technique can be used to induce mirrored facial reactions in the observer. More specifically, we tested if nonconsciously presented happy versus angry faces lead to more smiling (activity in the zygomaticus major muscle) and less frowning (corrugator supercilii muscle, cf. Dimberg et al., 2000).

We also retain the measure of behavioural priming used in previous studies by having participants rate an ambiguous stimulus (Chinese symbol) after each video. This could shed light on a possible interplay between bodily and behavioural priming effects. It is often assumed that these two different aspects of emotional reactivity are closely interrelated, with some theories of embodiment even proposing that a bodily reaction towards a stimulus such as a change in facial expression can causally influence evaluative decisions (Winkielman, Niedenthal, Wielgosz, Eelen, and Kavanagh, 2015; McIntosh, 1996). More specifically, it has been assumed that one's own facial activation can influence evaluative decisions via so-called facial feedback (e.g. that more frowning activation would be related to more negative ratings; cf. Larsen, Kasimatis, and Frey, 1992). If such accounts were true, one would expect to find a relationship between a participant's facial reaction and rating tendency, in a way that a higher degree of smiling/frowning would predict a more positive/negative rating.

Overall, the current study combines the GCC paradigm with EMG measurements of facial muscle activation for the first time in order to evaluate the extent to which unconscious facial activation can be induced via this method. If dynamic expressions presented using GCC are capable of inducing facial activation we should observe a pattern of less frowning (corrugator supercilii activation) and more smiling (zygomaticus major activation) during the presentation of happy as compared to angry expression videos. By asking participants to rate an ambiguous target stimulus directly after each prime video, we also tested if any induced change in smiling/frowning activation would leads to a subsequent behavioural effect, i.e. more positive/negative evaluations.

2. Method

2.1. Participants

Participants were 111 students (70 female) from the University of Sussex. All participants reported corrected-to-normal vision and had no prior knowledge of the Chinese characters used for test stimuli. Since preliminary analysis of the EMG data revealed that three participants showed average activation >2.5 standard deviations above the mean of the sample, these were treated as outliers and excluded from the final analysis, resulting in a sample of 108 students with a mean age of 27.77 ($SD = 10.18$). Based on previous EMG experiments we anticipated a small to medium effect size. We therefore utilized GPower to conduct an a priori power analysis for a repeated measures between factor ANOVA with a medium effect size ($f = 0.25$). This indicated that the total sample size required to achieve a power of 0.8 was 98. We sought to exceed this target, hoping to recruit 110 participants anticipating a number of exclusions and recognising that a medium effect was on the optimistic side.

2.2. Materials

Face stimuli comprised of 16 video clips (taken from Kouider et al., 2011), each showing the face of one of eight actors performing either a happy or angry expression. Each clip lasted for 2.5 s, whereby in the first second each actor showed a neutral expression, followed by the enactment of the happy or angry expression during the next 0.5 s, which was then maintained at peak intensity for the last second. In order to facilitate the crowding effect, 45 non-informative, quasi-random patterns were employed as flankers around the face stimuli. These flankers had a similar size and oval shape as the faces in the videos. For testing the effect of the face presentations on subsequent evaluations, 80 Chinese characters were taken from an internet database (http://en.glyphwiki.org/), each consisting of the same number of brush strokes. All stimuli were presented in greyscale against a black background on a 21″ Dell Trinitron P1130 monitor with a refresh rate of 85 Hz and a screen resolution of 1280×1024 pixels.

Eye gaze was measured via a head-mounted SR Research Eyelink II eye tracker with a sampling rate of 250 Hz and a spatial resolution of 0.01°. Facial EMG was measured with pairs of 4-mm AG/AG-Cl touch-proof electrodes filled with conductive paste (Biopac GEL 100). Prior to electrode attachment, participants' skin was cleaned with Nuprep skin preparation gel in order to reduce resistance. Electrodes were then placed on the regions of interest according to the recommendations of Fridlund and Cacioppo (1986). The signal was recorded via a Biopac MP36 measurement unit at a sample rate of 2000 Hz.

2.3. Procedure

Participants were seated with a chin rest at a distance of 54 cm from the display. Since it has been suggested that performing a motor action can increase the sensitivity to observations of similar actions (Schütz-Bosbach and Prinz, 2007), the experiment started with a conscious observation and imitation task of the facial expression stimuli. More specifically, all videos were presented in the centre of the screen twice in randomized order and participants asked to imitate the expressions they saw. It was hypothesized that such a conscious imitation might help to facilitate muscle activation in the ensuing unconscious presentation of the videos.

The main part of the experiment consisted of parafoveal, crowded displays of the expression videos. Each trial started with a white fixation cross (approx. size: 1° width × 1° height) appearing towards the top of the screen. Participants were instructed to focus on this cross at all times. After one second, while the fixation cross remained present, one of the videos (3.2° × 3.8°) appeared towards the bottom of the screen surrounded by six randomly chosen flankers (3° × 3°; 3.2° centre