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Gist perception in adolescents with and without ASD: Ultra-rapid categorization of meaningful real-life scenes



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ABSTRACT

Previous research has suggested the presence of a reduced preference to report and spontaneously interpret the global properties of a scene picture in adults with Autism Spectrum Disorder (ASD). Contrary to what is seen in typically developing (TD) participants, gist perception in ASD seems to occur mostly in a more explicit manner with focused attention. The current study used a set of non-social and social ultra-rapid categorization tasks to investigate gist perception in adolescents with and without ASD. When we instructed the participants to rapidly identify briefly presented object or scene information, we found that adolescents with ASD performed worse than TD participants. These findings complemented our previous study on ultra-rapid categorization in adults with or without ASD, in which no group-level differences in gist perception were observed. When categorization specifically entailed the fast processing of socially salient information, both adolescents and adults with ASD performed worse than TD participants. The combination of these results suggests an age-dependent improvement in general categorization ability but more long-lasting difficulties in rapid social categorization in individuals with ASD. We suggest that the poorer general performance of adolescents with ASD results from a less efficient rapid processing of global semantic structure.

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1. Introduction

At first my observations took an abstract and generalizing turn. I looked at the passengers in masses, and thought of them in their aggregate relations. Soon, however, I descended to details, and regarded with minute interest the innumerable varieties of figure, dress, air, gait, visage, and expression of countenance.

from "The Man of the Crowd" (1845) by Edgar Allan Poe

In an ultra-rapid categorization paradigm (e.g., Rousselet, Joubert, & Fabre-Thorpe, 2005; Vanmarcke & Wagemans, 2015a), typically developing (TD) participants succeed at detecting the identity of the presented object or scene almost perfectly (even with 20 ms exposures). This suggests that our visual system can rapidly process a vast amount of perceptual

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information, and that TD participants have a tendency to process the overall Gestalt (gist) at the expense of details and surface features (Edgin & Pennington, 2005). Such natural tendency to quickly make sense of complex daily-life situations by extracting the gist of the scene, however, might not be equally strong in all individuals. Previous research has indicated that people with Autism Spectrum Disorder (ASD) are less inclined to process and use information at the level of overall structure and meaning. For instance, when making absolute categorical judgements, individuals with ASD show less inclination to use the overall average similarity of stimuli (Church et al., 2010). Moreover, category formation has been shown to develop atypically in children and adults with ASD (Edwards, Perlman, & Reed, 2012). More precisely, category formation in ASD will likely include a larger number of small-sized and exemplar-based categories than in their TD counterparts, not only with regard to non-social object and/or scene categorization, but also with respect to complex social situations (Mottron & Burack, 2006). Previous studies have indicated that individuals with ASD have problems in transferring sensory learning from one social context to another, generally leading to either situation-dependent or atypically generalized perceptual learning (Plaisted, 2001; Plaisted, O’Riordan, & Baron-Cohen, 1998). These problems in visual categorization, both in the categorization of objects in isolation (Blair, Frith, Smith, Abell, & Cipolotti, 2002) and in complex social situations (Chaminade, Fonseca, Rosset, Cheng, & Deruelle, 2015), may play a major role in the observed deficits in important cognitive processes, such as social cognition, language comprehension, and rapid decision making, in people with ASD.

A recent meta-analysis on local/global processing (Van der Hallen, Evers, Brewaens, Van Den Noortgate, & Wagemans, 2015) has indicated that individuals with ASD are generally slower in tasks requiring global processing, especially when local incongruent information is present in the stimulus. These differences in visual perception in ASD are generally captured by two competing neurocognitive frameworks. The first is the Weak Central Coherence hypothesis (WCC; Dakin & Frith, 2005), indicating that people typically have a tendency to process the overall Gestalt at the expense of details and surface features. It explains the performance of individuals with ASD as having a processing bias for local information coinciding with a failure to extract the more global aspects of the visual information. The presence of local or global processing demands will therefore predict their superior or inferior performance on a given task, respectively. In a revised version of the WCC account of visual processing in ASD, it is suggested that a reduced preference instead of an inability in global processing defines the differences in perception between people with or without ASD (Happé & Booth, 2008; Koldewyn, Jiang, Weigelt, & Kanwisher, 2013). In contrast with the WCC hypothesis, the Enhanced Perceptual Functioning (EPF) theory states that an overactivation of primary perceptual functions explains the focus of individuals with ASD on details (Mottron, Dawson, Soulières, Hubert, & Burack, 2006). It thereby stipulates an increased processing of local stimulus elements but not a failing or reduced global bias.

The current literature provides divergent evidence for both theories (Changizi, Hsieh, Nijhawan, Kanai, & Shimojo, 2008), implying the need for an overarching theoretical framework. One way to provide that theoretical backbone is by embedding the behavioral results into a coherent view of their corresponding neurological processes. By indicating timing and location of the different stages in visual perception in a modern view on the cortical hierarchy, a better understanding of these findings can be attained. We argue that such a view is offered by the Reverse Hierarchy Theory (RHT) (Hochstein & Ahissar, 2002; Ahissar & Hochstein, 2004). RHT is a perceptual theory in TD participants that dissociates early implicit from later explicit perception. Moreover, it dissociates the temporal early-late distinction from the structural distinction between low- and high-level areas in the brain. In particular, the theory proposes that visual processing goes through a fast feedforward sweep of processing to get a first rapid awareness of the conceptual gist of the scene. Following this first implicit perception, feedback connections then focus attention to specific low-level elements in the display. This makes detailed visual information available for conscious awareness, leading to explicit ‘vision with scrutiny’. This occurs at low-level visual areas since that is where the neural maps have retinotopy and neurons have sufficiently small receptive fields to capture the details. So, the two-stage theory indicates that initial scene perception is based on widely distributed attention identifying ‘the forest before the trees’, while later vision focuses attention to details in the display (trees, trunks, leaves, etc.). In addition to the classic structural hierarchy of low- and high-level areas, RHT proposes a reverse temporal hierarchy of early but high-level and late but low-level vision in TD participants. We thereby suggested that this early, high-level (global) processing is performed more slowly in people with ASD. This would suggest a slower gist extraction and thus slower and/or less accurate categorization and recognition of complex visual information in everyday life.

This hypothesis was tested in adults with and without ASD using an ultra-rapid categorization task with complex real-life scenes (Vanmarcke, Van der Hallen et al., 2016), but no group-level differences in performance were found when the task explicitly required a rapid visual gist identification. It is important to note, however, that this task was employed with clearly predefined task instructions and without perceptual masking of the stimulus information. When performing a free description open encoding task with masked stimulus presentation and less explicitly defined task instructions, adults with ASD did perform worse than their TD counterparts in rapidly extracting the global meaning (e.g., forest, desert, . . .) of a complex visual scene (Vanmarcke, Mullin et al., 2016). Simultaneously, this study also indicated that participants with ASD were better than TD participants in providing correct object descriptions (e.g., chair, table, . . .) with longer presentation times, although no evidence was found to support the claim of an enhanced low-level feature detection in ASD. Taken together, these observations suggest the presence of a reduced implicit preference to rapidly report and interpret the global properties of a whole in people with ASD, in line with a recent study by Koldewyn et al. (2013). These subtle differences in the implicit processing underlying gist perception in ASD therefore suggest that the early, high-level global processing is generally preserved. In contradiction with TD adults, however, global processing seems to occur in a more explicit fashion requiring focused attention, especially when the presented stimuli or scenes require the fast processing of information about

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