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Association between autistic traits and emotion adaptation to partially occluded faces

Chengwen Luo, Edwin Burns, Hong Xu *

Division of Psychology, School of Humanities and Social Sciences, Nanyang Technological University, Singapore

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ABSTRACT

Prolonged exposure to a happy face makes subsequently presented faces appear sadder: the facial emotion aftereffect (FEA). People with autism spectrum disorders and their relatives have diminished holistic perception of faces. Levels of autism can be measured continuously in the general population by autistic traits using the autism-quotient (AQ). Prior work has not found any association between AQ and FEA in adults, possibly due to non-holistic processing strategies employed by those at the higher end of the spectrum. In the present study, we tested whether AQ was associated with FEA to partially occluded faces. We hypothesized that inferring emotion from such faces would require participants to process their viewable parts as a gestalt percept, thus we anticipated this ability would diminish as autistic traits increased. In Experiment 1, we partially occluded the adapting faces with aligned or misaligned opaque bars. Both conditions produced significant FEAs, with aftereffects and AQ negatively correlated. In Experiment 2, we adapted participants to obscured faces flickering in luminance, and manipulated the facilitation of holistic perception by varying the synchronization of this flickering. We found significant FEAs in all conditions, but abolished its association with AQ. In Experiment 3, we showed that the association between AQ and FEA in the occluded conditions in Experiment 1 was not due to the recognizability or perceived emotional intensity of our adaptors; although the overall FEAs were linked to emotional intensity. We propose that increasing autistic traits are associated with diminishing abilities in perceiving emotional faces as a gestalt percept.

1. Introduction

Humans have an incredible ability to perceive and recognize facial emotions in others, with emotion perception thought to be driven mainly by two types of information conveyed by an emotional face: featural (e.g., the curve of a smiling mouth; Martin, Slessor, Allen, Phillips, & Darling, 2012; Tanaka et al., 2012) and holistic (i.e., the percept of the face as a single, coherent whole; Calder & Jansen, 2005; Calder, Young, Keane, & Dean, 2000). One group of people thought to suffer from deficits in the holistic perception of faces are those with Autism Spectrum Disorders (ASD). ASD is typically characterized by a wide range of social and communication impairments, including deficits in facial expression perception (Behrmann, Thomas, & Humphreys, 2006). However, the existence of emotion perception impairment in ASD is still a topic of heated debate (Bird & Cook, 2013; Harms, Martin, & Wallace, 2010), with some authors speculating that they might not even exist at all (Bird & Cook, 2013). Autistic traits have been widely accepted as a continuous construct with ASD at one extreme, and from there extend continuously into the neurotypical population (Baron-Cohen, 1997; Frith, 1991). These traits can be measured using a self-administered questionnaire called the Autism-spectrum Quotient (AQ; Baron-Cohen, Wheelwright, Skinner, Martin, & Clubley, 2001). This tool has been used to examine possible associations between autistic traits and particular cognitive processes, including those of face processing (Ewbank et al., 2014; Rhodes, Jeffery, Taylor, & Ewing, 2013), with increasing levels of autistic traits linked to reduced processing of facial identity and selectively poorer face recognition in men, but not women (Rhodes et al., 2013).

Emotion adaptation paradigms have been used to examine emotion processing abilities in those with ASD. Viewing a happy face for several seconds leads to subsequently presented faces appearing sadder, with such shifts in perception known as facial expression aftereffects (FEA; Webster, Kaping, Mizokami, & Duhamel, 2004). Adaptation paradigms are particularly useful as

* Corresponding author at: Division of Psychology, Nanyang Technological University, 14 Nanyang Drive, HSS-04-06, Singapore 637332, Singapore.
E-mail address: xuhong@ntu.edu.sg (H. Xu).

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they can reveal differences in emotion perception even when recognition performance alone has failed (Liu, Montaser-Kouhsari, & Xu, 2014). One adaptation study found emotional faces generated similar FEA to happy faces in people with ASD and neurotypical controls (NT), but the ASD group exhibited smaller FEA to sad faces (Rutherford, Troubridge, & Walsh, 2012). Interestingly, adapting to negative emotions (e.g. fear, anger and disgust) was more likely to evoke a negative afterimage in people with ASD, in contrast to NT who perceived positive aftereffects, suggesting abnormal processing of emotions in ASD. However, it has been argued that these aberrant aftereffects in ASD may have been due to such cases having difficulties in using emotional labels, rather than impaired processing of emotion *per se* (Cook, Brewer, Shah, & Bird, 2014). Cook et al. (2014) demonstrated comparable FEA between adults with autism and NT controls when such labeling issues were removed. It may therefore seem that levels of autism are not associated with any differences in the perception of emotion as indexed by FEA.

It has been hypothesized that those with ASD may only exhibit seemingly intact emotion adaptation aftereffects due to atypical processing of faces (Cook et al., 2014). Those with ASD could have developed the use of compensatory face processing strategies to counter any experienced difficulties: for example, non-holistic, whereby they extract facial information from individual facial features rather than processing the face as a coherent whole (Joseph & Tanaka, 2003; Klin, Jones, Schultz, Volkmar, & Cohen, 2002). Support for this suggestion comes from evidence that the mouth appears to abnormally drive emotion perception in those with ASD (Neumann, Spezio, Piven, & Adolphs, 2006; Spezio, Adolphs, Hurley, & Piven, 2007) and their subclinical relatives (Adolphs, Spezio, Parlier, & Piven, 2008). In these cases, seemingly neurotypical face adaptation aftereffects might be due to them perceiving faces from the mouth region. Indeed, this is certainly a possibility as previous work has shown that a mere curved line, mimicking a happy mouth's curve, can still produce FEA in the absence of any face (Xu, Dayan, Lipkin, & Qian, 2008). It should be stressed, though, that it is far from clear whether those with ASD (and their subclinical relatives) actually perceive facial emotion in a similar way as subclinical individuals merely high in autistic traits. The possibility that there is a diminishing ability to perceive emotion in a holistic fashion as autistic traits increase in the neurotypical population is certainly, however, of interest. Such a finding would infer that those with ASD are not abnormal in their emotion perception behavior *per se*, but merely utilizing a neurotypical face processing strategy that is similar to those that are subclinically high in autistic traits.

It has been suggested that amodal completion, the ability to infer a stimulus's full form when it is partially obscured (Kasai & Murohashi, 2013; Michotte, Thines, & Crabbe, 1964), is related to processing in the Lateral Occipital Complex (Hegdé, Fang, Murray, & Kersten, 2008; Lerner, Hendler, & Malach, 2002), a region shown to exhibit abnormal neural responses (Hubl et al., 2003) and volumetric differences (Ecker et al., 2012; Nickl-Jockschat et al., 2012) in ASD. By inducing amodal completion during emotion adaptation, for example by applying opaque bars over the adapting face, we can test our participants' abilities to utilize holistic information during emotion perception (Nakayama, Shimojo, & Silverman, 1989; Yokoyama, Noguchi, Tachibana, Mukaida, & Kita, 2014). As mentioned above, those with ASD and their relatives may use non-holistic strategies to process facial emotion. By partially obscuring the face, our participants will be required to perceive emotion through amodal completion of the viewable face parts into a gestalt percept. We anticipate that such a paradigm will reveal an association between emotion adaptation and autistic traits that has previously been unobserved. By contrast, if no association between AQ and FEA to obscured faces were to be found, then it would imply that holistic perception of facial emotion does not diminish in the form of FEA across increasing levels of autistic traits.

In the current study, we sought to answer two questions: 1) Does the FEA to partially obscured faces reveal a previously unidentified association with autistic traits in adults? 2) Can partially obscured adapting faces be amodally completed to generate FEA in NT adult participants? We designed the following experiments to test these possibilities. In the first experiment, we tested whether partially obscuring our adapting faces would reveal a previously unidentified relationship between FEA and AQ. Under such circumstances, participants will have to amodally complete the partially viewable adaptor face into a single holistic percept to process its emotion and produce FEA.

2. Experiment 1

In our first experiment, we adapted our participants to happy faces that were partially occluded by using aligned or misaligned opaque bars (Fig. 1). Our use of opaque bars has a number of benefits over commonly employed paradigms that are typically reported to test holistic processing. These tasks include: face inversion paradigms (Yin, 1969), where holistic processing is thought to be disrupted by faces being viewed upside down, or face composite tasks (Young, Hellawell, & Hay, 1987), where holistic processing is disrupted by misaligning two face halves. First, we are testing participants with face configurations that are still kept within their canonical formation (i.e., the T-shaped inner zone of the face's features), instead of disrupting this template through inversion or misalignment of the adapting face. Thus, any processing of our occluded faces' emotions must be due to our participants' typically employed abilities to perceive an upright face as a whole percept. Further to this, it is still unclear whether inversion merely disrupts holistic processing in a quantitative (Sekuler, Gaspar, Gold, & Bennett, 2004) or qualitative (Rossion, 2008) fashion. Similarly, there have been recent concerns as to what aspects of face processing the composite face task actually indexes (Murphy, Gray, & Cook, 2016). The fact that those with ASD have been shown to exhibit neurotypical face inversion effects but atypical composite effects (Teunisse & de Gelder, 2003) would seem to suggest that the two tasks might measure qualitatively different aspects of face processing. These debates suggest a simpler paradigm whereby faces' configural information is kept relatively intact, but partially occluded, might reveal the extent to which participants' can typically process facial emotion in a holistic fashion as indexed by FEA.

Here we present aligned or misaligned bars over an adapting face. We anticipate that the aligned bars should facilitate a coherent perception of the adapting face due to its fairly natural display. If participants are able to fill-in the missing facial parts in high-level cortical areas, and form a global representation of the faces, then the FEA should consist of the viewable local (i.e., viewable featural information, such as the eyes) and global (i.e., ability to infer emotion by grouping viewable parts together into a whole percept) components of the aftereffect. Those high in autistic traits have been associated with diminished abilities in global perception (Brosnan, Scott, Fox, & Pye, 2004; Kasai & Murohashi, 2013). We therefore anticipate that the holistic component in our FEA will diminish as autistic traits increase due to diminishing abilities in amodal completion of the viewable parts coherently. In our misaligned condition, however, we anticipate that the unnatural positioning of the bars will disrupt holistic perception of the adapting face for all participants; prior work has shown such unnatural items are more difficult to process than those that are occluded in a natural way (Johnson & Olshausen, 2005). We therefore expect no association to be found between autistic traits and FEA in this condition.