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Configural processing in autism and its relationship to face processing

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Abstract

Studies of the perceptual performance of individuals with autism have focused, to a large extent, on two domains of visual behavior, one associated with face processing and the other associated with global or holistic processing. Whether autistic individuals differ from neurotypical individuals in these domains is debatable and, moreover, the relationship between the behaviors in these two domains remains unclear. We first compared the face processing ability of 14 adult individuals with autism with that of neurotypical controls and showed that the autistic individuals were slowed in their speed of face discrimination. We then showed that the two groups differed in their ability to derive the global whole in two different tasks, one using hierarchical compound letters and the other using a microgenetic primed matching task with geometric shapes, with the autistic group showing a bias in favor of local information. A significant correlation was also observed between performance on the face task and the configural tasks. We then confirmed the prediction that the ability to derive the global whole is not only critical for faces but also for other objects as well, as the autistic individuals performed more slowly than the control group in discriminating between objects. Taken together, the results suggest that the bias for local processing seen in autistic individuals might have an adverse impact on their ability to process faces and objects.

Keywords: Local; Global; Visual processing; Objects; Greebles; Faces; Configural

1. Introduction

"And this is how I recognize someone if I don't know who they are. I see what they are wearing, or if they have a walking stick, or funny hair, or a certain type of glasses, or they have a particular way of moving their arms, and I do a Search through my memories to see if I have met them before." (Christopher, the 15-year old autistic protagonist in The Curious Incident of the Dog in the Night-time by Mark Haddon).

"I often get into embarrassing situations because I do not remember faces unless I have seen the people many times or they have a very distinct facial feature such as a big beard, thick glasses or a strange hairstyle."(in "Thinking in Pictures and Other Reports from my Life with Autism" by Temple Grandin).

Autism is a developmental disorder that is associated with a number of characteristic deficits, most notably in the domains of social interaction, communication and imaginative behavior (Frith, 2003; Klin, Jones, Schultz, Volkmar, & Cohen, 2002; Volkmar, Lord, Bailey, Schultz, & Klin, 2004). It is further defined by the finding that most autistic individuals exhibit a restricted and repetitive behavioral repertoire. Abnormalities in visual processing have also been documented in autism (Kanner, 1943; Society for Autistic Children, 1978), although the nature and extent of the visuoperceptual impairment in these individuals remains a topic of debate. Many previous studies have focused on two visuoperceptual behaviors

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in autism, one related to face processing and the other related to the derivation of organized wholes from perceptual parts. While both lines of investigation have been fruitful, each set of findings remains somewhat controversial and, moreover, there has only been minimal consideration of the relationship between these behaviors in autism. We consider some of the existing data from each domain and then the possible relationship between them before we outline the current studies.

Many studies of face processing in children with autism have demonstrated the presence of an impairment that is widespread and present from an early age (Dawson et al., 2002), affecting both the perception of and the memory for faces (Ellis, Ellis, Fraser, & Deb, 1994; Hauck, Fein, Maltby, Waterhouse, & Feinstein, 1998; Klin et al., 1999; Langdell, 1977). The perceptual difficulties also affect the perception of the affect of faces (Hobson, 1986; Hobson, Ouston, & Lee, 1988), the perception of direction of gaze (Jolliffe & Baron-Cohen, 1997) and sometimes even the perception of gender (Hobson, 1987; Njiokiktjien et al., 2001). The same is true for adults with autism, although the impairment is apparently less severe in older individuals and in more cognitively able individuals (Boucher & Lewis, 1992). The reported decrement in face processing is consistent with a series of recent functional imaging studies demonstrating atypical or weak activation of the fusiform gyrus, the preeminent area involved in face processing (Critchley et al., 2000; Grelotti et al., 2005; Pierce, Muller, Ambroses, Allen, & Courchesne, 2001; Schultz et al., 2000), despite normal retinotopic and early visual system organization (Hadjikani et al., 2004; Pierce, Haist, Sedaghat, & Courchesne, 2004). The neuroimaging findings are not without challenge, however: a very recent study has shown significant fusiform activation in autism, especially in the right hemisphere, as would be expected, and with greater activation in response to familiar than unfamiliar faces, as is also expected (Hadjikani et al., 2004; Pierce et al., 2004; see also, Dalton et al., 2005). The autistic individuals do show a more limited cortical network than controls in response to familiar faces in this study, but the presence of FFA activation in autism is important and contrasts with most existing studies.

The second perceptual domain, concerning the extent of global or holistic processing in autism, has also been well-studied with many, but not all, investigations reporting that autistic individuals tend to focus more on the parts of a stimulus and to experience difficulty in deriving the global entity or whole.[1] For example, autistic individuals fail to take the entire visual context into account (Happé, 1996; Ropar & Mitchell, 1999) and fail to perceive impossible geometric figures, a task which requires part integration (Mottron & Belleville, 1993). Using a wide variety of paradigms, investigations have also revealed that autistic individuals show enhanced detection of local targets in visual search (Plaisted, O'Riordan, & Baron-Cohen, 1998; Plaisted, Swettenham, & Rees, 1999), perform well on tasks such as Block Design and Object Assembly that require a local focus (Minshew, Goldstein, & Siegel, 1997) and exhibit superior performance in detecting embedded figures (Happé, 1999; Jolliffe & Baron-Cohen, 1997; Shah & Frith, 1983). One recent study has revealed that autistic children use gestalt grouping heuristics significantly less often than controls do, resulting in difficulties appreciating inter-element relationships (Brosnan, Scott, Fox, & Pye, 2004). These findings are compatible with the framework, termed 'weak central coherence' (Frith, 2003; Frith & Happé, 1994), which posits that a fundamental problem in autism is the difficulty in drawing together or integrating individual pieces of information (perceptual or conceptual) to establish meaning, with the resultant reliance on piecemeal, local information rather than on the overall context. Despite the existing evidence, the extent to which autistic subjects truly do show a local bias or do fail to derive the whole is somewhat controversial in itself and this point is specifically addressed in the experiments below.

Although there are now rich literatures focusing on the nature of face processing and the tendency to focus on local rather than global information in autism, each domain has many open questions and, moreover, there is little consideration of the relationship between these visual processes. This relationship, however, is of great interest in cognitive neuroscience. Faces form a class of perceptually similar visual stimuli and are, therefore, thought to be the paradigmatic example of a stimulus that relies heavily on configural processing, with the gestalt or holistic properties of the stimulus possibly even overriding the contribution of its individual components (Farah, Wilson, Drain, & Tanaka, 1995; Leder & Bruce, 2000; Maurer, Le Grand, & Mondloch, 2002; Tanaka & Farah, 1993; Tarr & Cheng, 2003; Yovel, Paller, & Levy, 2005). One might expect then that any difficulty in deriving the global configuration would substantially impair the ability to process faces. Indeed, individuals with integrative visual agnosia who experience difficulty in deriving configural information, are also impaired both at recognizing known faces and at discriminating novel faces. The reverse finding is also reported: individuals who are impaired at face processing either as a result of a brain damage (acquired prosopagnosia) (Barton, Press, Keenan, & O'Connor, 2002; Behrmann & Kimchi, 2003) or as a result of a congenital problem are also impaired at extracting configurations from local elements (Behrmann et al., in pressBehrmann, Avidan, Marotta, & Kimchi, 2005; Le Grand, Mondloch, Maurer, & Brent, 2004). A further indication of the relationship between faces and configurations comes from comparisons of performance on upright versus inverted faces, relative to objects. Typically, for normal individuals, recognition and discrimination of faces is better for upright than for inverted faces (Yin, 1969) and this difference holds to a lesser extent for objects. The disproportionate face versus object inversion effect is taken to reflect the fact that upright faces are processed globally or as a whole with extraction of the second-order

[1] The terms global, holistic and configural are often used interchangeably in the literature and we do so here too. However, we examine possible distinctions between them in the final discussion.