Neuropsychologia 51 (2013) 2702–2708

Contents lists available at ScienceDirect

Neuropsychologia

journal homepage: www.elsevier.com/locate/neuropsychologia

Autistic traits are linked to reduced adaptive coding of face identity and selectively poorer face recognition in men but not women

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ARTICLE INFO

Article history:
Received 23 May 2013
Received in revised form
16 August 2013
Accepted 20 August 2013
Available online 29 August 2013

Keywords:
Autistic traits
Broader autism phenotype
Face recognition
Face identity aftereffects
Individual differences

ABSTRACT

Our ability to discriminate and recognize thousands of faces despite their similarity as visual patterns relies on adaptive, norm-based, coding mechanisms that are continuously updated by experience. Reduced adaptive coding of face identity has been proposed as a neurocognitive endophenotype for autism, because it is found in autism and in relatives of individuals with autism. Autistic traits can also extend continuously into the general population, raising the possibility that reduced adaptive coding of face identity may be more generally associated with autistic traits. In the present study, we investigated whether adaptive coding of face identity decreases as autistic traits increase in an undergraduate population. Adaptive coding was measured using face identity aftereffects, and autistic traits were measured using the Autism-Spectrum Quotient (AQ) and its subscales. We also measured face and car recognition ability to determine whether autistic traits are selectively related to face recognition difficulties. We found that men who scored higher on levels of autistic traits related to social interaction had reduced adaptive coding of face identity. This result is consistent with the idea that atypical adaptive face-coding mechanisms are an endophenotype for autism. Autistic traits were also linked with face-selective recognition difficulties in men. However, there were some unexpected sex differences. In women, autistic traits were linked positively, rather than negatively, with adaptive coding of identity, and were unrelated to face-selective recognition difficulties. These sex differences indicate that autistic traits can have different neurocognitive correlates in men and women and raise the intriguing possibility that endophenotypes of autism can differ in males and females.

1. Introduction

Autism is a developmental disorder characterized by deficits in social communication, social interaction and restricted and repetitive behaviors. Milder expression of autistic traits can also occur in relatives of individuals with autism, in the "Broader Autism Phenotype" (Losh & Piven, 2007; Piven, Palmer, Jacobi, Childress, & Arndt, 1997; Ronald & Hoekstra, 2011; Sucksmith, Roth, & Hoekstra, 2011). There is also evidence for continuous, quantitative variation in autistic traits in the general population (Baron-Cohen, Wheelwright, Skinner, Martin, & Clubley, 2001; Constantino & Todd, 2003; Hoekstra, Bartels, Cath, & Boomsma, 2008). As a result, the concept of a broader autism phenotype can be extended to encompass this variation.

Autism is a highly heritable disorder, but its genetic basis remains poorly understood (Geschwind, 2011; Rutter, 2000; Skuse, 2007). Interest in the broader phenotype has been fueled by a search for endophenotypes that may have a simpler genetic basis than the disorder itself (but see Flint & Munafò, 2007). Endophenotypes are heritable (internal) features or processes that are related to, but simpler than, the entire disorder (Flint & Munafò, 2007; Geschwind, 2011; Gottesman & Gould, 2003). They indicate genetic susceptibility to autism and so should occur more often in family members than the general population. They should also co-vary with levels of autistic traits in the general population.

People with autism can experience a range of face processing difficulties and atypicalities (for reviews, see Dawson, Webb, & McPartland, 2005; Golarai, Grill-Spector, & Reiss, 2006; Sasson, 2006; Webb, Faja, & Dawson, 2011; Weigelt, Koldewyn, & Kanwisher, 2011). Subtle face processing difficulties have also been reported in relatives of individuals with autism (for recent reviews, see Fiorentini, Gray, Rhodes, Jeffery, & Pellicano, 2012; Sucksmith et al., 2011) although these are not always found (Wilson, Freeman, Brock, Burton, & Palermo, 2010). These findings raise the possibility that atypical face-processing mechanisms could be an endophenotype for autism.

One potential mechanism underlying these difficulties is reduced adaptive coding of faces. The adaptive nature of face-coding

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http://dx.doi.org/10.1016/j.neuropsychologia.2013.08.016

mechanisms is highlighted by face aftereffects, in which exposure (adaptation) to a face alters our perception of a subsequently presented face (for reviews see Rhodes & Leopold, 2011; Webster & MacLeod, 2011). For example, exposure to a face biases us to see an identity with opposite features (Leopold, O'Toole, Vetter, & Blanz, 2001; Rhodes & Jeffery, 2006; Tsao, Freiwald, Tootell, & Livingstone, 2006). This bias to see an identity that is *opposite* (relative to the average) the adapting face in face-space (Fig. 1), suggests that the average face functions as a perceptual norm for coding identity. The use of norms and their calibration by experience likely contributes to our ability to discriminate and recognize thousands of faces despite their similarity as visual patterns (Rhodes & Leopold, 2011; Webster & MacLeod, 2011). Indeed recent studies have linked individual differences in face recognition ability with differences in adaptive coding (Dennett, McKone, Edwards, & Susilo, 2012; Rhodes, Jeffery, Taylor, Hayward, & Ewing, submitted for publication).

Importantly, the size of face identity aftereffects is reduced in children with autism (Pellicano, Jeffery, Burr, & Rhodes, 2007) and in relatives of children with autism (Fiorentini et al., 2012). These findings support the hypothesis that reduced adaptive coding of face identity is an endophenotype for autism. In the present study we test this hypothesis further by examining whether adaptive coding of identity is negatively associated with levels of autistic traits in the general population. If reduced adaptive coding is an endophenotype for autism, as hypothesized, then higher levels of autistic traits should be associated with smaller face identity aftereffects.

We also examined whether face recognition ability is reduced in individuals with higher levels of autistic traits. If higher levels of autistic traits are associated with smaller face identity aftereffects, as hypothesized, then they might also be associated with poorer face recognition, because adaptive coding helps us recognize faces (Dennett et al., 2012; Rhodes et al., submitted for publication; Rhodes & Leopold, 2011; Webster & MacLeod, 2011). Although face recognition is impaired in autism, little is known about face recognition in the broader phenotype (Sucksmith et al., 2011). Only one study has assessed face recognition in family members (Wilson et al., 2010). It found impaired face recognition for fathers, but not mothers, of individuals with autism. Two studies have examined the association between face recognition and autistic

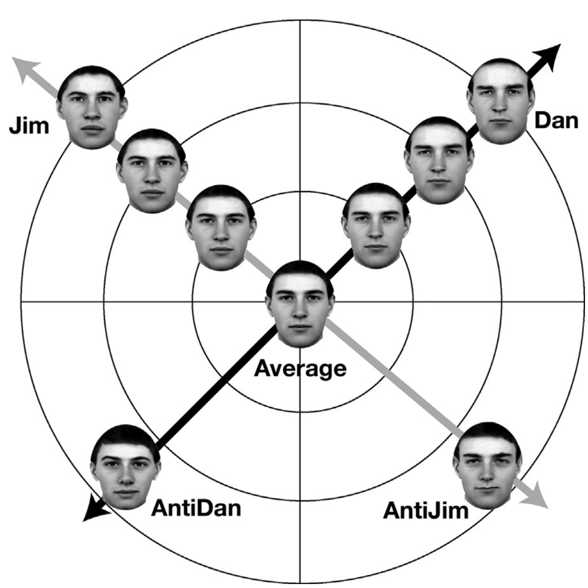

Fig. 1. A hypothetical two-dimensional face-space with two identities, Dan and Jim (plus reduced-identity-strength versions), together with antifaces that have opposite properties to those identities, and an average male face. In the identity aftereffect, exposure to a face (e.g., antiDan) shifts the average (norm) towards that face, biasing perception selectively towards the opposite identity (e.g., Dan).

traits in undergraduate samples, but results were weak and mixed (Hedley, Brewer, & Young, 2011; Sasson, Nowlin, & Pinkham, 2012). Hedley et al. (2011) found a small, non-significant, negative correlation between the Cambridge Face Memory Test (CFMT) and AQ scores. Sasson et al. (2012) found marginally significant, negative correlations of Benton Facial Recognition Test scores with total Broader Autism Phenotype Questionnaire (BAPQ) scores and with BAPQ social/pragmatic language subscale scores, but a significant positive correlation with observed social skill. These studies provide very limited evidence that face recognition difficulties are part of the broader autism phenotype.

We measured autistic traits using the AQ and its subscales (Baron-Cohen et al., 2001) in a large sample of undergraduates. We measured face and non-face (car) recognition ability using the Cambridge Face Memory Test (CFMT) and the Cambridge Car Memory Test (CCMT), respectively. By including a measure of non-face recognition ability, we could assess whether autistic traits are linked selectively to *face* recognition ability. We measured adaptive coding of identity using face identity aftereffects. Reliable measurement of these aftereffects requires a lengthy psychophysical testing procedure, which was completed by just over half of our participants. To summarize, we reasoned that if reduced adaptive coding is an endophenotype for autism, as hypothesized, then higher levels of autistic traits should be associated with smaller face identity aftereffects and poorer face recognition in our undergraduate sample.

2. Method

2.1. Participants

Two-hundred and forty Caucasian, Introductory Psychology students participated for course credit (177 females, $M=19.2$ years, $SD=4.4$, range $=17$–46; 63 males, $M=19.4$ years, $SD=3.3$, range $=17$–38). In addition to general recruiting via the experimental participation pool, we invited students who scored in the highest and lowest 25% on the Autism-Spectrum Quotient (AQ) (Baron-Cohen et al., 2001), which had been administered to the entire class together with other questionnaires at the beginning of the semester. A substantial minority of participants (about 20%)[1] were recruited in this way in an attempt to increase the range of scores, and the AQ distributions should be interpreted accordingly. No information was available on psychiatric conditions.

2.2. Tasks and measures

2.2.1. The Autism-Spectrum Quotient (AQ)

This is a widely used self-report measure of autistic traits in adults with normal intelligence (Baron-Cohen et al., 2001). It has good inter-rater and test–retest reliability and yields significantly higher scores for individuals with Asperger Syndrome or high-functioning autism than controls. It contains 10 items in each of 5 domains: communication, social, imagination, local details and attention switching, for a total of 50 items. For each item, participants respond on a 4-point scale (definitely agree, slightly agree, slightly disagree, definitely disagree). Scoring was originally binary (0–1) for each item, but we followed the more recent practice of using a 4-point scoring system (e.g., Hoekstra et al., 2008; Manera, Del Giudice, Grandi, & Colle, 2011). We calculated a total score, AQ_Total, plus scores for two factors identified by a large scale psychometric study (Hoekstra et al., 2008): an attention to details factor (from local details items), AQ_Attention-To-Detail, and a social interaction factor (from items in the other four domains), AQ_Social. Both factors have acceptable internal and test–retest reliability (Hoekstra et al., 2008). Finally, we calculated a second total AQ score using the binary method, to check whether any participants exceeded the recommended clinical cut-off of 32 (Baron-Cohen et al., 2001).

2.2.2. Face identity aftereffect task

This task has been widely used to measure adaptive, norm-based coding of identity. We used a version adapted from previous studies (Jeffery et al., 2011; Rhodes et al., 2011) (for full details see Rhodes et al., submitted for publication). Briefly, on each trial participants viewed an adapting antiface followed by a target face presented at low identity strength (15%), which they had to identify (Fig. 1). Adapt and test faces were different sizes to minimize the contribution of low-level,

[1] Unfortunately, we did not record exactly how many participants were recruited in this way.