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Gestalt processing in autism: failure to process perceptual relationships and the implications for contextual understanding

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Background: Deficits in autism have been characterised as a bias towards local over global processing. This paper examines whether there is a deficit in gestalt grouping in autism. **Method:** Twenty-five low-functioning children with autism and 25 controls who were matched for chronological age and verbal mental age took part in the study. **Results:** The autism group utilised gestalt grouping principles (proximity, similarity, closure) significantly less than the controls. Calculating an overall index of gestalt grouping, the autism group performed at chance level. There was also a deficit in identifying certain impossible figures. This pattern was not reflected in a drawing task, in which the autism sample conformed more to gestalt grouping principles than controls (non-significantly). **Conclusions:** The results are discussed in terms of a failure in autism to process inter-element relationships that would allow for the appreciation of larger perceptually coherent units that comprise of multiple elements and, consequently, context. The processes are argued to be preattentive. **Keywords:** Autistic disorder, gestalt, visuo-spatial functioning.

Autism is defined as a deficit in socialisation, communication and imagination with stereotyped repetitive interests taking the place of creative play (APA, DSM IV, 1994; WHO, ICD-10, 1992). Some aspects of cognitive processing are preserved, however, resulting in an unusually spiky profile across Wechsler subtests (Happé, 1994; see Frith and Happé, 1994 for a review). The autistic profile is not consistent with generalised mental retardation or with a general deficit syndrome, but rather with a selective impairment in complex information processing (Minshew, Goldstein, & Siegel, 1997; Jolliffe & Baron-Cohen, 1997). A large proportion of individuals with autism, however, do also demonstrate learning difficulties. Rutter and Schopler (1987), for example, report that 70% of individuals with autism have an IQ below 70.

One of the features of the information processing bias that is specific to autism (and not learning difficulties generally) is an emphasis on processing what is termed 'local' information in precedence to 'global' information. This distinction is exemplified by Navon's (1977) hierarchical stimuli in which a large letter (the global level) is comprised of many small letters (the local level). Normal processing of these stimuli evidenced a 'global advantage', that is a tendency for the global analysis to take precedence over the local analysis (Navon, 1977; see Figure 1). Individuals with autism have been shown to demonstrate a lack of global advantage, although results are mixed (Mottron & Belleville, 1993; Mottron, Burack, Stauder, & Robaey, 1999a; Ozonoff, Strayer, McMahon, & Filloux, 1994; Plaisted, Swettenham, & Rees, 1999; Rinehart, Bradshaw, Moss, Brereton, & Tonge, 2000). This variation may occur as a result of methodological variation, such as the exposure time of the stimuli (Jolliffe & Baron-Cohen, 1997). Individuals with autism, however, have consistently demonstrated superior performances in other assessments that benefit from focusing upon the local level, such as the embedded figures test and block design Wechsler subtest (Shah & Frith, 1983, 1993) and a failure to succumb to visual illusions (Happé, 1996). In the normal processing of these tests global advantage may interfere with performance that benefits from a focus upon local processing. This emphasis upon local processing in autism informs theoretical models of autism, such as Weak Central Coherence Theory, that suggest a deviation from the global advantage norm described above of processing precedence for the global level, for local-level processing precedence (Frith, 1989; Frith & Happé, 1994; Happé, 1999).

Throughout the existing literature (both generally and with respect to autism), the terms 'global' and 'gestalt' have been used synonymously. Either the terms are grouped together ('the right hemisphere is more specialised for more holistic, global, gestalt-oriented processing' (van Kleeck, 1989, p. 1165)) or used interchangeably when describing weak central coherence theory ('since processes of global perception are disrupted in autism, these individuals would not suffer the interference by the gestalt in perception of the parts normally produced by global processing' (Plaisted et al., 1999, p. 733)). Kimchi (1992), however, argues that there are also significant differences between the two. To evaluate whether 'global' and 'gestalt' are synonymous, we need to briefly describe gestalt psychology.

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Figure 1

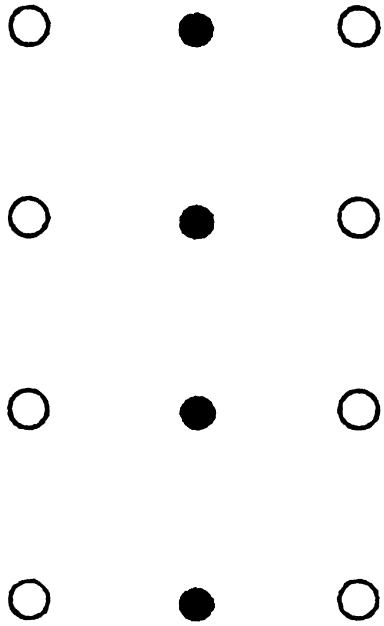

Figure 2

The gestalt philosophy is often summarised by the phrase 'the whole is more than the sum of the parts'. By this, Wertheimer (1924, p. 7) proposed that 'the properties of any of the parts are determined by the intrinsic structural laws of the whole' (cited in Westheimer, 1999; see for a review and present-day evaluation). A clear example of this is provided by the Titchener circles illusion. In this illusion, two circles are judged to be of the same size. However, when one circle is surrounded by large circles and the other circle surrounded by small circles the former central circle looks smaller than the latter central circle. This illusion is used explicitly to suggest that the weak central coherence in autism may be related to gestalt processing by Happé (1996, p. 874), who argues that 'In this illusion the central circles presumably become part of a whole figure gestalt which changes subjects' perception of these parts'. It is by understanding these emergent properties that the gestaltist claim can best be understood.

The investigation of gestalt principles typically involves stimuli that comprise of square arrays of dots (e.g., Nebes, 1978). The gestalt law of proximity dictates that when the dots are slightly closer to neighbouring dots in the same column than to its neighbours in the same row, vertically orientated columns should be perceived (with closer row than column neighbours being perceived as horizontally orientated rows). The perception of columns (or rows) is therefore an emergent property that would not be evident from examining the component parts in isolation.

Elements are also grouped by the gestalt principle of similarity, such that equidistant lines of dots whose columns are alternately black and white will be perceived as columns (see Figure 2). The principle of common colour can be treated as a particular instantiation of the overall principle of grouping by similarity (Quinlan & Wilton, 1998). Indeed, when the two principles of proximity and similarity are placed in conflict (such that columns alternate between black and white dots but the dots are closer to their row than column neighbours), the principle of similarity overrides the principle of proximity and columns are perceived. These grouping principles have been found to be very robust during experimental manipulations of scale (Kubovy, Holcombe, & Wagemans, 1998). The principle of closure also dictates the perception of more enclosed figures such that, of several perceptual organisations, the one that produces a 'closed' rather than an 'open' figure will be perceived. These principles are manifestations of the Law of Pragnanz, which posits that the simple and most stable form will be perceived (Koffka, 1935).

There are undoubtedly overlaps between the conceptualisations of 'global' and 'gestalt' processing, in addition to associations with a hemispheric specialisation in the right hemisphere (van Kleeck & Kosslyn, 1989) and with early stages of perceptual processing (Julesz, 1965; Treisman & Paterson, 1984). Both terms refer to an initial information processing step of the identification, discrimination or classification of holistic properties of stimuli, prior to an awareness of the processing of component properties. Kimchi (1990, 1992; Kimchi & Palmer, 1982) argues, however, that the global and local levels are phonomologically independent (as replacing the elements of the patterns does not affect the perception of the overall form) in a manner that is not true for gestalt stimuli, and that this underpins the theoretical distinction between global and gestalt stimuli.

This mirrors the work of Pomerantz (1983), who distinguished between two types of relationships that exist between the local and global level. Place relationships describe configurations (such as Navon's stimuli) in which the global form can be identified by the placement of the local elements, without reference to the identity of the local elements. (For example, the global H in Figure 1 would be perceived whether the local elements were Ts, as in the figure, or Ls. Indeed, if one squints at the figure, it is possible to see the global form without being able to identify the local form.) The critical feature of these place relationships is that any of the local elements could be interchanged with each other without affecting the stimuli. The second types of relationships are nature relationships. Nature relationships describe configurations in which the global form is defined by the nature of the local elements. Structural or relational properties between the local elements are critical, such that interchanging the local elements with each other would alter the global form (for example, if the top two dots in Figure 2 were interchanged, the perception of columns would no longer be apparent). Love, Rouder, and Wisniewski (1999) have shown that these nature relationships underpin the identification that a column or row contains equivalent elements (or forms an 'equivalence class') prior to the identification of what the elements are. Equivalence classes conform to gestalt principles, e.g., proximity or similarity, described above. In Figure 2, for example, columns are perceived by forming equivalence classes based upon the similarity of the elements within columns compared to similarity across rows, prior to the identification of the elements as dots. It is the relational properties between the local elements that define the gestalt form. As discussed above, the gestalt form determines the perception of the local elements, in this case as *columns* of dots.

Relational processing is argued to be important in many cognitive functions, such as face processing. Indeed problems in face identification have been the presenting symptom in some individuals who have then been diagnosed with Asperger's syndrome (Ellis & Leafhead, 1996). These relational properties are salient in normal face recognition, such that face recognition is severely disrupted when the relational properties are violated (e.g., upside-down faces, or recognising parts of faces). Face recognition in individuals with autism, however, is not disrupted when these relational properties are violated. For example, autistic children have a deficit when matching facial features in the context of a complete face but not when the features are presented in isolation (Teunisse & de Gelder, 1994). The relational properties that hold between the local elements of gestalt, but not hierarchical, stimuli therefore warrant further investigation.

Drawing upon the distinction made by Pomerantz discussed above, Kimchi (1992, p. 35) concludes that 'the hypothesis actually tested using hierarchical patterns is that processing of properties of higher level units precedes processing of properties of lower level units. This is a legitimate and viable hypothesis, but is not the same as testing the hypothesis that processing of holistic properties of a visual object precedes processing of its component properties' and that one should be cautious about making inferences about holistic/gestalt processing from the global/local paradigm. Whilst there are undoubtedly overlaps between global and gestalt processing, the nature relationships within the latter stimuli are crucial. This is exemplified by Quinlan and Wilton (1998, p. 430) who state that 'in order to understand how gestalt principles operate it appears necessary to consider processes that operate within and between groups of elements'. The stimuli used to date to study global processing have examined the processing of place relationships. Through the use of gestalt stimuli, the present study aims to extend the paradigm into nature relationships. This is particularly pertinent as gestalt principles form part of many theories of perceptual processing (Marr, 1982; Gregory, 1998; Ulman, 1990; see Westheimer, 1999 for a review) and connectionist models of these processes (Epstein, 1988). Consequently there has been much recent research into the gestalt principles specifically (Chey & Holzman, 1997; Kubovy et al., 1998; Lewis & Frick, 1999; Quinlan & Wilton, 1998).

The advantage in block design, embedded figures and failure to succumb to visual illusions suggests problems with coherence in autism at a relatively early perceptual or attentional stage (Happé, 1996). Mottron (1999) also argues that the bias in autism resides at an early stage of perceptual processing and extends beyond the visual modality to be a multi-modal abnormality (Mottron, Peretz, & Menard, 2000). A lack of central coherence is also manifest at later stages of cognitive processing, however, in high-level extraction of meaning when processing homographs, for example (Happé, 1997). The issue of the level at which weak central coherence is manifest is interesting as Happé's evidence for a deficit in succumbing to visual illusions cited earlier has not been replicated when altering the task. Ropar and Mitchell (1999) have found that there are no differences in autism samples to succumbing to visual illusions. The authors, however, asked participants to adjust lines to reflect those of the perceived Muller–Lyer line lengths, rather than asking whether the lines looked the same size or different. The authors propose that a motor, rather than verbal, response removes the bias to local-level processing. The perception of impossible figures also requires appreciation of the parts violating the structure of the whole and has been used as a methodology to investigate the perception of emergent properties in autism. Scott and Baron-Cohen (1996) report that individuals with autism fail to identify impossible figures at a perceptual level and Mottron, Belleville, and Menard (1999b) report that the incongruity does not disrupt individuals with autism at a motor level. This is potentially significant at a neuropsychological level as, beyond the gestalt grouping processes under investigation, two cortical visual systems are hypothesised to primarily underlie visuomotor processing (Milner & Goodale, 1995) and object recognition (or 'where' and 'what' pathways, Ungerleider & Mishkin, 1982). In addition to gestalt stimuli, the present study will include a visuomotor and object recognition task.

Given the theoretical distinction between global and gestalt phenomena and the significance of gestalt grouping principles, the present study aims to evaluate whether the deficits identified in global processing in autism can be extended to gestalt processing for verbal and motor responses. Weak Central Coherence Theory explicitly refers to a 'failure to perceive gestalt' (Happé, Briskman, & Frith, 2001, p. 300) based upon tasks such as the embedded figures test and block design discussed above. The present study will explicitly examine this proposal using gestalt stimuli.

Method

Participants

Fifty participants were recruited from six metropolitan schools. The children with autism ($n = 25$) were mainly drawn from special schools for autism, although some were located in mainstream education. All had received a diagnosis of autism from experienced clinicians using the guidelines of standard criteria such as DSM-IV (APA, 1994). The control group ($n = 25$) were matched on chronological age and verbal mental age (VMA). Consequently they all had an educational statement of Moderate Leaning Difficulties (MLD) and attended the same (or similar) schools as the autism group. The ages and verbal abilities are reported in Table 1.

The samples averaged a chronological age of around 10 years with a verbal metal age of around 5 years. The main purpose of VMA assessment was to ensure that all participants would be able to interpret instructions. There were no significant differences in VMA ($t = 1.14$, $df = 48$, n.s.) nor chronological age ($t = 1.83$, $df = 48$, n.s.) between the groups. The present study does not include a normal control group. The aim was to have chronological aged and verbal mental age matched controls for the largest group of children with autism, those with associated learning disabilities. By definition, it would not be possible to get a normal matched group. Chronological age is a significant variable in matching groups (see Happé, 1995) and the inclusion of younger normal children would not be a viable comparison group as this would assume that MLD is only a developmental delay rather than a deviance (in the present study, there were no significant correlates of age).

Table 1 Sample characteristics, means (SD in brackets) and range of scores

	Autism $N = 25$ Mean (SD) range	MLD $N = 25$ Mean (SD) range	$*p < .05$
Age in months	135 (46) 69–194	117 (17) 96–169	n.s.
VMA in months	57 (21) 36–108	63 (14) 42–96	n.s.

Design

Verbal mental age was assessed using the TROG (Bishop, 1983). Similar testing to that which was utilised in the present study has been successfully completed with children with a VMA of 3 years (Kimchi, 1990; Kramer, Ellenberg, Leonard, & Share, 1996).

Matrices were constructed that were (row × columns) 2 × 3, 3 × 2, 4 × 3 and 3 × 4. There were two examples of each of these four matrix sizes. One example grouped vertically and one horizontally for each matrix size. The smaller matrices were 2 cm × 4 cm and the larger matrices 4 cm × 5.5 cm. The dots were either 1 cm or 1.5 cm from adjacent dots (dependent upon whether the grouping was vertical or horizontal). These dimensions were selected for providing a clear example of the grouping phenomenon. The dots were 4 mm in diameter and the matrices centred upon white card 21 cm square. The matrices are constructed so that one answer will illustrate a grouping response and one will not (see Figure 2). The presentation of the matrices was randomly ordered. There were additional stimuli that interspersed the matrices so that two matrices were never presented in succession (these additional stimuli are reported elsewhere; Scott, Brosnan, & Wheelwright, submitted) to minimise the effects of perseveration. This was successful as none of the participants with autism responded exclusively in one direction. There were 8 matrices that could be grouped by similarity and 8 matrices that could be grouped by proximity.

Initially participants were tutored upon what a line of dots was. For example, a line of five dots was presented and the participant was told that this was ONE line. Both filled and empty circles were used for each participant. The lines were presented diagonally, not in the vertical or horizontal orientations of the test stimuli. No participant failed to grasp this principle readily, evidenced by supplying appropriate responses to the number of lines (i.e., 2 or 3 in the 2 × 3 matrices and 3 or 4 in the 3 × 4 matrices).

A grouping/gestalt response was scored with a '1' and a non-gestalt response scored with a '0' for all the gestalt stimuli. Thus there were potential proximity scores and similarity scores both ranged from 0 to 8, with a hypothetical chance score of 4.

The principle of proximity was also assessed using an 'odd line out' task. Seven lines appear on the page arranged in three proximal pairs and a single line (see Figure 3). Participants were asked 'which line is the odd one out?' or 'which line looks like the odd one out?' (see below). Children pointed to one of the lines. One was recorded for a grouping response for the leftmost element, otherwise zero and the locations of errors were noted. The principle of closure can also be demonstrated with a slight variation to this stimulus. Extending the tops and bottoms of the lines can make the stimulus look like sides of boxes and consequently the other end of the array looks like the odd one out (see Figure 3). Gestalt grouping required identifying the rightmost element, which scored 1, otherwise 0 and locations of errors were noted. As before, a gestalt response was

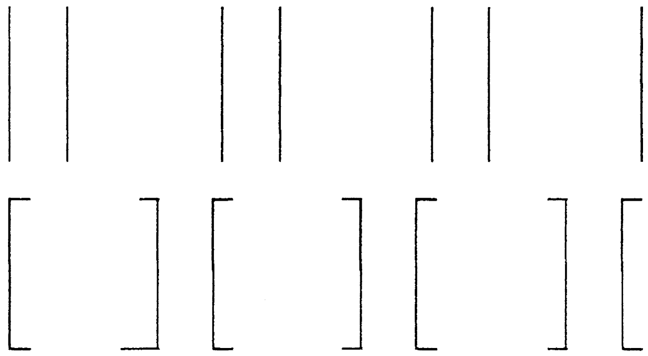

Figure 3

recoded as 1, giving a range of 0 to 1 for these two assessments, with a hypothetical chance score of .5 for both these items. This will be used for comparing the group mean against a chance mean of .5.

Participants were also presented with two examples of figures and asked 'which one is impossible?' (after Scott & Baron-Cohen, 1996). On each occasion one stimulus was possible and one was not. There were two geometric stimuli (Penrose triangle and a square equivalent) and two fantasy stimuli (a cow with two heads, a woman with four legs) (see Mottron et al., 1999b and Scott & Baron-Cohen, 1996 respectively). Identifying the impossible figure requires perception of the whole figure and the incongruity of the gestalt interferes with processing the local parts of the figure (Mottron et al., 1999b). Again, scores could range from 2 (if both correctly identified) to 0 for both geometric and fantasy stimuli, with a chance mean of 1 for both sets of stimuli.

Four examples from the Bender-Gestalt copying task were included. These simple drawings could be copied in accordance with gestalt principles or not. For example, columns of proximal dots can be drawn as columns (gestalt) or drawn as rows. A circle slightly overlapping with a square could be drawn as these two gestalts or the drawer could start with part of the circle and continue with the square when reaching the overlapping point. Scores could range from 4 (all drawn in accordance with gestalt principles) to 0. Additionally, the quality of the drawing (irrespective of whether gestalt principles are adhered to during its construction) is rated through a formalised scoring structure ranging from 0 to 24 (Bender, 1938).

Based upon Navon's original stimuli there was a large W made up of small Vs and a large H made up of small Ts. The stimuli were constructed to be the same size as the gestalt stimuli within the experiment. Consequently each spoke of the global letter was around six local letters wide (Navon's original stimuli were one local letter wide). Participants could look as long as they wanted at the stimuli to keep presentation consistent with the gestalt stimuli. Previous research has demonstrated that individuals with autism can be prompted to both hierarchical levels (Plaisted et al., 1999) and that exposure time is a critical variable (Jolliffe & Baron-Cohen, 1997). These global/local stimuli were included to provide a control for the gestalt stimuli rather than for comparison to other studies of hierarchical stimuli. The aim was to provide stimuli that could be responded to in a number of ways that were not gestalt stimuli. For the hierarchical stimuli, 1 point was recorded if both letters were identified and 0 if only 1 letter was identified. As there were two hierarchical stimuli, there was a possible maximum score of two. It was, of course, possible that participants would not be able to identify letters. If this were the case, they were excluded from the analysis. In the event, this occurred in both groups relatively equally (autism = 6, MLD = 7 excluded). (Were these participants to be included, the non-significant difference reported in Table 2 below remains non-significant with both groups having a mean of 1.3 and a standard deviation of .9.) Most (79%) of the remaining participants saw both global and local letters and around 80% of both groups reported the global letter first. Seven (4 autism, 3 MLD) participants only reported one letter, 5 of whom reported the global letter. One autism and 1 MLD participant reported only the local letter.

A second control task was included to provide an additional assessment of non-gestalt visual processing. Recognition of non-optimal forms can be impaired in isolation from recognition of optimal forms (of the same images) in patients with 'apperceptive' difficulties. With apperceptive agnosia the construction of the perceptual representation at a cortical level is intact but there is a deficit matching this representation with stored representations (see Humphreys & Bruce, 1989). Mottron et al. (1997) identify a case study with a diagnosis of autism in whom they detect apperceptive agnosia deficits. The task is therefore relevant and non-gestalt and taken from McCarthy and Warrington (1990). Participants were presented with black and

Table 2 Gestalt grouping in low-functioning children with autism or MLD, means (SD in brackets) and range of scores

Stimuli (maximum)	Autism Mean (sd) range	MLD Mean (sd) range	* $p < .05$ ** $p < .01$
Similarity (8)	4.6 (1.1) 2–6	5.2 (1.3) 3–8	*
Proximity (8)	4.6 (1.0) 3–7	5.2 (1.3) 3–8	*
Odd one out (1)	.5 (.5) 0–1	.8 (.4) 0–1	*
Closure (1)	.2 (.4) 0–1	.4 (.5) 0–1	*
Fantasy figure (2)	1.7 (.7) 0–2	2.0 (.0) 2–2	*
Geometric figure (2)	1.4 (.6) 0–2	1.4 (.7) 0–2	n.s.
Gestalt index (.5)	.06 (.15) −.15––.29	.21 (.15) −.04–.44	**
Draw total (24)	14.7 (3.7) 7–21	14.2 (4.7) 5–23	n.s.
Draw gestalt (4)	3.6 (.6) 2–4	3.0 (1.4) 0–4	n.s.
Hierarchical stimuli (2)	1.8 (.4) 1–2	1.8 (.4) 1–2	n.s.
Overlapping fruit (7)	5.6 (2.5) 0–7	6.0 (1.6) 0–7	n.s.

white outlines of four fruits (banana, apple, pear, cherries) separately that they had to identify in response to the question 'what can you see in this picture?' This was to ensure that the participants could recognise and name the items and they were randomly interspersed with the gestalt items above. This was not problematic for the samples but if the cherries were labelled grapes, this was not corrected and 'grapes' was considered a correct response for the overlapping figures task. The overlapping figures task required participants to identify the same black and white outlines but presented overlapping each other. Two instances of this task were presented, one with three pieces of fruit and one with four pieces of fruit. These were also randomly interspersed with the items above, appearing after the separate pictures of the fruit. For the overlapping fruit, 1 point was scored for each fruit identified in the 3 and 4 overlapping figure displays (totalling a maximum score of 7). The mean was very high but 4 participants represented outliers, receiving a score of 0 (autism = 3, MLD = 1) having identified the pictures in isolation and attempting an answer to the overlapping figures ('a kettle' on 2 occasions, see Figure 4).

All scores were initially recorded as the participants were being assessed. All assessments were videoed and subsequently rated again by a second research assistant blind to the ratings of the first researcher and the group from which the participants came. This yielded very high agreement (96% of responses), with disagreements resolved by discussions with the authors who were also blind as to which group the participant under discussion was from.

Procedure

Testing took place over two sessions, both of which occurred within a week of each other. Participants were taken from their classroom and individually tested. Initially participants were tutored upon what a line of dots was, as described earlier. Participants were told that they would see lots of different pictures and be asked one question about each picture. The participants were told that the questions might be different and to listen carefully to each question.

The cards were placed upon a table in front of each participant who was asked the appropriate question in one of two formats, e.g.: 'how many lines are there?' or 'how many lines does it look like there are?' (see Scott et al., submitted). Subsequent analysis revealed no differences between these two question formats with the present stimuli and the data were collapsed accordingly (see discussion).

Appropriate permissions were gained prior to testing and participants were allowed to withdraw or not respond if they so chose. Consequently there are small variations in the degrees of freedom where a child may have failed to respond to one of the stimuli. Given the information processing bias described above, it was predicted that the autism group would display a bias away from gestalt processing using traditional gestalt stimuli. Given the directionality of this prediction, one-tailed *t*-tests were used to examine group differences.

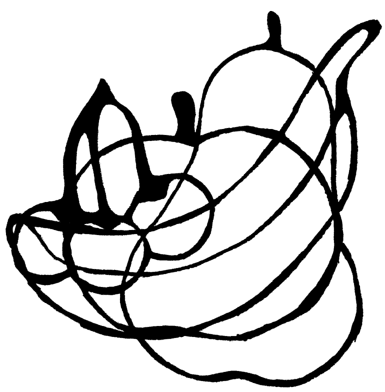

Figure 4

Results

A repeated measures ANOVA was conducted with 6 levels of the within-group factor (the 6 assessments of gestalt processing in Table 2) and the diagnostic criteria (autism vs. MLD) as the between-group factor. There was a significant difference between these two groups ($F = 6.77$, $df = 1$, $p = .013$) which will be analysed initially, in addition to a within-group difference ($F = 253$, $df = 5$, $p < .001$) with a non-significant interaction ($F = .043$, $df = 5$, n.s.).

There were 16 gestalt dot stimuli in all, 8 grouped by proximity and 8 grouped by similarity. In Table 2, a higher score represents a greater number of gestalt groupings. The children with a diagnosis of autism grouped significantly less on the blocks of dots tasks than the children with a statement of MLD for both proximity ($t = 1.71$, $df = 45$, $p < .05$) and similarity ($t = 1.75$, $df = 44$, $p < .05$) stimuli.

This was replicated on the second proximity task of identifying the line that was not in a proximal pair as the odd one out. Once again, the autism sample grouped by gestalt principles significantly less than the MLD group on this task ($t = 1.83$, $df = 34$, $p < .05$) and the similar task evoking the grouping principle of closure just failed to reach significance ($t = 1.67$, $df = 43$, $p = .0501$).

The identification of impossible figures drew mixed results. Whilst the group with autism identified the fantasy figure that was impossible significantly less than the MLD group ($t = 2.31$, $df = 41$, $p < .05$), there were no differences in the geometric figures ($t = .41$, $df = 41$, n.s.). Finally, the two groups completed the drawing of the Bender gestalt figures to a similar degree of competence ($t = .36$, $df = 45$, n.s.) and a similar level of gestalt grouping ($t = 2.0$, $df = 45$, n.s.). This finding is non-significant as the difference is not in the predicted direction. The MLD group deviated from drawing using gestalt grouping more than the autism group. A Bonferroni post hoc analysis was conducted, as the difference was not in the predicted direction, which rendered the statistic non-significant. Additionally, there were no group differences in the two control tasks of hierarchical

Table 3 Average gestalt grouping in low-functioning children with autism or MLD (0 = No gestalt grouping, 1 = Total gestalt grouping) compared on a one sample *t*-test with a test variable = .5 (to represent random grouping, except where shown)

Stimuli (test variable = .5, except where shown)	Autism average	* $p < .05$ ** $p < .01$	MLD average	* $p < .05$ ** $p < .01$
Similarity	.57	*	.65	**
Proximity	.58	**	.65	**
Odd one out (.143)	.53	**	.79	**
Closure (.143)	.19	n.s.	.42	*
Fantasy figure	.84	**	1.00	Assumed
Geometric figure	.68	*	.72	**
Gestalt index (0)	.06	n.s.	.21	**
Draw total	.61	**	.59	*
Draw gestalt	.91	**	.75	**
Hierarchical stimuli	.64	n.s.	.66	n.s.
Overlapping fruit	.81	**	.86	**

Note: As the fantasy figures for the MLD group has a zero standard deviation, this statistic cannot be calculated. The gestalt index ranges from −.5 to +.5, and is therefore tested against a test variable of zero.

stimuli ($t = .18$, $df = 45$, n.s.) and overlapping fruits ($t = .66$, $df = 44$, n.s.).

An index of gestalt grouping was calculated. The index aims to highlight the extent of the overall grouping bias for the stimuli above (excluding the motor output Bender gestalt drawing task and the two control tasks). The tasks were adjusted to be equally weighted (e.g., similarity grouping total divided by 8 as there were 8 stimuli). Additionally, .5 was subtracted to remove the chance response value (e.g., a similarity score of 5.2 would have an index of (5.2/8) − 4, that is averaged with the other indices. This would result in a range from 0 (grouping by chance) to .5 (grouping by gestalt). It is also possible to group at a level less than chance (through to −.5). This index provides a value of .06 for the Autism group and .21 for the MLD group that identifies the average bias towards a grouping response and is significantly different between the two groups ($t = 3.07$, $df = 36$, $p = .004$).[1]

It is clear that the autism group are grouping significantly less relative to the MLD group. To examine how these grouping levels compared to chance, one sample *t*-tests were conducted for both groups separately against a test variable of the chance value. The means from Table 2 are reflected in Table 3, having been divided by the number of stimuli to provide an average that is more consistent across tasks as it is not dependent upon the number of stimuli presented. A score of 0 would represent no gestalt grouping and a score of 1 would represent consistent gestalt grouping. Table 3 compares the autism groups against the hypothetical chance midpoint. Whilst the group differences above allowed for directional predictions, the group means could vary above or below this point and consequently two-tailed tests are reported.

Table 3 highlights that for most of the stimuli the autism group do achieve significantly above chance, the MLD group significantly more so. The matrices and impossible figures have a chance value of .5 and with 7 potential responses to the odd one out and closure stimuli there was a chance value of .143 (1/7). The index of gestalt grouping does not differ significantly from chance for the autism sample ($t = 1.61$, $df = 14$, n.s.) but is significantly different from chance for the MLD group ($t = 6.96$, $df = 22$, $p < .001$).[1]

Interestingly, for this composite variable the 95% confidence intervals do not overlap. The autism sample range from −.02 to .15 and the MLD sample range from .15 to .28. There were, however, 3 individuals with autism who scored above the MLD mean for the gestalt index and 3 individuals with MLD who scored below the autism mean. For both of these groups there were no discernible differences from their peers, for example chronological age (autism: $t = .51$, MLD: $t = .58$, both n.s.) or VMA (autism: $t = 1.49$, MLD: $t = .27$, both n.s.). These two groups also performed comparably to their peers on the control tasks.

Although the gestalt index assumes all tasks are assessing gestalt processing, there were within-group effects described at the beginning of this section. These were consistent for both groups as there was not a significant interaction. A Bonferroni pairwise comparison revealed a significant difference between all the gestalt assessments, except similarity matrices with proximity matrices ($p < .01$). A potential reason for this is that the odd-one-out tasks were not reflecting gestalt processing. Given the lack of difference for the geometric stimuli and the high means for the fantasy stimuli, the gestalt index was recalculated without these variables. For the traditional gestalt stimuli, the autism sample had a mean of −.04 ($sd = .18$) and the MLD sample had a mean of .13 ($sd = .19$), which was again significant

[1] Please note that the mean minus the average score divided by the number of items gives the same result (e.g., for similarity (5.2–4)/8). Also, the gestalt index uses a chance score of .5 for the odd-one-out task and closure task. Adjusting this to .143 merely shifts the distribution from −.38 to .62 with a midpoint of .12. This does not affect any of the *t*-tests reported.

($t = 2.67$, $df = 38$, $p = .006$). Similarly, this adjustment does not affect the variation from chance, which was non-significant for the autism sample ($t = .82$, $df = 15$, n.s.) and significant for the MLD sample ($t = 3.20$, $df = 23$, $p = .004$).

Discussion

Whilst normal processing has been found to be characterised by a global advantage, autism as been characterised as a bias towards local processing. Typically this has been assessed using global/local stimuli for which a place relationship holds between local elements. The present study examined the perception of gestalt stimuli for which nature relationships hold between the local elements. For the gestalt principles under investigation (proximity, similarity, closure) a consistent pattern emerged in which the autism sample grouped less than the MLD group. This is exemplified by the upper 95% confidence level limit of the autism group matching the lower 95% confidence level limit of the MLD group. This overall index of gestalt grouping also identified that the children with autism were grouping at a level not significantly different from chance, whereas the MLD children were.

The results are consistent with the characterisation of autism as an information processing bias away from the gestalt grouping principles underpinned by nature relationships in addition to the previously stipulated bias away from global processing underpinned by place relationships. As the nature relationships capture the configural relations between local elements, the present findings are consistent with arguments concerning face-processing deficits associated with autism.

This is particularly significant as gestalt grouping (as opposed to global processing) plays a large role in many theories of visual perception. This has the advantage, therefore, of specifying at a perceptual/cognitive level where perceptual biases in autism occur. The rapid extraction of configurations grouped by gestalt principles from multi-element visual arrays is widely accepted as an early stage of visual analysis (for example in Marr's theory, the grouping of the full primal sketch from the raw primal sketch). The inclusion of gestalt stimuli to the study of autism offers the potential to further specify Weak Central Coherence Theory. Duncan (1984; Duncan & Humphreys, 1989), for example, proposes that these grouping processes normally occur preattentively. The deficit in autism can be understood at a perceptual/cognitive level in terms of a bias away from processing the relationships between elements of the visual array that encourage visual input of similar parts (or equivalence classes) to appear as perceptually coherent units. Laeng, Shah, and Kosslyn (1999) report that normal perceptual analysis is initially attempted 'over the most comprehensive region of the visual input that appears as a perceptually coherent unit' (p. 83) and only when this fails does analysis progress to smaller portions. A deficit in processing the nature relationships that manifest themselves as gestalt grouping principles localises what is perceived to be perceptually coherent. Thus the deficit in autism is not characterised as a deficit in perceptual analysis but as a bias away from processing inter-element relationships that allow for the appearance of multiple elements as perceptually coherent.

A bias away from processing inter-element relationships could account for the failure to be influenced by context in autism (e.g., Shah & Frith, 1983; Jolliffe & Baron-Cohen, 1997). Most normal everyday visual perception occurs within context. There is a large body of literature that suggests the right hemisphere primarily subserves the processing underpinning gestalt and global analysis, while the left hemisphere primarily subserves the local analysis (Evans, Shedden, Hevenor, & Hahn, 2000; Hubner, 1998; see Ivry & Robertson, 1997 for a review). Whilst these theoretical accounts of the empirical data may implicate right hemisphere anomalies in autism, or a 'right hemisphere weakness' (Rinehart et al., 2000, p. 777), the evidence is not conclusive (Frith, 1997; Happé, 1999). Using global/local stimuli, Evans et al. (2000) showed that the processing of (unattended) context determined a later stage for the lateralisation of processing to either the right or left hemisphere and a consequent focus upon one level of processing. This suggests a hypothesis that, rather than hemispheric abnormalities, the failure to process inter-element relationships (and consequently context) allows for earlier lateralisation to the left hemisphere and a local processing bias. This is supported by the evidence that individuals with autism can be explicitly cued to process context or the global level (Snowling & Frith, 1986; Plaisted et al., 1999). Although not comparable to other hierarchical stimuli experiments, most children with autism could report the global level of these stimuli, which were used as a control in the present study. This is consistent with our recent research that shows that individuals with autism succumb to visual illusions (for example the Muller–Lyer illusion) when asked 'which line *looks* longer' but do not succumb when asked 'which line *is* longer'. This suggests that individuals with autism have access to physically accurate or psychologically distorted representations dependent upon the cue in the question. For the gestalt stimuli the wording has no effect, suggesting that for these inter-element relationships, a verbal cue did not encourage the processing of nature relationships. Under this hypothesis, the present study would suggest that gestalt phenomena only emerge through the processing of nature relationships. If these are not processed, there is no other level than the local level, which would provide an explanation for why the left hemisphere is defaulted to. Other aspects of perceptual organisation would also need to be examined (such as uniform connectedness, Palmer & Rock, 1994) but as preattentive gestalt grouping informs the perceptual units that are subjected to higher order attentional processing (Duncan, 1984), there are potential links between Weak Central Coherence Theory and executive functioning accounts of autism (e.g., Russell, 1998).

The good performance upon the overlapping fruits apperceptive task does not contradict this. The inclusion of this control task suggests that both samples can extract perceptually coherent overlapping items, and do not demonstrate symptoms of apperceptive agnosia, which is consistent with the perceptual bias away from gestalt grouping occurring preattentively in children with autism. Mottron et al. (1997, p. 704) conclude that the 'autistic disorder may in general be associated with a visual agnosia'. In the present study, most children with autism did pass the assessment associated with identifying a visual agnosia, suggesting that their 'what' pathway is intact (Ungerleider & Mishkin, 1982). There were, however, three exceptions. These three children (and one from the MLD sample) did identify all the fruits in isolation but none from the overlapping forms (two participants offering the suggestion of 'a kettle'). Consistent with Mottron et al., there may be a subset of the autism sample that additionally display agnosic difficulties.

The perception of impossible figures also requires the appreciation of the incongruity in the relationship between the parts and the whole. The results were ambiguous for these stimuli in the present study. For the fantasy figures, the results replicate the findings of Scott and Baron-Cohen (1986) of a deficit in children with autism identifying the impossible figure. There were no differences in the geometric figures, however. Given the lower means for both groups, it is conceivable that the geometric figures were more complex than the fantasy figures. Both groups scored significantly above chance on this task and given the high rate of correct responses for the fantasy figure (and the VMA control), it is improbable that the lower means are due to not understanding the language involved. Similar geometric figures have been used to demonstrate biases in autistic processing through a copying task (Mottron et al., 1999b). Mottron et al. found that the impossible figures were not drawn more slowly by the autism sample than possible figures, whereas the impossible nature of the figures interfered with non-autistic drawers.

This is interesting as Mottron et al. found an effect of the gestalt grouping when assessing a motor output task (drawing). This is not consistent with Ropar and Mitchell (1999) who failed to replicate a lack of succumbing to visual illusions in autism when using a motor output task (adjusting the length of the line for Muller–Lyer). Obviously the input is visual and there is a feedback loop between the visual input and the motor output but the autism sample did succumb to visual illusions when assessed using a motor output. The present study also showed that the tendency away from gestalt grouping was not reflected in the drawing task. Indeed, the autism sample drew more gestalt forms than the MLD matched controls. Initial analysis of the gestalt drawing task in the present study would appear to concur with Ropar and Mitchell that the bias away from gestalt grouping identified above is not manifest at a motor level. At a neuropsychological level, this suggests that the visuomotor stream (Milner & Goodale, 1995; or 'where pathway', Ungerleider & Miskin, 1982) is intact and can activate gestalt grouping. This would suggest that the bias does indeed reside in the preattentive grouping processes *per se* as the gestalt phenomena can be evidenced with motor output.

The gestalt index provides an overall level of gestalt processing but there were within-group differences for the gestalt tasks suggesting variability within the differing aspects of gestalt processing. It is likely that similarity and proximity are underpinned by differing preattentive mechanisms; a distinction warranting further investigation. However, the present study identified a consistent deficit in gestalt processing using a range of traditional gestalt stimuli in low-functioning children with autism compared to chronological age and VMA matched controls. Replication of these findings would be welcomed contrasting high-functioning children with autism with matched normal controls. Further investigation of processing beyond this level may also allow integration of low-level perceptual theories of autism with higher-level executive functioning theories of autism.

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