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Impaired detection and differentiation of briefly presented facial emotions in adults with high-functioning autism and asperger syndrome

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A R T I C L E I N F O

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A B S T R A C T

Although deficits in the recognition of emotional facial expressions are considered a hallmark of autism spectrum disorder (ASD), characterization of abnormalities in the *differentiation* of emotional expressions (e.g., sad vs. angry) has been rather inconsistent, especially in adults without intellectual impairments who may compensate for their deficits. In addition, previous research neglected the ability to *detect* emotional expressions (e.g., angry vs. neutral). The present study used a backward masking paradigm to investigate, a) the detection of emotional expressions, and b) the differentiation of emotional expressions in adults diagnosed with high functioning autism or Asperger syndrome (n = 23) compared to neurotypical controls (n = 25). Compensatory strategies were prevented by shortening the stimulus presentation time (33, 67, and 100 ms). In general, participants with ASD were significantly less accurate in detecting and differentiating emotional expressions compared to the control group. In the emotion differentiation task, individuals with ASD profited significantly less from an increase in presentation time. These results reinforce theoretical models that individuals with ASD have deficits in emotion recognition under time constraints. Furthermore, first evidence was provided that emotion *detection* and emotion *differentiation* are impaired in ASD.

1. Introduction

Persistent deficits in social communication and social interaction are core symptoms of autism spectrum disorder (ASD) (American Psychiatric Association, 2013). Emotion recognition plays an essential role in social interactions, as it lays the foundation for other social processes such as understanding the intentions and needs of others (Brothers, 2002; Couture, Penn, & Roberts, 2006; Patin & Hurlemann, 2015). Facial expressions are important for inferring the emotional state of another person (Adolphs, 2002a; Blair, 2003; Izard, 1977). Emotions depicted in facial expressions are often subtle and brief, thus need to be detected quickly to extract emotional cues from the face (Tracy & Robins, 2008). In neurotypical individuals, the accurate recognition of facial expressions seems to happen almost automatically (Dimberg, Thunberg & Elmehed. 2000; Sternberg, Wiking, & Dahl. 1998; Vuilleumier & Schwartz, 2001; Whalen et al., 1998) and occurs within milliseconds (e.g., Calvo & Esteves, 2005; Sweeny, Suzuki, & Grabowecky, 2013). To allow for such a high level of expertise and to enable the recognition of an emotional expression in the blink of an eye, neurotypical individuals draw on a distributed set of structures, such as the occipitotemporal neocortex, amygdala, orbitofrontal cortex and right frontoparietal cortices (Adolphs, 2001, 2002b).

Numerous studies on abnormal emotion recognition in ASD have been conducted and resulted in two meta-analyses demonstrating impaired recognition of facial expressions (Lozier, Vanmeter, & Marsh, 2014; Uljarevic & Hamilton, 2013). However, two recent studies argue that emotion recognition needs to be dissociated in two distinct stages: emotion detection and categorization/differentiation (i.e., Goren & Wilson, 2006; Sweeny, Suzuki, Grabowecky, & Paller, 2013). The first aspect describes the ability to detect whether an emotional content is portrayed in a facial expression (emotion detection), whereas the second aspect refers to a subsequent appraisal and categorization which specific emotion is displayed (emotion categorization/differentiation). More specifically, emotion detection focuses on the distinction between emotional and non-emotional facial expressions (e.g., angry vs. neutral expressions or yawning), whereas emotion differentiation categorizes different emotional facial expressions (e.g., sad vs. angry). First data on distinct processing for emotion detection and emotion differentiation derived from experiments from Goren and Wilson (2006). The authors could show that fearful faces are easily discriminated from neutral faces

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but are difficult to discriminate from sad faces. A further series of experiments by Sweeny et al. (2013) provided first empirical support that emotion differentiation can occur without emotion detection and vice versa. In consequence, these mechanisms are, at least partly, dissociated and can be investigated separately. Emotion detection relies more on the processing of specific facial features (such as visibility of teeth), while emotion differentiation is based on the processing of spatial relationships between individual facial features (Sweeny et al., 2013). The dissociation of emotion detection and differentiation is further supported by findings demonstrating that face detection and identification are separate processes that occur in separate levels of visual processing (Liu, Harris, & Kanwisher, 2002; Tsao, Freiwald, Tootell, & Livingstone, 2006). Further, studies of object recognition demonstrated that detection that an object is present dissociates from categorization of the object (Barlasov-Ioffe & Hochstein, 2008; Mack, Gauthier, Sadr, & Palmeri, 2008).

The differentiation of emotional facial expressions has been studied extensively in ASD, but individual findings remain inconsistent. Some studies found no significant difference in the recognition of basic emotions between individuals with ASD and neurotypical individuals (e.g., Ozonoff, Pennington, & Rogers, 1990, Evers, Kerkhof, Steyaert, Noens, & Wagemans, 2014; Fink, de Rosnay, Wierda, Koot, & Begeer, 2014), or in the recognition of socially more complex emotions (Tracy, Robins, Schriber, & Solomon, 2011; Williams & Happé, 2010). In contrast, several studies have identified deficits in the differentiation of negative basic emotions like fear, anger, and disgust, but not in positive emotions (e.g., Enticott et al., 2014; Humphreys, Minshew, Leonard, & Behrmann, 2007; Philip et al., 2010). Others have reported a general deficit in emotion differentiation (e.g., Dziobek, Fleck, Rogers, Wolf, & Convit, 2006; Sucksmith, Allison, Baron-Cohen, Chakrabarti, & Hoekstra, 2013). Compensation strategies that cover underlying deficits may explain the discrepancy in facial emotion recognition in ASD between studies. Previous results implicate that individuals with ASD use explicit compensation strategies to compensate for deficits in emotion recognition. Social processing in its explicit form is usually concerned with controlled processing, which is rather flexible, but also demands many cognitive resources. In contrast, implicit social processing is usually considered to be more automatic and time efficient, but inflexible and limited in terms of cognitive resources (Harms, Martin, & Wallace. 2010; Kaland, Mortensen, & Smith, 2011; Kliemann, Rosenblau, Bölte, Heekeren, & Dziobek, 2013; Senju, 2012). Behavioral and neuroimaging studies have proposed that individuals with ASD use more effortful cognitively based compensatory mechanisms to decode facial expressions compared with neurotypical individuals (Harms, Martin, & Wallace, 2010), such as explicitly associating frowned eyebrows with anger (e.g., Dyck, Piek, Hay, Smith, & Hallmayer. 2006; Teunisse & de Gelder, 2001). Individuals with ASD show altered processing mechanisms such as rule-based processing instead of template-based perception when exposed to emotional facial expressions (Rutherford & McIntosh, 2007), and fixate atypically on the presented face (Sasson et al., 2007). These observations support the use of explicit compensation strategies by individuals with ASD.

One way to avoid explicit compensation strategies is to use short presentation times and backward-masking, as this approach increases task difficulty and reduces visual awareness of stimuli (e.g., Rump, Giovannelli, Minshew, & Strauss, 2009; Sweeny, Suzuki, Grabowecky, & Paller, 2009; Sweeny et al., 2013). Most previous studies presented stimuli for an unlimited time, thus giving participants the opportunity to employ higher level skills. To the best of our knowledge, only a few published studies have presented stimuli for less than 500 ms. Clark, Winkielman, and McIntosh (2008) reported poorer subliminal characterization (15 or 30 ms exposure) of emotional faces (angry vs. happy) by adults with ASD than neurotypical controls. In agreement, Rump et al. (2009) found that adults with high-functioning ASD were less able to detect emotions from dynamic stimuli with a maximum presentation time of 500 ms than control individuals. Therefore, using limited presentation time and backward-masking procedures may be a promising way to reliably measure deficits in emotion differentiation in adults with ASD.

Although emotion differentiation has been well investigated in ASD, emotion detection to our best knowledge has not been tested directly. Preliminary conclusions can be drawn from studies of the "anger superiority effect" investigating whether individuals with ASD detect angry facial expressions faster and more accurately than happy facial expressions from an array of simultaneously presented neutral distractor faces, which is the case in neurotypical individuals (Ashwin, Wheelwright, & Baron-Cohen, 2006; Krysko & Rutherford, 2009). Participants with ASD showed no significant difference (Krysko & Rutherford, 2009) or marginally reduced (Ashwin et al., 2006) anger superiority effect compared to neurotypical individuals, which might indicate unimpaired general emotion detection abilities. In addition, ASD and neurotypical individuals showed no significant difference in detection times for target emotional faces (i.e., happy and angry faces) from an array of identical distractor faces (neutral and emotional), which suggests unimpaired emotion detection abilities in ASD (Ashwin et al., 2006; Krysko & Rutherford, 2009). However, all distractor faces were identical and presented simultaneously in these studies. In summary, whether individuals with ASD show deficits in emotion detection has not been conclusively determined.

To further advance the study of emotion recognition in ASD, the respective components of emotion detection and emotion differentiation should thus be assessed separately (Harms et al., 2010; Kennedy & Adolphs, 2012; Tracy et al., 2011; Uljarevic & Hamilton, 2013). In addition, the possible use of compensatory strategies should be restricted, as such processes might (at least in part) explain heterogeneity in the results from previous studies. For these reasons, the present study compared emotion detection and differentiation between adults with ASD and neurotypical controls using a two-interval forced-choice backward masking paradigm. In order to vary the degree of visual awareness and limit the use of compensation strategies, equidistant increases of presentation durations were used (33, 67, 100 ms). Based on previous findings (Clark et al., 2008), we expected a poorer performance in emotion differentiation by adults with ASD compared with neurotypical controls. Studies of anger superiority have provided insufficient evidence for an emotion detection deficit in ASD, therefore we investigated this ability systematically.

2. Methods

2.1. Participants

Twenty-three adults (seven females, 16 males) diagnosed with high-functioning autism (i.e., without intellectual impairment) or Asperger syndrome (ASD group) and 25 (7 females, 18 males) neurotypical individuals (control group) participated in the study. Groups were carefully matched with respect to age, gender, and verbal IQ, which was measured through a German vocabulary test ("Wortschatztest" [WST]; Schmidt & Metzler, 1992). All participants were German native speakers and had normal or corrected-to-normal vision (for details see Table 1).

All ASD participants were recruited through the autism outpatient clinic of the Charité – Universitätsmedizin Berlin. Participants were diagnosed by experienced psychiatrists and psychologists according to DSM-IV/ICD-10 criteria for Asperger syndrome and autistic disorder using the Autism Diagnostic Observation Scale (ADOS, Lord et al., 2000) and the Autism Diagnostic Interview-Revised (ADI-R, Lord, Rutter, & Le Couteur, 1994) if parental informants were available (n = 13). In addition, a semi-structured clinical interview based on the criteria for autism and Asperger syndrome in the Diagnostic and Statistical Manual of Mental Disorders, 4th edition (DSM-IV; APA, 2000) was used and participants completed the Autism Spectrum Quotient questionnaire (AQ, Baron-Cohen, Wheelwright, Skinner, Martin, &