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ScienceDirect
Research in Developmental Disabilities 28 (2007) 197–206
Research in Developmental Disabilities

Global and configural visual processing in adults with autism and Asperger syndrome

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Received 25 January 2006; received in revised form 21 February 2006; accepted 23 February 2006

Abstract

This study was designed to explore how adults with autism and Asperger syndrome (ASD) would visually process compound figures. They were tested in two tasks, one involving hierarchical global/local stimuli, the other involving face-like or geometrical stimuli where the processing of the inter-elemental spatial relationships was emphasized. Adults with ASD showed, like controls, a preference for the global level of the hierarchical stimuli. With the stimuli involving inter-elemental spatial relationship manipulations, the adults with ASD showed a preference for local elements, whereas controls did not show a preference. This supports earlier findings from children with ASD, suggesting that though individuals with autism may process global aspects of stimuli in priority, they tend to specific aspects in stimuli containing both local and configural elements.

Keywords: Autism; Visual processing; Global; Configural; Local; Development

Increasing evidence show an atypical visual processing style in autism. This includes the processing of details in priority, in opposition to controls for whom the global context is most salient. This particular processing style in autism has been named weak central coherence (e.g., Frith, 1989) and it has been suggested that this capacity to focus on local elements may bring about superior performance in various domains, notably in visual tasks.

Reports in favor of a local perceptual processing style in persons with autism have been noted on tasks demanding the detection of a feature target embedded in a set of distractors (e.g., Plaisted, O'Riordan, & Baron-Cohen, 1998) or a feature hidden in a bigger surrounding such as the Embedded Figures Test (e.g., Jolliffe & Baron-Cohen, 1997; Shah & Frith, 1983). The

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0891-4222/$ – see front matter
doi:10.1016/j.ridd.2006.02.007

talented performance in assembling bi-colored cubes to match a model (the Block Design Task) has also been suggested due to the capacity to dissociate the model into local elements (e.g., Shah & Frith, 1993).

The use of a local strategy has also been found in the processing of faces. Whereas typically developing children process faces in a configural manner, children with autism usually show poor performance in tasks requiring an analysis of the whole face (e.g., Hobson, Ouston, & Lee, 1988; Weeks & Hobson, 1987). Conversely, several researchers also report that individuals with autism perform better when a feature-by-feature (i.e., local) analysis of faces. They outperform controls in tasks that presumably emphasize a local analysis of the stimuli, such as inversion tests, where faces are presented upside down (e.g., Hobson et al., 1988; Langdell, 1978; Miyashita, 1988; Rondan & Deruelle, 2004; Tantam, Monagham, Nicholson, & Stirling, 1989).

Although an increasing number of observations show atypical visual behaviours in autistic individuals, the nature and the extent of the particulars remain a source of debate. Some argue in favor of a local processing style, while others suggest that autistic individuals are capable of processing global forms.

Most of the studies revealing preserved global processing result from experiments involving divers paradigms of hierarchical figures in which stimuli are presented at both the global (larger form) and local (smaller form) level. Smaller forms are assembled to represent a coherent global form. A global-to-local processing order was found with high functioning adolescents with autism (e.g., Mottron, Burack, Stauder, & Robaey, 1999), with high functioning children with autism (e.g., Ozonoff, Strayer, McMahon, & Filloux, 1994), as well as in low functioning children with autism (e.g., Deruelle, Rondan, Gepner, & Fagot, in press). Similarly, Plaisted, Swettenham, and Rees (1999) found that autistic children were quicker to respond to the global than to the local aspects of hierarchical stimuli in a selective attention task, though a local advantage was found in a divided attention task with the same participants, suggesting that different tasks may elicit different types of processing. Some studies show global advantage, while others show local advantage. Several factors may impact on the development of a global or a local perceptual bias.

Age may have an effect on the emergence of global visual abilities (e.g., Deruelle, Rondan, Gepner, & Tardif, 2004; Rondan & Deruelle, 2004). It has, for example, been shown that children with autism use high rather than low spatial frequencies when processing faces, suggesting a local processing style (e.g., Deruelle et al., 2004). In the study by Deruelle and colleagues, the children with autism and Asperger syndrome (ASD) were aged between 4 and 13 years (mean age = 9 years) with a verbal mental age between 4 and 12 years (mean = 6 years). A significant improvement of performance with age was noted in the low, but not in the high spatial frequency condition of the autistic group. As links have been established between low spatial frequency and global processing (e.g., Hughes, Nozawa, & Kitterle, 1996), these findings suggest that their capacity to take the global aspects of faces into consideration increased with age. This conclusion was confirmed in a subsequent study using the same stimuli for adults with autism. Indeed, a group of adults with autism relied, like controls, more on low than high spatial frequencies in faces (e.g., Rondan & Deruelle, 2004). Taken together these experiments argue that some aspects of visuospatial processing may evolve with age in autistic individuals. This finding would be in line with general development. For example, though typically developing children recognize faces as wholes, they are less skillful compared to adults (e.g., Carey & Diamond, 1994; Pellicano & Rhodes, 2003).

Another possible cause of the contradictory results may be the type of task demand. An increasing number of studies recommend not assimilating all forms of global processes as one and the same, but to differentiate the various modes of processing wholes. Following this line of argument, one may distinguish at least two different forms of global processing. Global processing may be considered the processing of the highest level of the hierarchical stimuli. Configural processing may be defined as the processing of the interspatial relations between elements. The distinction between the notion of global and configural processing has been debated in the recent research by Behrmann et al. (2006) and Brosnan, Scott, Fox, and Pye (2004), and has been directly tested in a study by Deruelle et al. (in press) in a group of children with ASD. The first experiment in the study by Deruelle et al. (in press) tapped global and local processing by using the classical hierarchical figures introduced by Navon (e.g., Navon, 1977). In these figures, local elements were assembled to form a global coherent whole. The children with autism performed like the two groups of typically developing children matched for chronological age and mental age and showed a global preference in this task. In the second experiment of the study, local elements were assembled, but this time the task tapped configural (i.e., interspatial relations between elements) versus local processing. In this experiment, the children with autism showed a preference for the processing of the local elements whereas controls did not show a preference. Thus, in two similar paradigms, but soliciting different processes (i.e., global and configural) the same group of children with autism displayed contrary results. Yet, this dissociation was never directly assessed in adults and as age may have an effect on this capacity, it is important to verify this aspect by testing a population of adults with ASD. If the two types of global/configural processing are also analyzed differently in adults with autism this may be an additional argument in favor of their dissociation.

The main goal of the current research was thus to investigate how adults with autism would perceive stimuli containing either global and local elements or configural and local elements. The same experiments were replicated as those used on children with ASD (Deruelle et al., in press). An experiment using hierarchical stimuli inspired from Navon (1977) was run. The main core of the literature suggests that a global perceptual bias exists in adults (e.g., Fagot & Deruelle, 1997; Navon, 1977), children and infants (e.g., Kimchi, 1990; Macchi Cassia, Simion, Milani, & Umilta, 2002).

1. Experiment 1

1.1. Method

1.1.1. Participants

A first group, the autistic group (ASD), was comprised of 26 adults (3 women and 23 men) with Asperger syndrome ($N = 21$) and high functioning autistic disorders ($N = 5$) aged from 18 to 43 years ($M = 26$ years 2 months; S.D. = 7 years 3 months). Adults of this group were all diagnosed according to the DSM-IV (A.P.A., 1994) criteria for autism and Asperger syndrome. In order to ensure the diagnosis, and whenever it was possible ($N = 18$), parents of participants with ASD were asked to answer the Autism Spectrum Screening Questionnaire (ASSQ; Ehlers, Gillberg, & Wing, 1999), during a semi-directive interview. All participants tested scored above 24 on the ASSQ. IQ scores were measured with the WAIS-III (Wechsler, 1997) and ranged from 59 to 150 ($M = 91.6$, S.D. = 26.6). None of the participants were known to have associated medical problem or gross visual disorders.

A second group (CONT) comprised 26 normally developing adults individually matched with the adults with ASD on gender and chronological age ($M = 27$ years 8 months; S.D. = 6 years 2 months). They were all free of psychiatric and neuropsychological history.

Half of the participants underwent Experiment 1 first and then Experiment 2, the other half were tested in the reverse order.

1.1.2. Stimuli

The stimuli used were the so-called hierarchical figures illustrated in Fig. 1. Each stimulus was composed of 8 local elements organized to form a larger global shape. Possible shapes at the global and local levels were the letters H, T, L, S or O, and the geometrical patterns were circles, squares or crosses. The stimulus set comprised an equal number of letter- and geometrical-stimuli. Moreover, global shapes could be identical or different from the local shape, resulting in two distinct types of stimuli: consistent and conflicting stimuli. At a viewing distance of 60 cm, the stimuli measured approximately 2° of visual angle, and the local elements measured 0.5°.

1.1.3. General procedure

Participants were individually tested in a quiet room at CNRS. They were seated in front of a 14 in. screen portable computer on which stimuli were presented. On each trial, the subjects viewed a display containing a target top figure along with two side-by-side comparison bottom figures. One comparison figure showed the same global shape as the target but was made of different local elements; the other showed the same local shapes as the target but was arranged to form a global shape different from the target figure. The task was to indicate the first, most immediate, impression on which of the two comparison figures at the bottom 'looks most like' the target figure. Participants had to press the 'a' keyboard button when they chose the comparison figure on the left side, and the 'p' button when choosing the comparison figure on the right side. Patches of different colors identified these keys (note that a French keyboard was used). Participants were instructed prior to the task that there was no correct or incorrect answer, which made the task less threatening.

1.1.4. Testing procedure

Each participant underwent a total of 36 test trials and 4 learning trials, in which the target figure was a consistent shape in half of the trials, and a conflicting one in the other half. Each type of comparison figure shared only one level (global or local similarities) with the target and

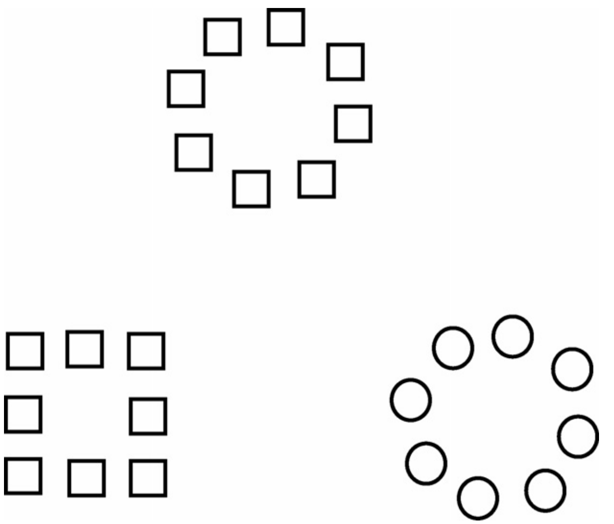

Fig. 1. Illustration of hierarchical stimuli used in Experiment 1.

appeared equally often on the left or right positions. The order of presentation of the displays was randomized for each participant.

2. Results

For each group, two-tailed *t*-tests were performed to verify the number of global choices that differed from chance. A significant bias toward global choices was found in both testing groups (ASD: M global choices = 24.3, $t(1, 25) = 2.1$, $p = .04$; CONT: M global choices = 28.2, $t(1, 25) = 7.8$, $p = .0001$).

To complement these analyses, *t*-test for independent samples were computed to compare the mean number of global choices obtained in the ASD group to the number of global choices obtained in the control group. Adults with ASD did not differ significantly from controls in this respect ($t(1, 25) = 1.5$, $p = .12$). The finding that the adults with ASD responded like controls, suggest that they have some propensity for encoding the global aspect of the shape in the priority sequence.

Spearman Rank Correlation tests ($p < .05$) were also computed between the number of global choices by the adults with ASD and their chronological age and IQ score. These tests showed that the number of global choices was independent of both chronological age (Rho = .15, $p > .4$) and global IQ (Rho = .01, $p > .9$).

3. Discussion

The present results support findings that children (e.g., Deruelle et al., in press) and adolescents (e.g., Mottron et al., 1999) with ASD process global forms in priority in hierarchical tasks depicting global and local forms. This processing style is that of typically developing adults (e.g., Fagot & Deruelle, 1997; Navon, 1977), children and infants (e.g., Kimchi, 1990; Macchi Cassia et al., 2002).

With the same paradigm as the one used in the present study children with ASD, performed like typically developing controls. However, a local bias was reported on the same group of children when the stimuli contained spatial relationship versus local processing (e.g., Deruelle et al., in press). To verify whether a local preference may also be demonstrated in adults with ASD, similar conditions of testing as in Deruelle et al. (in press) were replicated.

If configural processing evolves with age, adults with autism should not depict a local bias (as was the case of children with autism (e.g., Deruelle et al., in press)), but they should show results similar to that of controls.

4. Experiment 2

4.1. Method

4.1.1. Participants, stimuli and general procedure

Participants were the same as in Experiment 1. The experimental procedure was the same as before, but included schematic face and geometrical shape stimuli instead of hierarchical stimuli. These stimuli were previously used in two studies with children (e.g., Deruelle, Mancini, Livet, Cassé-Perrot, & de Schonen, 1999; Deruelle et al., in press). Testing involved the presentation of eight original patterns (four schematic faces and four geometrical patterns). As illustrated in Fig. 2, the global choices differed from the sample by the shape of the local elements, while the

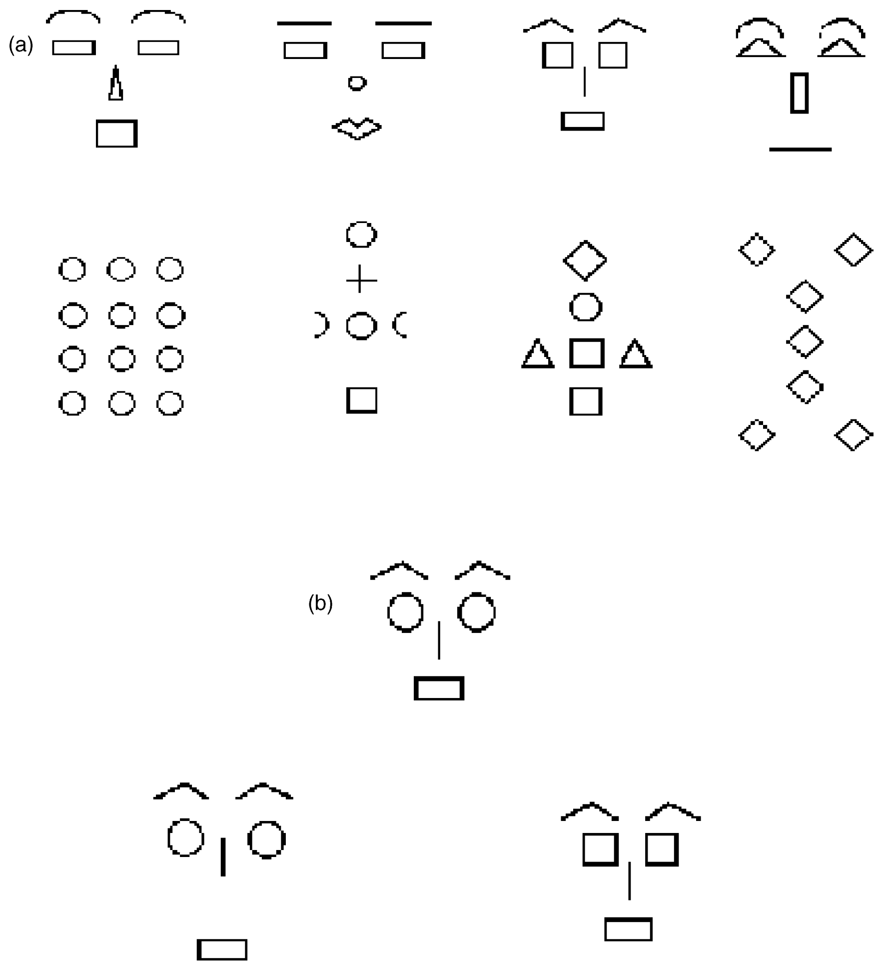

Fig. 2. Illustration of compound figures employed in Experiment 2 (a) and illustration of local and configural variations for one of them (b).

configuration remained identical for these two forms. In turn, the local choices differed from the sample by the inter-elemental distance. The shape of these local elements remained constant. Stimulus were approximately same visual size as the stimuli of Experiment 1.

Each subject participated in 32 trials corresponding to four presentations of each original figure as targets. On each trial, the target figure was presented in conjunction with two other patterns: its local and its configural match. Four additional trials were run before the session as training/warm up trials. The other aspects of the procedure were the same as in Experiment 1.

4.1.2. Results

Two-tailed paired *t*-tests were computed to verify if the results obtained with facial pattern differed from those obtained with geometrical shapes. No significant difference between these two types of stimuli, regardless of group was found (ASD group, $t(1, 25) = .39$, $p = .7$; CONT group: $t(1, 25) = 1.5$, $p = .10$). Data collected with these two types of stimuli were consequently pooled for the analysis of perceptual biases.

For each group of subjects, two-tailed *t*-tests were then performed to verify if the number of global choices differed from chance. Controls did not show a preference for either kind of match (*M* configural = 14.03, S.D. = 5.8; $t(1, 25) = 1.01$, $p = .3$). By contrast, the group with ASD showed a reliable bias for choosing the local match (*M* configural = 10.03, S.D. = 8.7; $t(1, 25) = 3.4$, $p < .001$), thus demonstrating that these subjects have a local processing advantage. However, no reliable difference between the ASD and control groups was evident when the number of configural choice was considered (*t*-test for independent samples, $t(1–50) = 1.5$, $p = .12$).

As in the previous experiment, Spearman Rank Correlations revealed that the number of configural choices in the ASD group was independent of both chronological age (Rho = .25, $p > .1$) and global IQ (Rho = .121, $p > .5$).

Because the procedures and subjects were identical in Experiments 1 and 2, direct comparison between these experiments is possible. For 17 adults with ASD, comparison between these studies indicated a shift from a significant preference for the global matches in Experiment 1 to a preference for the local matches in Experiment 2. The reverse local-to-configural shift was never observed. In contrast, in the control group, only one subject presented a shift from a significant global bias to a significant local bias.

5. Discussion

Experiment 2 was designed to assess configural versus local processing in adults with ASD by means of geometrical and schematic face patterns. A local preference was found both with the facial and non facial stimuli, suggesting that this local preference in tasks containing both local and configural stimuli is not face specific. This local preference was noted earlier using the same paradigm in a group of children with autism, whereas matched controls did not show this preference. As the results obtained by adults with ASD differ from controls, it does not seem that this capacity evolves with age in the ASD group.

6. General discussion

The main goal of this research was to evaluate spontaneous visual preferences of adults with ASD in two tasks: a hierarchical figure task emphasizing global versus local processing and a configural–local task where interspatial relations between elements were manipulated. In the first task, adults with ASD performed like matched controls and preferred the global forms to the local elements. In the second task, the clinical group showed a local bias with both the face and non face stimuli, while controls did not show a preference. The local bias in adults with ASD was found in both the face and non face stimuli. Furthermore, the group with ASD showed a shift from global processing in the first task to local processing in the second task, whereas this was found for only 1 out of 26 controls.

The finding of intact global processing and deficient configural processing confirms recent results obtained in two studies for children with autism (e.g., Brosnan et al., 2004; Deruelle et al., in press (which used the exact same paradigm)), as well as a study in high functioning adult individuals with autism (e.g., Behrmann et al., 2006), though this last study did not directly compare global and configural processing. These data give input to at least three issues.

First, increasingly researchers advocate for a dissociation between global and configural processing. The divergent results obtained in these two experiments, tapping the two different domains of global and configural processing, give evidence that these processes are distinctive. In line with earlier results (e.g., Brosnan et al., 2004; Deruelle et al., in press) this study suggests that individuals with autism have spared global processing, but more deficient configural processing. This dissociation may explain some of the controversies in the literature. As seen in the present report, individuals with autism are capable of processing global figures, such as hierarchical ones. Though not evaluated in this task, earlier findings have also reported preserved visual closure or holistic competences (e.g., Deruelle & Rondan, 2004; Rouse, Donnelly, Hadwin, & Brown, 2004). What remains difficult is the processing of the spatial relations between elements, as needed in configural processing (Experiment 2 in this report; Behrmann et al., 2006; Brosnan et al., 2004). However, in tasks applying configural demands, individuals may compensate by relying on local strategies when this is possible. Efficient local strategy processing may lead to better performance in these areas and may explain relatively good performance in, for example, the Block Design Task (Shah & Frith, 1993) or the Embedded Figures Task (Shah & Frith, 1983). Furthermore, this may provide some explanations to mixed performance in face paradigms. It seems that performance is spared in face paradigms appealing to the use of a local strategy, such as inverted faces (Langdell, 1978; Rondan & Deruelle, 2004), while deficits persist in tasks requesting configural processing.

This brings us to the second topic of discussion, the role of configural processing and faces. Configural processing is essential for the processing of faces. The poorer results in face tasks by individuals with autism could be explained by deficits in configural processing. Though it may be tempting to explain poorer performance in the present configural tasks by the nature of the social stimuli of faces, this argument does not hold as the configural stimuli used in Experiment 2 consisted of both schematic faces and geometrical forms. In both conditions the spatial relations between elements were manipulated. Independent of the stimuli, the adults with autism displayed a local bias in this study, suggesting that deficits were related to the processing needed and not the nature of the stimuli per se.

Finally, the aim of this study was to investigate if adults with autism would show a different perceptual bias in tasks tapping global or configural processing compared to earlier studies on children. Though autism is considered as a developmental disorder, few studies have sought to track the effect of age on various aspects of the disorder. However, within visual perception, a few studies have recently mentioned this facet and suggested that maturation may play a role in the development of certain competences. If some forms of global processing evolve with age, others remain deficient. Deruelle and colleagues (Deruelle et al., 2004; Rondan & Deruelle, 2004) discovered this through various paradigms. They showed that the processing of global aspects, as contained in spatial frequencies, may evolve with age (Deruelle et al., 2004; Rondan & Deruelle, 2004). In contrast, the more configural processing as requested in the processing of the spatial relationship between elements may be more difficult to evolve. Indeed, the study by Rondan and Deruelle (2004) revealed that though a group of adults with autism processed, like controls, low spatial frequencies better than high spatial frequencies, the group with autism did not show the inversion effect, contrary to controls, which indicates deficits in configural processing in the group with autism. In a similar vein, Edgin and Pennington (2005) suggested in a recent study that children with ASD were not developing enhanced spatial abilities across the ages in the study. They found that on the Children's Embedded Figure Task, the ASD group had better performance at younger ages, but both controls and the clinical group had equivalent performance levels at older ages. This would suggest that the enhanced local strategy in younger children may have declined with age in favour of a more global pattern. This present study gives support to the idea that configural processing remains complicated even for adults with autism, though they may more easily access global processing. The fact that the processing of these two aspects differ suggests that they are independent of each other.

In conclusion, we suggest that individuals with ASD are able to process global information and that their local bias may be related to the task, i.e., when a configural analysis is necessary. This configural deficit may persist through adulthood, though this speculation is relative novel and necessitates more enquires. Configural deficits, but intact global processing, have been highlighted in other pathologies, such as Williams syndrome (Deruelle et al., 1999), but the particularity in autism seems to be the capacity to compensate by enhanced local processing. This persisting deficit in configural processing may explain why even high functioning ASD individuals have difficulties in understanding facial expressions, as well as emotional and contextual information. Helping them to rely on more locally oriented indices, in conjunction with improving configural abilities may be useful.

Acknowledgments

We are grateful to the participants and to their families. This research was supported by SEDSU (FP6-2003-NEST-PATH).

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