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# Processing of compound visual stimuli by children with autism and Asperger syndrome

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Atypical modes of visual processing are common in individuals with autism. In particular, and unlike typically developing children, children with autism tend to process the parts of a complex object as a priority, rather than attending to the object as a whole. This bias for local processing is likely to be due to difficulties in assembling subparts into a coherent whole, as proposed by Frith (1989) using the term "weak central coherence" or WCC. This study was aimed to better characterize the processing of complex visual stimuli by children with autism. Thirteen children with autistic spectrum disorders were individually paired with children of two control groups, one matched on verbal mental age (VMA) and one matched on chronological age (CA). Participants from the three groups were tested in two tasks. The first task involved hierarchical global/local stimuli, inspired by Navon (1977). The second task employed compound face-like or geometrical stimuli. This task emphasized the processing of configural properties of the stimuli (i.e., spatial relationships). Children from the three groups showed a perceptual bias favouring the global dimension of the stimuli in the first task. By contrast, children with autism were deficient compared to normal children for the processing of the configural dimensions of the stimuli in the second task. These results suggest that visual cognition of children with autism is characterized by a dissociation between global and configural processing, with global processing being preserved and configural processing being altered in these children, therefore delineating the extents and limits of the WCC theory (Frith, 1989).

Les individus souffrant d'un syndrome autistique présentent souvent des comportements visuels atypiques. Contrairement aux sujets sains, ces individus traitent en priorité les parties des objets visuels complexes, plutôt que de traiter l'objet comme un tout. Ce biais en faveur du traitement local est probablement dû aux difficultés rencontrées par ces individus pour assembler les différentes parties d'un objet entre elles. Cette difficulté a été désignée comme révélant un déficit de cohérence centrale (weak central coherence, Frith, 1989). Le but de cette étude était de mieux caractériser le traitement des stimuli visuels complexes par les enfants autistes. Les performances de 13 enfants autistes ont été comparées à celles de 13 enfants appariés sur l'âge mental verbal et à celles de 13 autres enfants appariés sur l'âge chronologique. Les membres de ces trois groupes ont été testés dans deux types d'épreuves. La première épreuve faisait appel à des stimuli hiérarchiques du type de ceux utilisés par Navon (1977). La seconde épreuve utilisait des stimuli composites formant de schémas de visages ou des figures géométriques. Cette deuxième épreuve impliquait un traitement configural et non plus global, c'est-à-dire une prise en compte des relations spatiales qui unissent les éléments locaux. Les enfants des trois groupes présentent un avantage du traitement des dimensions globales dans la première épreuve. Toutefois, seuls les enfants autistes apparaissent déficients par rapport aux enfants contrôles dans le traitement configural imposé lors de la seconde épreuve. Ces résultats suggèrent que la cognition visuelle des enfants autistes est caractérisée

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par une dissociation entre le traitement des dimensions globales (qui serait préservé) et le traitement des dimensions configurales (qui serait déficitaire). Ces données permettent donc de préciser la notion de « Déficit de Cohérence Centrale » chez l'autiste.

*L*os individuos con autismo presentan un procesamiento visual atípico. Contrariamente a los niños sanos en desarrollo, los niños con autismo tienden a procesar prioritariamente las partes de un objeto complejo, y no atienden al objeto como un todo. Este sesgo por el procesamiento local se debe probablemente a las dificultades para juntar las partes en un todo coherente, tal como lo ha propuesto Frith (1989) bajo el término "Coherencia Central Débil (CCD)." Este estudio se propuso caracterizar mejor el procesamiento que hacen los niños autistas de los estímulos visuales complejos. Trece niños con trastornos del espectro autista se aparearon individualmente con niños pertenecientes a dos grupos de control, uno apareado en cuanto a edad mental verbal (EMV) y otro en cuanto a edad cronológica (EC). Se evaluó a los miembros de los tres grupos mediante dos tareas. La primera tarea entrañó estímulos jerárquicos globales/locales inspirados en Navon (1977). La segunda tarea empleó estímulos compuestos que formaban esquemas de caras o geométricos. Esta segunda tarea implicaba el procesamiento de propiedades de configuración de los estímulos (es decir, relaciones espaciales). Los niños de los tres grupos mostraron un sesgo en la percepción en favor de la dimensión global de los estímulos de la primera tarea. En contraste, los niños con autismo mostraron deficiencias comparados con los niños normales al procesar las dimensiones de configuración de los estímulos de la segunda tarea. Estos resultados sugieren que la cognición visual de los niños con autismo se caracteriza por una disociación entre el procesamiento global y el de configuración. El procesamiento global se preserva y el de configuración se altera en estos niños, por lo tanto delimita el alcance y los límites de la teoría CCD (Frith, 1989) en el autista.

One of the most recent theories accounting for the special cognitive profile of individuals with autism is the theory of "weak central coherence" (WCC; Frith, 1989; Happé, 1999). The hypothesis of WCC proposes that individuals with autism process sensory stimuli in fragments; this concerns visual stimuli in particular. In other words, WCC postulates that individuals with autism pay attention to the local details of scenes, rather than to their global attributes. Individuals with autism should therefore have difficulties integrating the local information into coherent meaningful wholes. Several lines of evidence support this WCC hypothesis, but as we will further discuss, contradictory results also exist.

The first supporting evidence for WCC is that individuals with autism or Asperger syndrome exhibit superior performance compared to controls in perceptual tasks involving a local analysis of the stimuli. Ability for local analysis appears, for instance, in tasks requiring the detection of hidden figures within larger meaningful drawings (Joliffe & Baron-Cohen, 1997; Shah & Frith, 1983), or in tasks requiring the detection of a feature target embedded in a set of distractors (Plaisted, O'Riordan, & Baron-Cohen, 1998; but see Brian & Bryson, 1996). Children with autism perform better than controls in the standard Wechsler Block Design task (Wechsler, 1997), presumably as the result of their greater aptitude to segment the blocks into small (local) shapes (Shah & Frith, 1993).

The second line of evidence in favour of WCC is the fact that children with autism often fail to succumb to various kinds of visual illusions, such as the Ponzo, Titchener circles, Muller-Lyer, Hering, and Poggendorf illusions (Happé, 1996). According to Happé, failure to experience these illusions reflects the fact that participants do not integrate the surrounding context of the figures, thus allowing focalization on the "to-be-judged" forms without misperceptions.

Also in support of WCC, several studies report a feature-by-feature (i.e., local) analysis of faces in children with autism. Thus, when the task requires an analysis of the whole facial pattern, autistic participants usually exhibit poor performance (e.g., for judging facial emotions; Gepner, de Gelder, & de Schonen, 1996; Hobson, Ouston, & Lee, 1988; Weeks & Hobson, 1987). In contrast, they outperform controls in tasks that presumably emphasize a local analysis of the stimuli, in particular in inversion tests, where faces have to be processed upside-down (e.g., Langdell, 1978; Hobson et al., 1988; Miyashita, 1988; Tantam, Monagham, Nicholson, & Stirling, 1989). In addition, children with autism are known to use high (i.e., local information) rather than low spatial frequencies when processing faces (Deruelle, Rondan, Gepner, & Tardif, 2004). Furthermore, autistic and Asperger adults exhibit a pattern of brain activity in face discrimination tasks different from that shown by normal adults, and similar to the pattern elicited when normal adults have to process nonfacial objects (Schultz et al., 2000); a finding that presumably reflects a feature-oriented mode of processing.

Contradictory findings exist, however, that do not support the WCC hypothesis. Most of these findings result from experiments involving the Navon paradigm, in which participants were presented with hierarchical global/local visual objects such as large letters composed of smaller letters (Navon, 1977). Thus, Mottron, Burack, Stauder, and Robaey (1999) tested global/local perception of high-functioning adults with autism, using hierarchical stimuli similar to those used by Navon (1977). Participants had to detect targets presented at a global (larger letter) or local (smaller letters) stimulus level and scores and response times were recorded. Similarly to normal participants (e.g., Navon, 1977), participants with autism displayed a global advantage, which does not accord with WCC. In addition, and similarly to normal participants, autistic participants presented reliable asymmetrical global-to-local interference.

A global advantage was complementarily observed in high-functioning children with autism. For instance, in Ozonoff, Strayer, McMahon, and Filloux's (1994) study, participants had to indicate if the hierarchical stimuli contained H or S letters at either the global or local level. Their response times were shorter on average for the larger letters than for the smaller ones. Plaisted, Swettenham, and Rees (1999) similarly found that children with autism were faster to respond to the global than to the local aspects of hierarchical stimuli in a selective attention task. An advantage of the local level was, however, obtained in a divided attention task with the same participants, suggesting that different tasks may elicit different types of processing. Finally, Rinehart, Bradshaw, Moss, Brereton, and Tonge (2000) examined local and global processing in high-functioning adults with autism or Asperger syndrome in a task involving hierarchically organized numbers. The two clinical groups conjointly responded faster to the global than to the local stimulus level, although autistic individuals made more errors in the global than in the local trials.

Which factor may explain why some studies show central coherence in children with autism while others suggest a weak central coherence? It is evident that the studies reported above have targeted different populations of autistic people, and this could explain some of the discrepancies between findings. Factors such as age, level of functioning and gender may also account for some of the inconsistencies. For all these factors, however, inspection of the literature fails to reveal any clear-cut causal relationship with WCC. Considering age first, evidence in favour of WCC was similarly found in adults (e.g., Hobson et al., 1988; Joliffe & Baron-Cohen, 1997) and children with autism (e.g., Deruelle et al., 2004; Happé, 1996). Considering level of functioning, evidence in support of WCC was found both in high- (e.g., Hobson et al., 1988; Joliffe & Baron-Cohen, 1997) and low-functioning individuals with autism (e.g., Tantam et al., 1989). An association between gender and WCC is even more difficult to evaluate, as studies on autistic individuals mainly include males due to a sex ratio in favour of males in this pathology.

The fact that some studies support WCC and others do not could be accounted for by task-related factors. In this respect, it should be noted that the majority of experiments with autistic populations using Navon's hierarchical stimuli revealed a perceptual bias favouring the global aspects of the stimuli. In contrast, other tasks placing a greater emphasize on the analysis of the inter-elemental relationship of a configuration are often associated with a local mode of processing in children with autism. This is, for instance, the case of paradigms involving facial stimuli (e.g., Davies, Bishop, Manstead, & Tantam, 1994; Deruelle et al., 2004). Although definitive conclusions on the exact nature of the processes involved in these tasks seem impossible at this point, these discrepancies suggest that children with autism approach the stimuli differently from controls, as a function of the task demand.

The aim of the current research was to search for a relation between WCC and task demand. For this purpose, two tasks involving compound stimuli made of geometrical shapes were selected, which were presumed to involve different modes of processing. The first task is directly inspired by Navon (1977). It used hierarchical geometrical shapes or letters, where forms have to be recognized at the global or local level. On the basis of the literature cited above, this task was expected to elicit a global advantage convergent with WCC. The other task was designed to elicit the same kind of processing as face discrimination tasks, in which findings seem to support WCC. Based on the observation that face-processing tasks require the analysis of relationships between spatial elements, participants in this second task discriminated between compound shapes differing in spatial relationships. It was expected that a comparison between the two experiments would help to identify the aspects of the tasks associated with WCC. In particular, absence of deficits in these two tasks would argue against WCC. In contrast, a deficit restricted to the second task should pinpoint some aspects of the tasks eliciting WCC.

Note that cross-experimental comparison is facilitated in our research because of the use of geometrical shapes in both Experiments 1 and 2. Also, though presented sequentially in this paper, the random test order of experiments for each participant permits this evaluation.

## EXPERIMENT 1

### Method

*Participants.* Thirty-nine children were tested, corresponding to three groups of 13 children. The first group—the clinical group—comprised children with autism ($N = 7$) and Asperger syndrome ($N = 6$) aged from 4 years 6 months to 15 years 5 months ($M = 9$ years 1 month, $SD = 2$ years 7 months). Children of this group were all diagnosed according to the DSM-IV (American Psychiatric Association, 1994) criteria for autism and Asperger syndrome (Table 1) by a child psychiatrist (BG)[1]. Developmental verbal age of these children was measured with the TVAP (Test de Vocabulaire Actif et Passif; Deltour & Hupkens, 1980). They ranged from 4 years 4 months to 15 years 5 months ($M = 7$ years 8 months, $SD = 3$ years 6 months). The severity of their autism or Asperger syndrome was estimated using the CARS (Childhood Autism Rating Scale; Schopler, Reichler, DeVellis, & Daly, 1980). CARS values ranged from 17 to 38 ($M = 30.1$, $SD = 7.7$). Five of these children attended a child day-care psychiatric unit for children with developmental disorders (Montperrin Hospital, Aix-en-Provence). Four children attended special educational programmes for children with learning disabilities, and the remaining participants normal schools. None of the participants had known associated medical or gross visual disorders. The two other groups comprised normally developing children matched with the children with autism on either gender and chronological age (i.e., CA group; $M$ age $= 10$ years, $SD = 2$ years 6 months) or gender and verbal mental age (i.e., VMA group; $M$ age $= 7$ years 7 months, $SD = 3$ years 4 months). All control participants attended mainstream schools and none of them had failed a grade during his/her education. Normal participants are therefore considered as having verbal abilities corresponding to their chronological age. All parents consented to the participation of their children. Participants were all already familiarized with the procedure employed in this experiment, due to their previous enrolment in Deruelle et al. 's (2004) study. Half of the participants underwent Experiment 1 before Experiment 2; the other half were tested in the reverse order.

**TABLE 1**
Details of control group participants

| *Subjects* | *Diagnostic* | *Gender* | *CARS* | *CA* | *VMA* |
|---|---|---|---|---|---|
| A1 | Asperger | M | 25 | 4.50 | 4.6 |
| A2 | Autism | M | 38 | 7.80 | 4.0 |
| A3 | Autism | M | 36 | 7.10 | 6.6 |
| A4 | Asperger | M | 20 | 8.50 | 8.5 |
| A5 | Autism | M | 38 | 8.50 | 4.5 |
| A6 | Autism | M | 38 | 10.00 | 4.6 |
| A7 | Autism | F | 32 | 10.20 | 6.9 |
| A8 | Autism | F | 36 | 10.60 | 6.3 |
| A9 | Asperger | M | 25 | 10.90 | 8.9 |
| A10 | Autism | F | 38 | 11.11 | 7.0 |
| A11 | Asperger | M | 22 | 12.10 | 12.1 |
| A12 | Asperger | F | 27 | 12.11 | 12.0 |
| A13 | Asperger | M | 17 | 15.50 | 15.5 |

CARS=Childhood Autism Rating Scale score; CA=chronological age; VMA=verbal mental age.

*Stimuli.* The stimuli used were the so-called hierarchical figures illustrated in Figure 1. Each stimulus was composed of eight local elements organized to form a larger global shape. Shapes at the global and local levels were letters (H, T, L, S) or geometrical shapes (circles, squares, and crosses). Letters were only combined with letters and geometrical shapes with geometrical shapes to form the hierarchical stimuli. In addition, for the letter as well as for the geometrical shape stimuli, the global shapes could either 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 subtended approximately 2° of visual angle, and the local elements subtended 0.5°. These visual global and local sizes were selected because previous studies have demonstrated that these sizes were adequate to reveal a global advantage in both normal children and children with autism (Mottron, Burack, Iarocci, Belleville, & Enns, 2003).

[1]Whether the Asperger syndrome and high-functioning autism should be treated without distinction in this kind of research has been, and is still, a matter for debate. Although differences between these two clinical groups can be found, recent investigations failed to reveal differences between these two clinical populations in terms of visuo-spatial ability (e.g., Miller & Ozonoff, 2000; Rinehart et al., 2000). This paper on visual cognition will therefore specify the clinical group to which the participant belongs, but consider these two groups together in the statistical analyses.

(a)

(b)

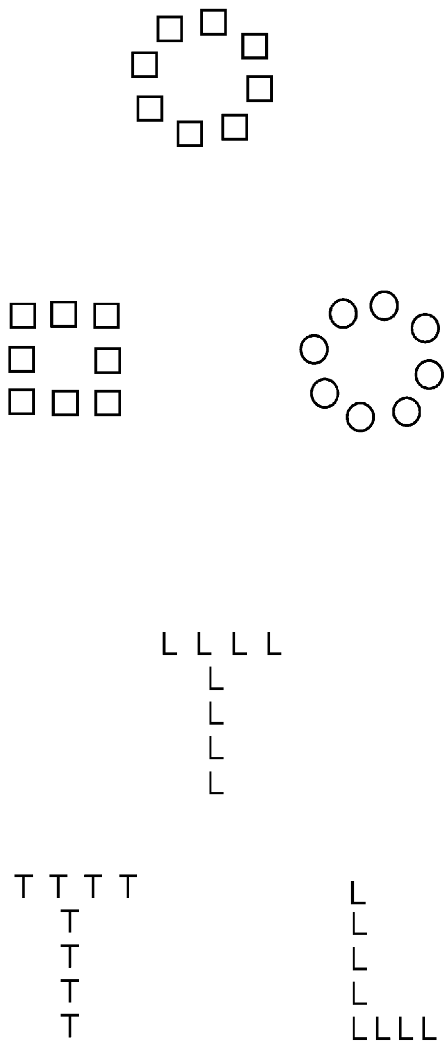

**Figure 1.** Illustration of the kind of hierarchical stimuli used in Experiment 1: (a) geometrical shapes and (b) letters.

*General procedure.* Participants were individually tested in a quiet room at the child day-care unit in the Montperrin hospital (Aix-en-Provence) or at their home. They were seated in front of a 14-inch screen portable computer on which stimuli were presented. On each trial, the participants 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 consisted of indicating one's 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 colours identified these keys. Note that a French keyboard was used. Autism and Asperger syndrome are often associated with motor clumsiness, which is considered by some authors to be a diagnostic criteria for these two syndromes (Ghaziuddin & Butler, 1998). The difficulty in controlling the motor aspect of the response sometimes distracted the participants from the main aspects of the procedure, i.e., the processing of the visual stimuli. To prevent such artifacts, and to avoid errors due to deficient motor control, the experimenter pressed the keyboard button corresponding to the response of the child. This procedure, associated with the inherent clumsiness of the clinical group, excluded the use of response times as dependent variables. Participants were instructed prior to the task that there was no correct or incorrect answer, which made the task unthreatening to all participants, including the youngest ones.

*Testing procedure.* Each participant underwent four practice trials, during which it was explained how to respond. They then underwent a total of 36 test 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 appeared equally often on the left or right position. The order of presentation of the displays was randomized for each participant.

## Results

The number of global choices was retained as the dependant variable. For each group, two-tailed $t$-tests were performed to verify if the number of global choices differed from chance. A significant bias toward global choices was found in all three groups: VMA—$M$ global choices = 83.6%, $t(1, 12) = 4$, $p = .001$; CA—$M$ global choices = 79.1%, $t(1, 12) = 2.8$, $p = .01$; clinical group—$M$ global choices = 72.8%, $t(1, 12) = 2.1$, $p = .05$.

To complement these analyses, $t$-tests for independent samples were computed to compare the mean number of global choices obtained in the clinical group to the number of global choices obtained in the VMA and CA control groups. Children with autism did not differ significantly from the VMA group in this respect, $t(1, 12) = 0.79$, $p = .43$. Similarly, no significant difference was obtained between the clinical and the CA groups, $t(1, 12) = 0.42$, $p = .67$. The finding that the children with autism show the same profile of results as the controls suggests that they have a propensity to rely on the global aspects of the shape.

Spearman rank correlation tests ($p < .05$) were also computed between the number of global choices by the autistic participants and their verbal mental or chronological age, and CARS score. None of these correlations were significant (verbal mental age: $Rho = .27$; chronological age: $Rho = .22$; CARS: $Rho = .19$, all $ps > .25$). Age was unrelated to the number of global choices for control participants as well (VMA group: $Rho = .003$, $p > .9$; CA group: $Rho = .23$, $p > .4$).

## Discussion

Results of the normally developing children are consistent with the main core of the literature, suggesting 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). The replication of a global bias in this study indicates that the task and the dependent variable retained in the analysis were well suited to tap global advantage effects. In addition, this experiment provides information on the development of global/local processing in children with autism. The fact that these children were indistinguishable from both VMA and CA controls in this experiment showed that global processing is already acquired between the ages of 4–15 years, thus confirming previous conclusions that the global advantage is present at a very early developmental stage (e.g., Macchi Cassia et al., 2002). Just as importantly, previous research has demonstrated that global biases may be present in high-functioning autistic populations using hierarchical letter or number stimuli (e.g., Mottron et al., 1999; Ozonoff et al., 1994; Plaisted et al., 1999; Rinehart et al., 2000). The current study demonstrates that such a global advantage for hierarchical stimuli is not restricted to high-functioning autistic individuals, but that children with a more severe autistic diagnosis may also show this global advantage.

To promote a discussion on the effects of task demand on perceptual biases, the next experiment used the same population and procedure as Experiment 1 but different types of stimuli. This second experiment used facial compound stimuli of schematic global faces composed of local geometrical shapes. For comparative purposes, Experiment 2 also consisted of nonhierarchical geometrical stimuli.

## EXPERIMENT 2

### Method

*Participants, stimuli, and general procedure.* Participants were the same as in Experiment 1. The experimental procedure was the same as before, but involved the schematic face and geometrical shape stimuli previously used by Deruelle, Mancini, Livet, Cassé-Perrot, and de Schonen (1999). Testing involved the presentation of 8 original patterns (4 schematic faces and 4 geometrical patterns), all illustrated in Figure 2a, and their 8 global or local matches, resulting in a total of 24 stimuli. As illustrated in Figure 2b, the global choices differed from the sample by the shape of the local elements, while the configuration remained identical for these two forms. The local choices differed from the sample by the inter-elemental distances, and the shape of these local elements remained constant. Stimuli subtended approximately the same visual size as the stimuli of Experiment 1.

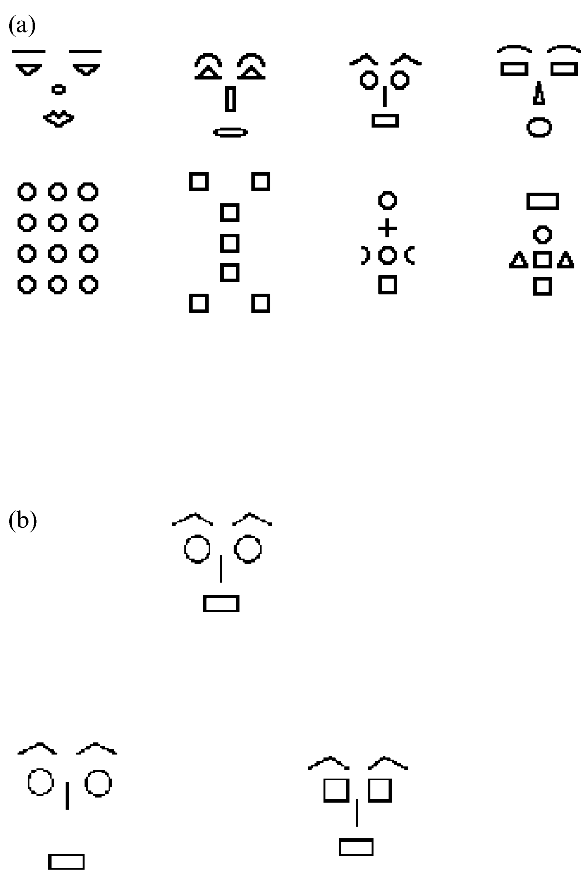


**Figure 2.** (a) Set of the original figures employed in Experiment 2 and (b) an illustration of local and configural variations for one of them.

Each participant participated in 32 trials corresponding to 4 presentations of each original figure used as targets. On each trial, the target figure was presented in conjunction with two other patterns: its local and its global matches. 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.

### Results

Two-tailed paired *t*-tests were firstly computed to verify if the results obtained with facial patterns differed from those obtained with geometrical shapes. Results showed no significant difference between these two types of stimuli: VMA group—*M* global face = 7.1, *M* global geometrical shape = 6.8, $t(1, 12) = 0.35$, $p > .7$; CA group—*M* global face = 7.1, *M* global geometrical shape = 7.0, $t(1, 12) = 1.51$, $p > .1$; clinical group—*M* global face = 3.1, *M* global geometrical shape = 3.3, $t(1, 12) = 0.36$, $p > .7$. In addition, a two-way analysis of variance (ANOVA), considering group (CA, VMA, and clinical) and test condition (face, geometrical shape) as factors confirmed that these factors did not interact significantly, $F(2, 36) = 0.01$, $p > .10$. Data collected with these two types of stimuli were consequently pooled for the analysis of perceptual biases.

For each group of participants, two-tailed *t*-tests were performed to verify if the number of global choices differed from chance. None of the control groups showed a preference for either kind of match: VMA group—$t(1, 12) = 1.4$, $p > .1$; CA group—$t(1, 12) = 0.77$, $p > .4$. In contrast, the autistic group showed a reliable bias in choosing the local match, $t(1, 12) = 8.8$, $p < .001$, thus demonstrating that these participants have a local processing advantage. Analyses further showed a statistical difference between the clinical and VMA groups, *t*-test for independent samples, $t(1, 12) = 4.0$, $p = .0004$, and between the clinical and CA groups, $t(1, 12) = 4.2$, $p = .0003$. On average for the group, a choice for the global match was obtained in 6.4 of the 32 test trials run with the clinical group, and 13.9 and 14.7 of the trials run with the VMA and CA control participants, respectively. In summary, only the clinical group showed a significant response bias, and this bias is clearly in favour of the local match. This finding confirms (1) that the clinical group perceives local consistencies among the stimuli and also (2) that the clinical group prioritizes the local in comparison to the configural information.

Spearman rank correlations showed that the number of local choices of children with autism is independent of both verbal mental age (*Rho* = .19, $p > .8$), chronological age (*Rho* = .05, $p > .4$), and CARS (*Rho* = .005, $p > .9$). No significant correlation was found between the age of the VMA and CA participants and the number of local choices (Spearman rank correlation test, *p*s > .1)

Because the general procedures and the participants were identical in Experiments 1 and 2, direct comparisons between these experiments are possible. For eight children with autism (i.e., A3, A5, A6, A8, A9, A11, A12, A13), comparison between these studies indicated a shift from a reliable preference for the global matches in Experiment 1 (inferred by a two-tailed chi-square test, $p < .05$) to a reliable preference for the local matches in Experiment 2. The reverse local-to-global shift was never observed. The number of children with autism shifting from global to local preference ($N = 8$) is significantly greater than the number of children with autism exhibiting a reverse shift ($N = 0$; Binomial test, $p < .05$). In addition, shifts appear unrelated to test order, as five of the eight participants showing a global to local shift were tested in Experiment 2 prior to Experiment 1, and the other three were tested in the reverse order.

### Discussion

Experiment 2 assessed global/local processing in children with autism using face-like and geometrical patterns. Results revealed a local advantage, which differs from the global preferential bias obtained in Experiment 1. Interestingly, there was no statistical difference between the facial and nonfacial stimuli. This finding indicates that the geometrical shapes and facial stimuli recruited similar processes, and that these processes are not face-specific. It is also noticeable, and important, that only the clinical group exhibited a local bias in this second experiment, highlighting an atypical processing mode in this group, compared to the two control groups.

## GENERAL DISCUSSION

The main goal of this research was to evaluate spontaneous visual preferences of children with autism in two tasks. A global preference was obtained in the first task using Navon-like hierarchical stimuli, and a local preference was obtained in the second task using nonhierarchical facial or geometrical patterns. Unlike controls, the clinical group also presented a reliable shift from a global to a local mode of processing in Experiments 1–2, which is unrelated to test order.

Which factor can account for this global to local shift in the clinical group? In normal participants, shifts from global to local processing have been reported as being controlled by several perceptual factors, such as the size of the global shapes, the density of the local elements, or the retinal locus of the stimuli (e.g., Kimchi, 1992). None of these factors can successfully account for the different results of Experiments 1–2, because the modes of stimulus presentation were maintained constant across experiments, for instance in terms of global and local visual sizes. In addition, because the same participants took part in Experiments 1 and 2, the effects cannot be attributed to a population bias. A more reasonable account for the current findings is to propose that Experiments 1 and 2 did not test the same visual abilities. It is possible that the critical dimension of the tasks leading to the global (Experiment 1) or local (Experiment 2) perceptual bias of children with autism concerns the structural organization of the two comparison stimuli. The comparison stimuli used in Experiment 1 differed in global overall shape, and the distance between the constituent elements remained identical across stimuli (see Figure 1). In contrast, the overall global structures of the stimuli were practically identical for the two comparison forms in Experiment 2; differences between these forms were mostly attributable to subtle variations in inter-elemental distances (see Figure 2b). On these grounds, the hypothesis may be advanced that Experiment 1 emphasized the analysis of global gestalts while Experiment 2 emphasized a consideration of the inter-elemental distances (and thus an analysis of spatial relationships). This idea is reminiscent of Kimchi's (1994) distinction between the global and configural modes of processing, the global mode being defined as the processing of the higher level of the hierarchical structure of the stimuli, and the configural processing being defined as the processing of the inter-relation among component parts.

Autistic participants adopted a global-oriented mode of perception in Experiment 1; so, this experiment suggests that the perception of the global structure of the stimuli is spared in this subset of participants. In contrast, and unlike typically developing controls, these same children with autism demonstrated a reliable local bias in Experiment 2. These local choices demonstrate that local stimulus changes are much more salient for children with autism than configural processing is. These results can be interpreted in two ways. First, it can be proposed that the clinical group has reduced competences (in comparison to controls) for configural processing, leading to a preference for the local match. Second, it might be that the clinical group is similarly capable of processing the configural and local information but exhibits, for some reason, a strategic preference for the local match. Although the current research cannot disentangle these two hypotheses, results of this present study converge with the main core of the literature, which suggests that children with autism have reduced competences for the processing of spatial relationships (e.g., Hobson et al., 1988; Miyashita, 1988; Tantam et al., 1989, but see Joseph & Tanaka, 2003). In addition, the fact that most of the clinical participants had convergent biases pleads for a perceptual origin of this effect. Further experiments are, however, needed to resolve this issue.

Frith (1989), followed by Happé (1996), proposed that the cognitive profile of individuals with autism is characterized by weak central coherence, or WCC. The WCC theory was, however, contradicted by several reports, mainly those resulting from studies using the Navon paradigm. The current study has the advantage of specifying the extents and limits of the WCC theory. In particular, it suggests that deficiencies associated with WCC are restricted to the configural mode of processing, but preserve the ability for global processing, as defined by Kimchi (1994).

The dissociation between global and configural modes of processing has a heuristic value in removing apparent discrepancies in the literature on children with autism (and possibly other disorders such as Williams Syndrome and children with congenital cataracts, e.g., Deruelle et al., 1999; Le Grand, Mondloch, Maurer, & Brent, 2001). It may first explain why children with autism show global precedence when tested with Navon's (1977) hierarchical stimuli (e.g., Ozonoff et al., 1994; Rinehart et al., 2000), as this task only implies the processing of the global structure of the form. Second, it may explain the poor performance of autistic individuals in facial discrimination tasks (e.g., Boucher & Lewis, 1992; Gepner et al., 1996; Hobson et al., 1988; Weeks & Hobson, 1987), as the spatial configuration of facial features is critical for face discrimination (e.g., Tanaka, Kay, Grinnell, Stansfield, & Szerchter, 1998). Third, the relatively good performance of autistic individuals in tasks such as the Wechsler Standard Block Design test (e.g., Shah & Frith, 1993) may also originate from their difficulties in processing spatial configurations.

It should finally be emphasized that autism is a multidimensional developmental disorder that is not only characterized by atypical visual processing. On the one hand, autistic profiles may be associated with preserved or even enhanced cognitive abilities (Frith, 1989; Happé, 1996; Mottron & Belleville, 1993). On the other hand, autism is also commonly associated with impaired social and communicative developments, as well as restricted interests or activities (e.g., Kanner, 1943). Whether the global/configural dissociation can account for these social impairments is unclear. Other theories, focusing for instance on deficits in executive functions or theory of mind, might better account for the atypical social behaviour of children with autism (e.g., Baron-Cohen, Leslie, & Frith, 1985). Still, the global/configural dissociation has the advantage of potentially accounting for both deficits and enhanced competencies in autistic children, while other theories only account for deficits.

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