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Response to familiar faces, newly familiar faces, and novel faces as assessed by ERPs is intact in adults with autism spectrum disorders

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ABSTRACT

Individuals with autism spectrum disorders (ASD) have pervasive impairments in social functioning, which may include problems with processing and remembering faces. In this study, we examined whether posterior ERP components associated with identity processing (P2, N250 and face-N400) and components associated with early-stage face processing (P1 and N170) are atypical in ASD. We collected ERP responses to a familiar repeated face (Familiar), an unfamiliar repeated face (Other) and novel faces (Novels) in 29 high-functioning adults with ASD and matched controls. For both groups, the P2 and N250 were sensitive to repetition (Other vs. Novels) and personal familiarity (Familiar vs. Other), and the face-N400 was sensitive to repetition. Adults with ASD did not show significantly atypical processing of facial familiarity and repetition in an ERP paradigm, despite showing significantly poorer performance than controls on a behavioral test of face memory. This study found no evidence that early-stage facial identity processing is a primary contributor to the face recognition deficit in high-functioning ASD.

1. Introduction

Autism is defined by impairments in the areas of social interaction and communication and marked by the presence of a restricted repertoire of behavioral activities and interest. Although not identified as a core phenotype of autism spectrum disorders (ASD), face processing and recognition is thought to be a relative area of weakness for many individuals with ASD (for review see Dawson et al., 2005; Jemel et al., 2006; Webb, 2008). Briefly, alterations in face processing in ASD may include: biases toward high spatial frequency information in faces (e.g., Deruelle et al., 2004; de Jong et al., 2008); reduced configural processing of faces (e.g., Faja et al., 2009; Teunisse and de Gelder, 2003); alternative patterns of attention to features within the face such as atypical or reduced eye attention (e.g., Langdell, 1978; Klin et al., 2002; Pelphrey et al., 2002; Sterling et al., 2008b); and differential patterns of responses to familiar vs. unfamiliar faces (Pierce et al., 2004; Pierce and Redcay, 2008). Although disruptions in the early processing of facial identity could contribute to face recognition deficits in ASD, few studies have examined this question. This paper uses electroencephalography (EEG) to explore the neural correlates of face identity processing in individuals with ASD relative to typical controls, in relation to behavioral measures of face memory, cognitive functioning, and symptom levels.

1.1. Early stage processing of faces

Models of early-stage face processing have differentiated between face detection, involving the characterization of first-order facial structure, and face identification, which involves processing facial features and their second-order spatial relations (Bruce and Young, 1986; Maurer et al., 2002). One way to characterize these stages of face processing is to examine event-related potentials derived from electroencephalography, as specific waveform components have been associated with different stages of face processing.

Face detection has been associated with the N170, a posterior-temporal component that peaks between 130 and 190 ms to face stimuli (Bentin et al., 1996). This component typically responds to faces on a categorical but not individual level or based on familiarity (e.g., Eimer, 2000; Herzmann et al., 2004; Tanaka et al., 2006; but see Caharel et al., 2005; Jemel et al., 2010). Several studies have

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examined the N170 response to novel faces in individuals with ASD. Early work found that the N170 response to novel faces was slowed in adolescents and adults with ASD (McPartland et al., 2004; O'Connor et al., 2007), suggesting differences in the structural phase of face processing that may be correlated with face recognition skills (McPartland et al., 2004). More recent work has suggested that latency differences are not observed when attention is directed to the eye region, although subtle atypicalities in holistic or configural processing (a reduced inversion effect) may remain (Webb et al., in press).

1.2. Identity processing

Identity processing has been most consistently associated with the N250 and face-N400 components in typical adults. These components are negative-going deflections over posterior-temporal electrodes measured between 200–300 ms and 300–500 ms after stimulus onset, respectively. Both components appear to be modulated by pre-experiment facial familiarity (Jemel et al., 2010; Schweinberger et al., 1995; Schweinberger et al., 2002a,b), face learning (Kaufmann et al., 2009; Tanaka et al., 2006), and face repetition (Begleiter et al., 1995; Eimer, 2000; Herzmann et al., 2004; Itier and Taylor, 2004; Schweinberger et al., 1995) suggesting that they are involved in processing facial identity. More recently, Jemel et al. (2010) found both the N170 and N250 amplitude signaled overt face recognition with later components such as the face-N400 increased in amplitude approaching overt recognition, suggesting that the face-N400 reflects the automatic activation of the face representation system without necessitating conscious recognition.

Modulation of the P2 has also been associated with mnemonic processing of faces. The P2 is a positive component immediately following the N170 that is thought to reflect feedback-driven re-activation of primary visual areas (Kotsoni et al., 2007). Modulation of the P2 has been found to be related to: feature detection and encoding (Itier and Taylor, 2002; Luck and Hillyard, 1994), perceptual expertise (Stahl et al., 2008; Wiese et al., 2008), short term memory (e.g., Taylor et al., 1990), subsequent recognition and recall (Halit et al., 2000; Smith, 1993), pre-experimental familiarity (Caharel et al., 2002), and repetition (van Strien et al., 2009). It has been suggested that the P2 response to a face may reflect the degree to which continued configural processing is required for recognition (Caharel et al., 2002; Latinus and Taylor, 2006). The modulation of the P2, N250 and face-N400 by familiarity and repetition has not been examined in adults with ASD.

One previous study provides evidence that the neural correlates of identity processing may be atypical in young children with ASD. In a study with 3- to 4-year-old children, Dawson et al. (2002) found that children with ASD did not show differentiation between their mother's face and an unfamiliar face over components that responded to identity in typical children and children with developmental delay (the Nc, P400, and slow wave). Although the relation between these components and the adult N250 and face-N400 is unclear, these findings suggest that exploring the neural correlates of identity processing in adults with ASD is an important avenue of investigation.

1.3. Current paradigm

In this report, we presented adults with ASD and IQ and gender matched controls three types of facial stimuli: a face that was *a priori* familiar (Familiar), a face that was repeated but initially unfamiliar (Other; Tanaka et al., 2006), and novel non-repeated faces (Novels). Familiarity was addressed by comparing the Familiar and Other stimuli, which differed on *a priori* exposure but were similar on within paradigm repetition. A picture of a personally familiar face was used because famous faces (often used with typical participants) may not have the same meaning to adults with ASD and familiar faces may evoke more typical neural activity in individuals with ASD (Pierce et al., 2004; Pierce and Redcay, 2008). Repetition was addressed by comparing the Other and Novels, which were both unfamiliar at the start of the paradigm but differed in repetition within the paradigm. High-density ERP responses were recorded and comparisons between face types were made at the P1, N170, P2, N250, and face-N400. We also explored whether any variables that differed between the groups were related to symptom levels, language abilities, or behavioral measures of face recognition.

2. Materials and methods

2.1. Participants

Two groups of adults participated in the study: 39 individuals with autism spectrum disorder (ASD) and 38 controls (neuropsychiatrically healthy individuals). ASD participants all had current clinical diagnoses of ASD and met research diagnostic standards for ASD based on the Autism Diagnostic Observation Schedule-Western Psychological Services (ADOS-WPS; Lord et al., 2002), Autism Diagnostic Interview social and communication domains (ADI-R-WPS; Rutter et al., 2003) and expert clinical diagnostic judgment based on DSM-IV criteria. Exclusionary criteria for participants with ASD included diagnosis of Fragile X, seizures, significant sensory or motor impairment, major physical abnormalities, serious head injury, and use of anti-convulsant or barbiturate medications. Exclusionary criteria for control participants included birth or developmental abnormalities, brain trauma, psychotropic medication usage, a first degree relative with autism, significant sensory or motor impairment, major physical abnormalities, or history of serious head injury. Some participants were involved in a larger study on face processing and social skills, results of which are reported elsewhere (Bernier et al., 2007; Faja et al., 2008, 2009; Kleinhans et al., 2009; Murias et al., 2007; Sterling et al., 2008a,b; Webb et al., in press).

Twenty-nine individuals with ASD and 28 controls provided adequate artifact-free data. Of this ASD group, 12 participants met DSM-IV criteria for Autistic Disorder, 2 met criteria for Pervasive Developmental Disorder, Not Otherwise Specified, and 15 met criteria for Asperger's Disorder. Table 1 presents sample demographic and descriptive information, including Wechsler IQ scores (Wechsler, 1997) for both groups.

2.2. Behavioral tests

The Wechsler Memory Scale—Third Edition, Faces Subtest (Wechsler, 1997) was used to assess immediate and delayed recognition memory for faces. Participants view 24 stimuli presented each for 2 s. To test recall, immediately and after a 30 min delay, the participant is presented with 48 stimuli and the participant indicated if the stimulus was one that he or she was asked to remember.

2.3. EEG recording procedure

2.3.1. Stimuli and procedure

Stimuli consisted of grey-scale digital images of faces presented on a computer monitor with a grey background. All facial images were standardized so that the center of the eyes was presented at the center of the screen; visual angle for the faces was 11° (height) by 7.6° (width). Stimuli were presented randomly in 3 blocks of 58 trials. Trials came from four different stimulus categories: a repeating familiar face (Familiar, total trials = 50), a repeating unfamiliar face (Other, total trials = 50), non-repeating unfamiliar faces (Novels, total trials = 50), and houses (Targets; total trials = 24). The familiar face was a neutral picture of the participant's family member or close friend (e.g., parent, roommate, or spouse). The Other face was another participant's family member or close friend. The Familiar face and