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Adults with autism spectrum disorder show evidence of figural aftereffects with male and female faces

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ABSTRACT

The norm-based coding model of face perception posits that face perception involves an implicit comparison of observed faces to a representation of an average face (prototype) that is shaped by experience. Using some methods, observers with autism spectrum disorder (ASD) have shown atypical face perception, but other methods suggest preserved face perception. Here, we used a figural aftereffects paradigm to test whether adults with ASD showed evidence of norm-based coding of faces, and whether they encode separate prototypes for male and female faces, as typical observers do. Following prolonged exposure to distorted faces that differ from their stored prototype, neurotypical adults show aftereffects: their prototype shifts in the direction of the adapting face. We measured aftereffects following adaptation to one distorted gender. There were no significant group differences in the size or direction of the aftereffects; both groups showed sex-selective aftereffects after adapting to expanded female faces but showed aftereffects for both sexes after adapting to contracted face of either sex, demonstrating that adults with and without ASD show evidence of partially dissociable male and female face prototypes. This is the first study to examine sex-selective prototypes using figural aftereffects in adults with ASD and replicates the findings of previous studies examining aftereffects in adults with ASD. The results contrast with studies reporting diminished adaptation in children with ASD.

1. Introduction

1.1. Autism spectrum disorder

Autism spectrum disorder (ASD) is characterized by deficits in social communication and interactions as well as repetitive and restrictive behaviors and interests (American Psychiatric Association, 2013). The ability of individuals with ASD to process social information in faces has been an area of focused research in recent decades, but there is still no clear understanding of the specific face processing deficits in the current literature. While many studies have focused on measuring performance accuracy on various face perception tasks, relatively few studies have examined the perceptual mechanisms underlying face perception. Face adaptation and norm-based coding are purported to facilitate typical face perception, however, a limited number of studies have examined face adaptation in adults with ASD (e.g., Cook, Brewer, Shah, & Bird, 2014; Walsh et al., 2015). Examining face adaptation and norm-based coding in ASD will provide a direct test of whether face perception processes are the same in individuals with ASD compared to typical observers.

1.2. Norm-based face processing in typical individuals

Typical adults are expert face processors and show superior performance on face-based visual perception in comparison to other visual stimuli (see Maurer, Grand, & Mondloch, 2002, for a review). The norm-based coding model of face perception (Rhodes & Leopold, 2011; Webster & MacLeod, 2011) suggests that the perception of faces involves an implicit comparison of perceived faces to a prototypical or average face (Rhodes et al., 2005; Rhodes, Jeffery, Watson, Clifford, & Nakayama, 2003). This average face is thought to be dynamic, updating constantly as an individual experiences faces.

1.3. Face aftereffects

Previous studies have used an aftereffects paradigm to examine norm-based coding of faces. A face aftereffect is an effect, caused by prolonged exposure to a face, on the perception of a subsequent face (or group of faces; see Webster & MacLeod, 2011 for a review). In order to test the hypothesis that individuals' face prototype can

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be calibrated by recent visual experiences, several researchers have measured the results of exposure to artificially distorted faces, an approach known as figural face aftereffects (e.g., Jaquet & Rhodes, 2008; Jaquet, Rhodes, & Hayward, 2007; Little, DeBruine, & Jones, 2005; Little, DeBruine, Jones, & Waitt, 2008; Rhodes et al., 2003, 2004; Watson & Clifford, 2003, 2006; Webster & MacLin, 1999). The figural face aftereffects paradigm involves recalibrating individuals' average face representation by exposing them to a series of faces that are distorted in a similar manner (e.g., extreme spacing between the eyes and mouth, expansion or contraction). This is thought to create neural adaptation and to shift the observer's average face representation in the direction of the distortion (MacLin & Webster, 2001; Rhodes et al., 2003). By measuring individuals' normality ratings of a range of faces before and after adaptation, an experimenter is able to infer a change in the facial characteristics that are perceived as most normal. These changes in normality ratings correspond to changes in the average face representation.

The figural aftereffects paradigm has also been used to explore whether various categories of faces are encoded by overlapping neural populations. If two categories of faces (e.g., male and female) were coded by separate neural populations, then adapting participants to distorted faces from one category should induce aftereffects for that category without affecting the other category. In contrast, if the two categories of faces were coded by common or overlapping neural populations, then adapting participants to one category of faces should create measureable aftereffects for both categories. Furthermore, if discrete neural populations code the two categories of faces, it should be possible to recalibrate the average representation for each category in opposite directions, leading to aftereffects in opposite directions for the two categories, e.g., contracted versus expanded (Rhodes et al., 2003). Figural face aftereffects have been demonstrated for race (Jaquet et al., 2007; Jaquet, Rhodes, & Hayward, 2008; Little et al., 2008), and sex (Little et al., 2005; Jaquet & Rhodes, 2008) and are seen even with inverted faces (Rhodes et al., 2004; Watson & Clifford, 2006).

1.4. Separate encoding of prototypes for each sex

Little et al. (2005) used the simple (i.e., aftereffects created and measured within a sex category) and opposing (i.e., male and female faces adapted to opposite distortions) figural aftereffects paradigms together to examine whether male and female face prototypes are encoded by distinct or overlapping neural populations. Across three experiments, participants displayed sex-selective simple and opposing aftereffects, which the authors interpreted as evidence for distinct neural representations of male and female faces. Jaquet and Rhodes (2008) used similar methods as well as a more sensitive measure and found similar sex selective aftereffects, but the authors also reported aftereffect transference to test faces of the unadapted sex, a pattern suggesting common neural underpinnings for male and female faces. Taken together, these studies suggest that male and female faces are encoded with partly, but not fully, overlapping neural populations.

1.5. Face aftereffects in individuals with autism spectrum disorder

Previous research has provided conflicting results regarding deficits in face processing in ASD. Some studies report atypical performance on specific face processing tasks such as emotion or identity recognition, while others report typical performance (see Jemel, Mottron, & Dawson, 2006; Sasson, 2006; Weigelt, Koldewyn, & Kanwisher, 2012 for reviews). Face aftereffects paradigms can be used to explore the psychological relationships among face categories, such as emotional expressions (Rutherford, Chattha, & Krysko, 2008). Rutherford, Troubridge, and Walsh (2012) used an aftereffects paradigm to examine the psychological organization of facial expressions in adults with ASD and found atypical psychological organization of the six basic emotions. Aftereffects can also be used to test for reduced or abnormal norm-based coding of face information. Pellicano, Jeffery, Burr, and Rhodes (2007) employed an identity aftereffects paradigm to demonstrate that norm-based coding of facial identity was atypical in children with ASD. Ewing, Pellicano, and Rhodes (2013) demonstrated that children with ASD show smaller figural aftereffects for upright faces, but not inverted faces or cars, suggesting selective deficits for upright faces. Similarly, Ewing, Leach, Pellicano, Jeffery, and Rhodes (2013) reported that children with ASD show reduced identity aftereffects when attention to adapting faces is controlled suggesting that diminished adaptation is not likely due to inattention to adapting stimuli.

Only one study has used the aftereffects paradigm to examine opponent coding and face adaption in adults with ASD. Cook et al. (2014) examined identity and expression aftereffects in adults with ASD and reported no group differences in the size of either type of aftereffect, indicating intact adaptation to facial identity and expression. The difference between these results and those of experiments showing atypical face adaptation in children with ASD may indicate a developmental delay in face adaptation in the ASD population, however, this needs to be explored further. The figural aftereffects paradigm has yet to be used to examine norm-based coding in adults ASD populations. As this paradigm is well established in typical populations and considered a useful experimental tool for examining face adaptation and norm-based coding, we used this paradigm to test whether adults with ASD show evidence of norm-based coding just as typical observers do, and whether adults with ASD encode separate prototypes for male and female faces, just as typical observers do.

1.6. The current research

The current experiment was designed to examine the extent to which high-functioning adults with ASD show evidence of norm-based coding and show distinct perceptual representations of male and female faces. We employed a figural face aftereffects paradigm, which is a well-established experimental tool for measuring face aftereffects but has never been used with an ASD population. We tested whether adults with ASD would show evidence of simple sex selective aftereffects to the same extent as typical individuals by adapting them to faces of one sex distorted in one direction and then measuring their subsequent perception of faces of both sexes. If adults with ASD encode gender information as typical individuals do, we would expect participants to show aftereffects for test faces that are primarily contingent on the sex of the adapting face. For example, if they are adapted to female distorted faces, they should show stronger aftereffects for female faces compared to male test faces, although some transfer of aftereffects may occur (see Jaquet & Rhodes, 2008). If adults with ASD encode sex information in faces atypically, we might find group differences in either the size or the direction of the aftereffects.

2. Methods

2.1. Participants

Participants were 20 high-functioning adults (13 males, average age 26.8 years, range 18–39) with a diagnosis of ASD and 20 typical adults (17 males, average age 29.5, range 20–40). The groups did not significantly differ in chronological age or IQ (see Table 1 for demographic information). Four additional participants (2 ASD) were excluded because of technical error (1 ASD, 2 typical participants) or inattentiveness (1 ASD participant).