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ORIGINAL PAPER

Gestalt Perception and Local-Global Processing in High-Functioning Autism

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Abstract This study examined gestalt perception in high-functioning autism (HFA) and its relation to tasks indicative of local visual processing. Data on of gestalt perception, visual illusions (VI), hierarchical letters (HL), Block Design (BD) and the Embedded Figures Test (EFT) were collected in adult males with HFA, schizophrenia, depression and normative controls. Individuals with HFA processed gestalt stimuli less in accord with gestalt laws, particularly regarding the principle of similarity. Gestalt processing correlated positively with global processing of the HL. EFT and BD performance correlated negatively with VI susceptibility in HFA. All clinical groups succumbed less to VI than the normative sample. Results suggest decreased gestalt perception in HFA, being associated with a more general local visual processing bias.

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Introduction

Cognitive approaches have substantially enriched the understanding of mental dysfunctions and alterations possibly underlying autism. A lack of 'theory of mind' is the most prominent cognitive model for failure in social and communicative reciprocity, while executive dysfunction and 'weak central coherence'(WCC) serve to explain the non-social aspects of the disorder (Hill & Frith, 2003). The WCC theory postulates that individuals with autism prefer a cognitive style characterized by piecemeal or local processing, rather than context-driven or global processing; the latter being typical for normative perception (Frith, 1989; Frith & Happé, 1994). The framework of WCC has also been used to explain strengths on certain visuo-spatial tasks in autism, for instance superior performance on the Embedded Figures Test (EFT) and the Block Design Test (BD) from the Wechsler Intelligence Scales (Shah & Frith, 1983, 1993). Proponents of this framework argue that local processing style might be an advantage for successful completion of these tests, which require to resist the drive to experience one global visual stimuli in favor of seeing a composition of single elements. However, this presumption is not supported throughout, as some studies also found individuals with autism not to exhibit better mastery of the EFT and the BD (Brian & Bryson, 1996; Ozonoff, Pennington, & Rogers, 1991). Moreover, Mottron and colleagues

(Mottron & Burack, 2001; Mottron, Burack, Iarocci, Belleville, & Enns, 2003) have forwarded a subtly differing theory for these test results in autism, called the 'hierarchization deficit model'. This theory presumes that people with autism are as able as others to process global and local visual stimuli. Nevertheless, unlike in typical development, individuals with autism do not ascribe particular importance to specific stimuli and put them into a processing hierarchy. Parts and wholes are processed with similar efficiency. Therefore, contrary to WCC theory, the hierarchization model explains superior performance of individuals with autism on the BD and the EFT by an inefficient global strategy used in typical development rather than a local processing advantage (or global impairment) in autism. Although the predicted patterns of results are similar in the WCC theory and the hierarchization deficit model.

It is still unclear at which stage of perception WCC or a hierarchization deficit exists in autism. Happé (1996) studied this issue by investigating if individuals with autism do succumb to common two-dimensional visual illusions. Normally, visual illusions are not perceived in accordance to their pure physical properties, but owing to context visual elements are rather automatically integrated to generate an inaccurate judgment. She hypothesized if WCC appears at a preattentive level, then people with autism should process the parts of the illusions locally, so that they would not be fooled by the misleading effect of the stimuli. Results revealed that compared with both healthy individuals and individuals with learning difficulties the autism sample indeed made more accurate judgments about the illusions, indicating neglect of global context very early in perception. Nevertheless, subsequent research on the processing of visual illusions yielded no differences between individuals with autism and clinical as well as typically developed samples (Hoy, Hatton, & Hare, 2004; Ropar & Mitchell, 1999, 2001).

Another more recent source of debate regarding research on local-global processing in autism and in general is whether it is appropriate to use the terms 'global' and 'gestalt' synonymously or to subsume gestalt processing under global perception, respectively. It is well established that grouping based on gestalt principles is crucial for the perception of global structures composed of spatially separated local elements (e.g. Han & Humphreys, 1999). Thus, 'gestalt' and 'global' may not summarize exactly the same mechanisms. At least some aspects of gestalt processing might precede global processing or could be a prerequisite for more far reaching global perception. Gestalt processing can be understood as an early preattentional perceptual system serving subsequent higher order cognition. However, in the past, most authors have used the constructs of 'gestalt' and 'global' rather interchangeably in autism research. In a valuable discussion of the subject, Brosnan, Scott, Fox, and Pye (2004) have pointed out, that despite unquestionable overlaps between the two conceptualizations, there are also significant differences. Based on the contributions to local versus global processing by Navon (1977) and gestalt theory (Wertheimer, 1925) they derive several conclusions (p. 460–461). On one hand, they agree that both the terms global and gestalt "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" (~bottom-up). On the other hand, quoting Kimchi and Palmer (1982) and Kimchi (1992), they argue that "the global and local levels are phonomologically independent (as replacing the elements of the pattern 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". Applying the ideas of Pomerantz (1983), they argue that this is due to the fact that 'place relationships' exist between the elements in local-global configurations. Here, the global form can be identified by the placement of the local elements, without reference to the identity of the local elements (local elements can be interchanged with each other without affecting the stimuli; see Fig. 4). In contrast, gestalt stimuli are characterized by 'nature relationships' between its elements: the global form is defined by the nature of its parts (local elements can not be interchanged without altering the global form/gestalt; see Fig. 1**c**).

Brosnan et al. (2004) therefore used gestalt principle stimuli to examine visual processing in children with low-functioning autism. Compared to a matched group of children with learning difficulties, the autism group judged gestalt stimuli significantly less following the gestalt laws of proximity, similarity, and closure. The authors concluded that autism may be associated with a preattentive fundamental impairment to process gestalt principles defined by inter-element nature relationships in addition to the previously reported altered local-global processing in terms of place relationships. The work by Brosnan et al. (2004) shows that research on the processing of gestalt laws may provide important additional insights into the basic perceptual mechanisms in autism. However, as the authors mention themselves, their results require replication as well as the inclusion of other control groups and tasks in the design to corroborate the validity of their findings.

The objective of the present study was therefore to examine the gestalt processing principles of proximity, similarity, and closure in a group of high-functioning individuals with autism (HFA). Visual agnosia, a general perceptual inability to recognize even well defined objects, has been occasionally found in autism (Bölte & Bosch, 2005; Kracke, 1994; Mottron et al., 1997). Therefore, to control for the possible confound of gestalt principle processing and symptoms of visual agnosia, an apperceptive overlapping figures test was included, which is known to be sensitive to fundamental neuropsychological disorders of perceptual synthesis and object recognition. Aside from a normative sample, two clinical control groups, namely schizophrenia (SCH) and depression (DEP) were assessed. SCH and DEP seem to be adequate control samples as they both have shown altered gestalt and local-global processing (Coello, Ardila, & Rosselli, 1990; Johnson, Lowery, Kohler, & Turetsky, 2005; Uhlhaas, & Silverstein, 2003) and other features of cognitive abnormalities also detected in autism, such as executive dysfunction (Austin, Mitchell, & Goodwin, 2001; Bowie & Harvey, 2005). Moreover, there are noteworthy symptomatic overlaps between HFA and SCH as well as a considerable comorbidity of HFA and DEP (Ghaziuddin, Ghaziuddin, & Greden, 2002; Konstantareas & Hewitt, 2001). Finally, autism, SCH, and DEP are all considered disorders with a major genetic component and family studies suggest that depressive and schizoid symptoms may be part of both the broader phenotype in relatives of autism and SCH (Rutter, Silberg, O'Connor, & Simonoff, 1999). Therefore, the comparison of HFA, SCH, and DEP should be useful to specify the severity and nature of possible gestalt processing alterations in autism. Aside from the comparison of gestalt processing, we also aimed to determine group differences on tasks indicative of local-global processing as well as their intercorrelation within the groups and their relationship to gestalt mechanisms. Hence, data on a series of visual tasks indicative of different aspects and levels of local-global processing (hierarchical letters, visual illusions, BD, EFT) were also collected.

We hypothesized decreased gestalt and global processing in HFA, SCH, and DEP compared to the normative control groups and even less gestalt and global processing in autism compared to the clinical control groups. No group differences were expected for the overlapping figures control task. In terms of construct validity, we expected gestalt measures to positively correlate with each other. Furthermore, positive correlations between gestalt perception and global processing and decreased gestalt perception and local processing, respectively, were predicted.

Method

Participants

Fifteen adult participants with idiopathic HFA, 15 with SCH, 15 with DEP and 15 typically developed control participants were recruited for this study. All participants were male and largely parallel with regard to nonverbal ($F(3,60) = .85$, $P = .48$) and verbal IQ ($F(3,60) = .50$, $P = .69$) as assessed by the Raven matrices and the Multiple-Choice-Vocabulary-Test (Lehrl, 1991), respectively. The samples differed concerning chronological age ($F(3,60) = 10.7$, $P < .001$); participants with DEP were significantly older than those with HFA ($P < .001$) and the normative group ($P < .001$). Demographic sample data are summarized in Table 1.

Individuals with HFA fulfilled the ICD–10 research criteria for the disorder (F84.0) as well as the autism algorithm cut-offs in German versions of the Autism Diagnostic Interview-Revised (Bölte, Rühl, Schmötzer, & Poustka, 2006) and the Autism Diagnostic Observation Schedule (Rühl, Bölte, Feineis-Matthews, & Poustka, 2004). Participants in the SCH sample had received a diagnosis of paranoid schizophrenia (ICD-10, F20.0), which was corroborated by using data from the Positive and Negative Syndrome Scale (Kay, Fiszbein, & Opler, 1987). Participants with SCH were inpatients with a reduced positive symptomatology that allowed psychological testing. All received atypical neuroleptic and partly additional low dose antidepressive or anxiolytic medication at the time of the study. Participants in the DEP sample fulfilled ICD-10 criteria for major depression (F32) and the cut-offs for moderate to severe depression on the Hamilton Depression Scale (Hamilton, 1986). Members of the normative sample were non-clinical, non-academic staff of the authors' departments and first semester students of psychology. None of them was currently under any form of mental treatment and described themselves as not suffering from any significant psychopathological symptoms according to Achenbach's Young Adult Self Report (Arbeitsgruppe Deutsche Child Behavior Checklist, 1998).

Measures

Gestalt Principles

Gestalt psychology is based on the observation that humans often experience things that are not a part of simple sensations. According to this framework there is a strong automatic tendency to perceive stimuli as meaningful wholes ("Gestalten") rather than as single perceptual elements (Wertheimer, 1922, 1923). The

Table 1 Sample characteristics

N	Autism (A) 15	Schizophrenia (S) 15	Depression (D) 15	Normative (N) 15	
Age (*m*, SD)	25.8 (7.7)	34.9 (10.5)	43.4 (12.4)	27.0 (6.7)	D > A,N,S**
NV IQ (*m*, SD)	100.1 (12.4)	97.4 (19.5)	100.1 (17.3)	105.9 (7.8)	*n.s.*
V IQ (*m*, SD)	108.1 (13.7)	106.9 (10.8)	112.5 (16.6)	110.1 (11.5)	*n.s.*

Note: ** = $P < .01$; n.s. = not significant; NV = nonverbal; V = verbal

perception of gestalt is based on a multitude of principles or laws of organization, all contributing to a percept characterized by a maximum of ''good'' (~regular, orderly, simple, symmetric) gestalt. Three of the most fundamental gestalt laws are: closure, proximity and similarity. The law of closure says that, if something is missing in an otherwise complete figure, we will tend to add it. The law of proximity states that objects that are close together are seen as belonging together. The law of similarity says that we will tend to group similar items together, to see them as forming a gestalt, within a larger form. Comparable to Brosnan et al. (2004), we generated tasks to assess these three laws of gestalt organization (Fig. 1). Each law was operationalized by eight visual tasks: two visual gestalt stimuli in four different graduations. For instance, the principle of closure was tested by showing a line in four different degrees of incompleteness (Fig. 2). This was done to reach stimuli with quantitatively varying gestalt loading. The size of all stimuli was 14.8 cm × 21 cm (A5). Stimuli were presented one at a time in random order with the participants sitting at a table. The participants were first instructed that they would be shown a series of figures. Their task would be to decide how objects were arranged on the images and to answer specific questions within 10 s. Subsequently, participants were asked to explain what they were seeing on the pictures. The questions were: ''What's shown here, one line or several lines?'' and ''Do you see a triangle?'' (closure), ''Which lines/stars belong together?'' (proximity) and ''Which lines of dots/pentagons belong together?'' (similarity). In addition, participants were requested to show what they meant by pointing at the respective objects with their index finger. As it is known that individuals with autism tend to interpret verbal expression literally, the appropriateness of these questions to obtain valid answers in terms of gestalt perception in participants with autism had been examined a priori in an independent autism sample. It revealed that a minority of participants with autism needed to enquire to understand the formulation, but spontaneous perception of the stimuli and response behavior was obviously not biased. In addition, these situations rarely also emerged in the all other samples. Answers indicating perception according to gestalt principles were scored with a '1' and non-gestalt responses scored with a '0'. Thus, the total score for judging the gestalt laws was 8 for each principle. In addition, an overall index of gestalt perception was computed incorporating all tasks with a maximum score of 24.

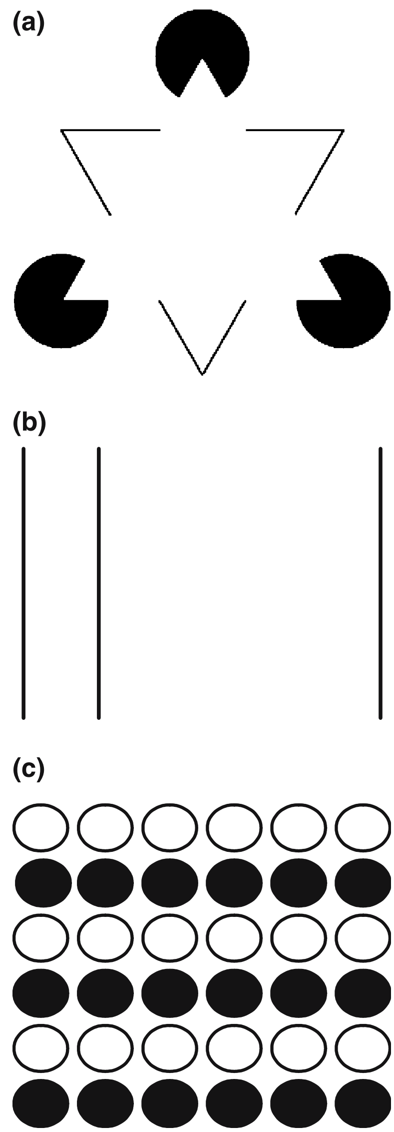

Fig. 1 Gestalt stimuli examples: (**a**) closure, (**b**) proximity, (**c**) similarity

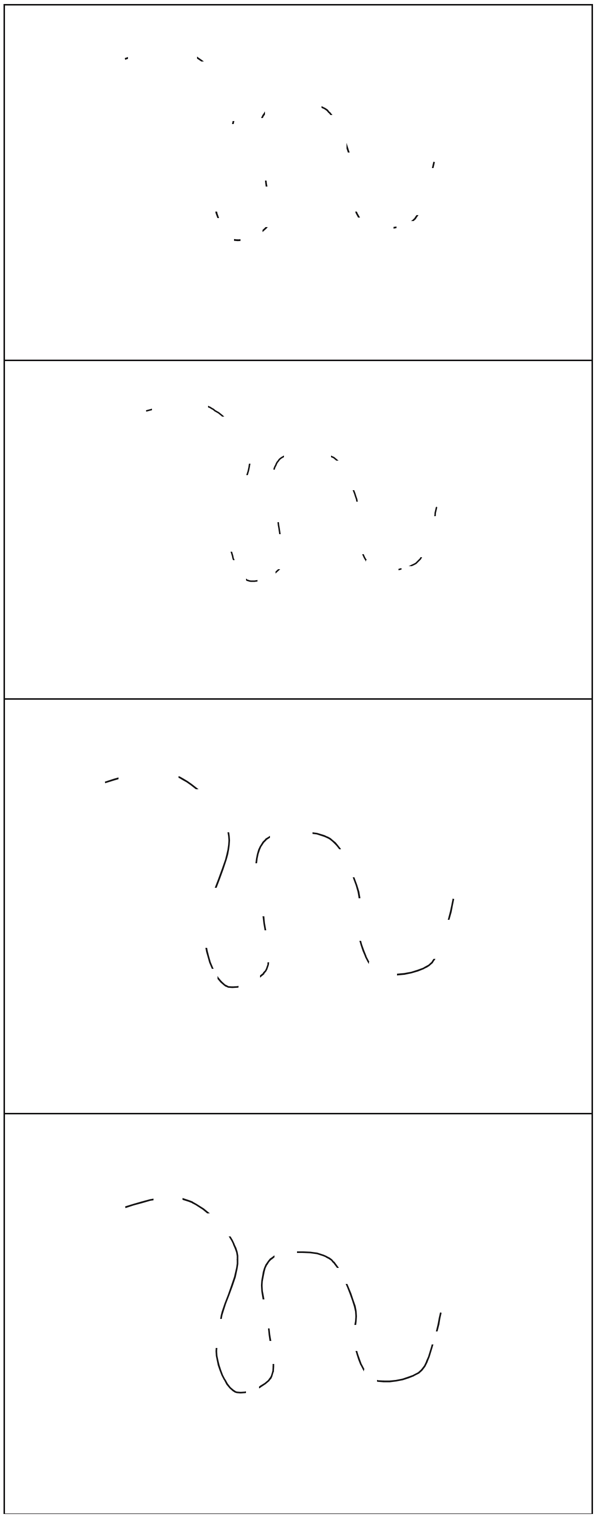

Fig. 2 Graduations of closure

It is worth mentioning that we used a stimuli for the assessment of closure (Kanisza triangle) that previously has been applied by Happé (1996) as a measure of visual illusion susceptibility. Nevertheless, this is not necessarily contradictory. As mentioned before, gestalt perception and global processing may not mean exclusively different things. Both share that something is experienced that is not necessarily a mandatory part of the sensation and therefore fits the definition of an illusion. We believe the Kanisza triangle is a good example of closure, because it induces perception of visual contours to generate closed shapes, unlike most other visual illusions that have been used in autism research, which generate an illusion of size, misalignment or bend. In fact, Happé's (1996) findings suggest that the processing of the Kanisza triangle does not follow the pattern of other illusions.

Overlapping Figures

To separate altered gestalt processing from potential symptoms of general failure to perceive objects in terms of visual agnosia, an object identification task was constructed. Five stimuli showing overlapping outlines of objects according to Poppelreuter (1917/1990) were presented. One stimuli showed five overlapping identical stars, while the other figures consisted of different overlapping outlines of objects (Fig. 3). Participants were asked to name the number and type of the objects displayed on each stimuli. Such tasks are particularly difficult to pass for individuals with severely impaired functions of the ventral visual stream, such as agnosia. A score of '1' was given for identifying the correct number of stars in the stimuli showing identical figures and if all objects in the stimuli showing different figures were correctly identified, respectively. Thus there was a maximum score of 5 for this task, with high values indicating good object recognition.

Local-Global Tasks

Four local-global measures were collected: a hierarchical letter task, visual illusions, BD and the EFT.

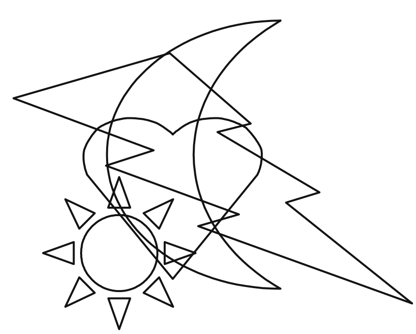

Fig. 3 Example of an overlapping figure

Although, they all have been claimed to be sensitive to local-global processing in autism, they differ regarding the required cognitive demand. The hierarchical letter task was used in this study to test the participant's spontaneous attention to either the single elements (local letters) or the composition of the elements (global letter). The visual illusions were included to test local-global processing in terms of feature integration on an early perceptual level. Local strategies based on sensation should lead to correct performance, whereas (global) strategies based on context should lead to illusion. Both BD and the EFT are visuo-spatial tasks, with the BD being based on three-dimensional visual construction and the EFT being based on two-dimensional visual search. Global processing of the BD and the EFT is assumed to be a disadvantage for fast and correct performance on these tests. On the contrary local processing should help to reproduce unsegmented block designs and to spot embedded figures.

Hierarchical Letter Stimuli

Five visual stimuli consistent with the concept by Navon (1977) were generated. A large L made up of 17 small Ss (Fig. 4), a F of 26 Es, a S of 31 Fs, an E of 37 Ps and a P of 33 Ls. The stimuli were formally presented in the same way as the gestalt stimuli (instruction, random order, A5 size, sitting at table). For each stimulus participants were asked which letter they were seeing (had seen) at first. A score of '1' was assigned, if the participants had seen the small letter (local processing) first and '0' if the large letter (global processing) was detected spontaneously. Hence, there was a total score of 5 on this set of tasks, with higher values indicating increasing local processing style.

Visual Illusions

The susceptibility to five visual illusions was tested: Titchener, Ponzo, Müller-Lyer, Poggendorff, and Hering. To reach a better differentiation between the groups, each illusion was shown once in its original form as well as four times in distracting gradual variants of it. For example, the Titchener's circles were presented in the regular form (two identical circles surrounded by either considerably bigger or smaller reference circles) as well as in four other versions, where the inner circle surrounded by smaller circles was indeed smaller than the other inner circle to a varying extent (Fig. 5). Participants were instructed that they were going to be presented pictures that could either exhibit visual illusions or not. Stimuli were shown one at a time, in random order on A5 sheets. In the following they were shown the visual illusions and asked whether the inner circles were identical in size or not (Titchener), the upper and lower line were equally long or not (Ponzo, Müller-Lyer), which of the left lines was continued on the right (Poggendorf), the vertical lines were straight or bend (Hering). Each correct answer was scored a '1', while a '0' was scored when individuals were succumbing to the illusions.

S
S
S
S
S
S
S
S
S
S
SSSSSSS

Fig. 4 Example for a hierarchical letter stimulus

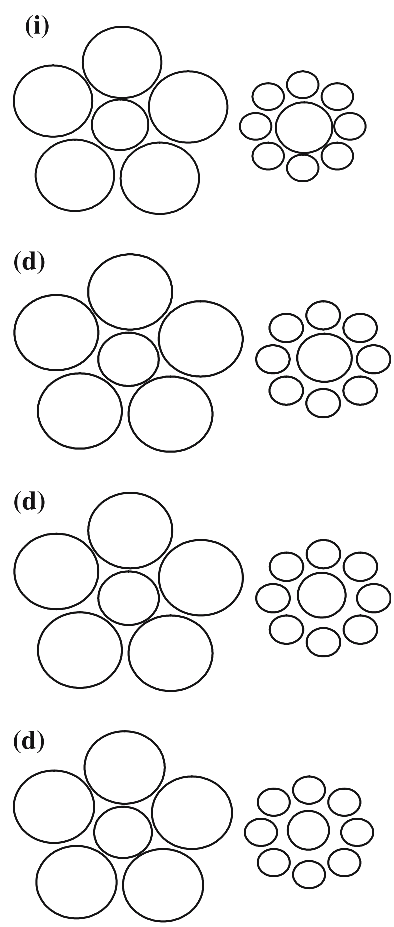

Fig. 5 Variations of the Titchener circles (i = illusion; d = distractors)

Thus, a total score of 25 could be reached on this scale, with higher scores indicating increasing local processing.

Embedded Figures Test

The EFT (Witkin, Oltman, Raskin, & Karp, 1971) is a scale to test a person's ability to detect a hidden simple shape within a complex figure. The test consists of two parallel forms (A and B) each comprising 12 items. In this study, we used the form A and the standard administration procedure. The average time to correctly complete one item in sec. (maximum 180) was used as dependent variable, with short response times indicating local processing.

Block Design

The BD test is a subscale of the Wechsler Intelligence Scales (Tewes, 1991) aiming to assess visual-spatial and visual-constructive abilities. The testee is presented with four or nine red and white blocks, depending on the item, and is asked to construct replicas of increasingly complex stimuli. The standard administration procedure was applied and scaled scores (maximum = 19) were used as dependent variables for subject's BD, with high values indicating local processing .

Design and Procedure

The study was approved by the local ethics committees of the participating departments and informed consent was gained prior to all assessments. Testing was carried out by four different investigators being either blind to the experimental hypotheses or the diagnosis of the participants at two clinical sites as well as at the participants' homes. Data was normally collected in one session with tests administered in random order. At one site, interrater reliability between two raters was determined for coding the nonstandardized tasks for gestalt processing, visual illusions, the hierarchical letter task and overlapping figures in the HFA sample. Here, the overall agreement reached 94% (kappa = .79). The study is an ex post facto, case-control group design, with one experimental group (HFA) and three control groups (SCH, DEP, normative). Four (3 + 1) dependent gestalt variables (closure, proximity, similarity, and summarizing gestalt index), an overlapping figures control task and four measures indicative of local-global processing (hierarchical letter stimuli, visual illusions, EFT, BD) were obtained. Except for a moderate correlation between closure and nonverbal IQ ($r = .36$), there were no significant associations between the gestalt measures, IQ and age. Nevertheless, there were some considerable correlations between nonverbal IQ and the EFT ($r = -.63$, $P < .01$) and nonverbal IQ and the overlapping figures task ($r = .66$, $P < .01$). Also age correlated with these two tasks ($r = .32$ and $r = .40$, $P < .05$) (Table 2). Because samples were not precisely matched for measures of IQ and partly differed with regard to age, these parameters were inserted as covariates and their confounding influence adjusted for in simultaneous analyses of covariance (*ANOVA*s), which were computed for each measure. The effect of the factor group was observed applying a one-tailed alpha level of .05. If *ANCOVA*s revealed significant group differences for a certain measure, additional post-hoc single group contrasts were calculated for these using conservative Scheffé-tests. Eta^2 (η^2) is provided for *ANCOVA* results to indicate the size of the group effect in terms of explained variance. Given the N of this study and alpha, the test-power (1-*beta*) for detecting significant group mean differences between the samples using an *ANOVA* was .09 for a small, .32 for a medium and .71 for a large effect. To determine the strengths and direction of relations between the measures Pearson correlations between the gestalt and other measures were computed for each participant groups separately, partialling out effects of performance IQ.

Results

Group Differences

Gestalt Tasks and Overlapping Figures

The group's performances on the gestalt tasks and other measures are shown in Table 3. There were no group differences on the overlapping figures control task ($F(6,60) = 0.4$, $P = .35$). On the other hand, participants with HFA used the gestalt principle of similarity significantly less ($F(6,60) = 33.3$, $P < .0001$) than the normative group ($P < .001$), the SCH sample ($P < .001$) and the DEP sample ($P < .001$). In addition, individuals with HFA used significantly less proximity ($F(6,60) = 2.3$, $P = .04$), than the normative and DEP sample ($P < .03$) and less closure ($F(6,60) = 2.5$, $P = .04$), than the normative sample ($P = .02$). Overall, using the summarized index of gestalt perception, the HFA sample judged the gestalt tasks significantly less ($F(6,60) = 4.9$, $P = .002$) in accord to gestalt laws than the normative sample ($P = .002$) as well as the DEP group ($P = .04$) and the SCH group ($P = .04$). The DEP and SCH group did

Table 2 Correlations between measures, nonverbal and verbal IQ and age in the complete sample ($N = 60$)

	Nonverbal IQ	Verbal IQ	Age
Gestalt tasks			
Similarity	.22	.15	.17
Closure	.36	.02	–.19
Proximity	.21	.16	.12
Other tasks			
Embedded Figures	–.63**	–.03	.32*
Block Design	.45**	.10	–.05
Visual illusions	.17	–.01	.02
Hierarchical letters	–.18	.05	.06
Overlapping Figures	.66**	.23	–.40**

Note: * $P < .05$, ** $P < .01$

not differ from the normative group on any gestalt measure. An individual analysis showed that 8 of the 10 lowest scoring participants on the gestalt index were members of the HFA group (1 DEP, 1 SCH). The participant with the lowest score on the gestalt index had HFA and a value of 13 (out of 24) on this measure. His nonverbal (96) and verbal abilities (106) were quite average for HFA group and he performed extraordinary on BD (16). In the ADI-R and ADOS he was scored well above the autism cut-off for all domains.

Local-Global Tasks

On the EFT, the HFA sample performed superior (F(6,60) = 2.7, $P = .03$) compared with the group of participants with SCH ($P = .04$) and DEP ($P = .03$), but not compared with the normative sample ($P = .50$). On the visual illusions tasks, the HFA, the SCH, and DEP group performed comparable ($P > .99$) and succumbed less to the stimuli than did the normative sample ($P < .02$)(F(6,60) = 5.7, $P = .001$). Although the HFA sample descriptively showed better performance on BD, these differences did not reach statistical significance (F(6,60) = 0.6, $P = .31$). Moreover, the groups did not differ on the hierarchical letter stimuli task (F(6,60) = 1.1, $P = .17$).

Intercorrelations of Measures

Correlations between the gestalt tasks and other tasks within each group are shown in Tables 4–7. The gestalt measures intercorrelated positively in all samples and moderate to high ($r = .31$ to .68; $P < .10$) in the HFA, DEP, and SCH group. As all members of the normative and the DEP group scored full on similarity, correlations with other measures could not be computed here. In the HFA group, similarity, closure and proximity correlated negatively and moderate to high with the hierarchical letters task ($r = –.41$ to –.61; $P < .05$). A negative association ($r = –.64$; $P = .005$) between the hierarchical letters task and gestalt measure of similarity also yielded in the SCH group. Within the DEP sample closure and the EFT showed a negative correlation ($r = .46$, $P = .04$). Regarding the local-global tasks, in the HFA group there were significant correlations between the EFT and BD and the visual illusions measures ($r = –.51$ and .61; $P < .03$). In addition, the EFT correlated negative with the hierarchical letters task ($r = –.41$, $P = .048$). In the normative sample, the EFT correlated negative with the visual illusions measures ($r = –.43$; $P = .04$). In the SCH group a considerable association between the hierarchical letters task and BD was identified ($r = –.49$; $P = .004$). All other correlations were neither strong nor significant.

Discussion

The objective of this study was to examine whether gestalt perception is altered in HFA and how gestalt perception is related to performance on presumed measures of local-global processing in HFA. In addition, we

Table 3 Groups' results (*means* and *SD*) on the gestalt, local-global measures and the overlapping figures task

	HF Autism (A)	Schizophrenia (S)	Depression (D)	Normative (N)	F (P)	η^2	post-hoc
Gestalt tasks (*max.*)							
Similarity (8)	7.1 (0.4)	7.8 (0.4)	8.0 (0.0)	8.0 (0.0)	33.3 (< .0001)	.66	S,D,N > A
Closure (8)	5.8 (1.4)	6.4 (1.5)	5.9 (1.4)	7.1 (1.2)	2.5 (.04)	.12	N > A
Proximity (8)	7.1 (1.4)	7.5 (0.9)	7.8 (0.4)	7.9 (0.4)	2.3 (.04)	.11	D,N > A
[Gestalt Index (24)	20.0 (2.6)	21.7 (2.1)	21.7 (1.4)	23.0 (1.2)	4.9 (.002)	.23	S,D,N > A]
Other tasks (*max.*)							
Embedded Figures (180)	45.8 (17.6)	75.9 (54.1)	79.2 (50.8)	51.5 (12.6)	2.6 (.03)	.13	S,D > A
Block Design (19)	10.9 (2.9)	10.0 (1.5)	10.1 (1.6)	10.3 (1.8)	.06 (.31)	.03	
Visual illusions (25)	11.7 (2.9)	11.7 (2.8)	11.9 (4.0)	8.4 (2.2)	5.7 (.001)	.25	A,S,D > N
Hierarchical letters (5)	1.5 (1.7)	1.7 (2.1)	1.8 (1.9)	0.8 (0.8)	1.1 (.17)	.06	
Overlapping Figures (5)	4.4 (0.7)	4.0 (1.5)	4.1 (0.8)	4.7 (0.5)	0.4 (.38)	.02	

Table 4 Partial correlations (controlling for nonverbal IQ) of gestalt, local-global measures and the overlapping figures task in the high-functioning autism sample ($N = 15$)

	Closure	Proximity	Embedded Figures	Block Design	Hierarchical letters	Visual illusions	Overlapping figures
Similarity	.45*	.31	–.25	.21	–.41*	–.10	.28
Closure		.68**	–.21	.25	–.53*	.19	.27
Proximity			–.22	.28	–.61*	.05	.19
Embedded Figures				–.49*	–.41*	–.51*	–.01
Block Design					–.15	.61**	.25
Hierarchical letters						–.11	–.10
Visual illusions							.17

Note: * $P < .05$, ** $P < .01$

Table 5 Partial correlations (controlling for nonverbal IQ) of gestalt, local-global measures and the overlapping figures task in the normative sample ($N = 15$)[a]

	Proximity	Embedded Figures	Block Design	Hierarchical letters	Visual illusions	Overlapping figures
Closure	.21	–.23	–.13	–.01	.19	.15
Proximity		.14	.15	.29	–.10	.19
Embedded Figures			.33	.12	–.43*	.24
Block Design				–.20	.08	.23
Hierarchical letters					–.13	–.18
Visual illusions						.12

Note: [a] Correlations for similarity could not be computed (no criterion variance); * $P < .05$

Table 6 Partial correlations (controlling for nonverbal IQ) of gestalt, local-global measures and the overlapping figures task in the depression sample ($N = 15$)[a]

	Proximity	Embedded Figures	Block Design	Hierarchical letters	Visual illusions	Overlapping figures
Closure	.46*	–.43*	.13	.01	.24	–.08
Proximity		.12	.21	.13	.19	.17
Embedded Figures			–.18	.11	–.08	.14
Block Design				–.15	.09	.04
Hierarchical letters					.10	–.18
Visual illusions						.09

Note: [a] Correlations for similarity could not be computed (no criterion variance); * $P < .05$, ** $P < .01$

Table 7 Partial correlations (controlling for nonverbal IQ) of gestalt, local-global measures and the overlapping figures task in the schizophrenia sample ($N = 15$)

	Closure	Proximity	Embedded Figures	Block Design	Hierarchical letters	Visual illusions	Overlapping figures
Similarity	.43*	.47*	–.11	.26	–.64**	.19	.26
Closure		.47*	.13	.10	–.10	.18	.29
Proximity			–.27	.09	–.23	.03	–.07
Embedded Figures				–.01	–.08	–.02	.16
Block Design					–.49*	.16	.37
Hierarchical letters						.13	.27
Visual illusions							.27

Note: * $P < .05$, ** $P < .01$

sought to find out how different measures indicative of local-global processing are related to each other. Participants with HFA showed significantly less usage of the gestalt principle of similarity compared with all control samples, less proximity usage than the normative and the DEP group and less closure than the normative group. Overall, applying a gestalt summary score, the group of individuals with HFA perceived the gestalt stimuli less in accord with the corresponding gestalt laws than all the other samples. The present study is in line with previous findings by Brosnan et al. (2004), who identified altered gestalt perception in low-functioning autism.

Particularly, our findings indicate that gestalt perception might be untypical regarding the law of similarity. Here, differences were not only found in contrast to normality, but also compared with participants with SCH and DEP, who also have been demonstrated to exhibit untypical or impaired gestalt perception (Coello et al. 1990; Uhlhaas & Silverstein, 2003), although the latter was not decisively supported by our findings. As participants with autism did not differ from the other groups on the overlapping figures task, it is unlikely that the current findings are confounded by more general neuropsychological deficits in percept synthesis (e.g. visual agnosia).

Regarding the tasks indicative of local-global processing, there were only two measures that differentiated some of the groups. Firstly, on the EFT, participants with HFA performed superior compared with both the SCH and DEP group and on the visual illusions task all three clinical groups showed less susceptibility to visual illusions than the normative group. Hence, and consistent with a multitude of previous studies (e.g. Mottron et al., 2003; Ropar & Mitchell, 2001; Shah & Frith, 1993), our findings suggest that the EFT assesses visuo-spatial abilities indicative of local-global processing that reliably differ between autism and other samples, although descriptive differences to the normative group did not reach significance in this study. Secondly, and consistent with the hypothesis forwarded by Happé (1996), our findings showed that participants with autism succumbed less to visual illusions than normative control participants. As the processing of visual illusions and gestalt perception are considered early preattentional functions (Duncan & Humphreys, 1989; Happé, 1996), the current findings may corroborate the notion that abnormalities in the perceptual architecture can already appear at low levels. This possibility is also suggested by recent neuroimaging findings (Bölte, Hubl, Dierks, & Poustka, 2006 (Submitted for publication)). Nevertheless, we also identified increased visual illusion susceptibility in SCH and DEP. Hence, some fundamental alterations in early perception might not be a phenomenon specific to autism, but shared with other mental disorders, which have demonstrated overlaps regarding cognitive malfunction with autism in other areas (e.g. executive function). In addition, our results are generally not in accord with Ropar and Mitchell (1999) who found no relative immunity to visual illusions in autism. It is therefore also possible that the detection of reduced illusion susceptibility may strongly depend on the chosen procedure (type of illusions; verbal/manual response, instruction) and selected participants.

The single measures of gestalt perception correlated consistently with one another. Thus, it can be concluded that the gestalt tasks probably were successful operationalizations of the construct of gestalt perception, although there were ceiling effects among the measures in some of the groups, especially for similarity in the normative and DEP samples. So overall clearer group differences and patterns of correlations between measures can have been suppressed due to relatively low variances. However, such effects might be hard to prevent, if very fundamental perceptual functions are tested, which are normally intact. There were several intercorrelations between similarity, closure, and proximity and the local-global measures among the HFA and the other clinical groups, all of them supporting the assumption of positive association between gestalt and global processing. In the HFA group, the gestalt measures correlated consistently negative with the hierarchical letters task, indicating that gestalt perception and spontaneous local attention are inversely related. The same was true for the SCH group, although only for the principle of similarity. In the DEP sample, closure showed a negative association with the EFT, suggesting that the automatic tendency in gestalt processing to visually add missing details to reach meaningful whole is diametrical to visual disembedding. A comparable pattern of correlation also emerged in HFA, but not strong enough to be statistically meaningful in this relatively small sample.

Interestingly, with regard to the intercorrelations between the local-global tasks, the highest associations revealed in the HFA sample for reduced susceptibility to visual illusions and good performance on the EFT and BD, respectively. This result is well in line with Happé's (1996) hypothesis that local processing could be accompanied by less susceptibility to visual illusions and contradicts the finding by Ropar and Mitchell (2001), who did not find any significant correlations between visuo-spatial performance on the BD and EFT and visual illusion susceptibility in their autism sample. Aside from this result, in the HFA sample performance on the EFT and BD correlated reliably with each other, but lower than reported by Ropar and Mitchell (2001). Therefore, both of these visuo-spatial tests perhaps tap partly comparable local-global functions in autism.

Besides the ceiling effects mentioned earlier, this study has several other limitations that perhaps compromise the generalizeability of our results. Most importantly, we almost exclusively examined male adult individuals, while previous studies on gestalt processing and susceptibility to visual illusions only included children or adolescents with autism or Asperger's syndrome. It might well be that developmental changes in terms of experience and maturation cause differences only for certain age ranges and results might also differ in female samples. Moreover, although comparable to previous studies, our sample size is not very large. Thus, we might have missed small and perhaps medium effects due to lack of power or sample selection effects. Regarding the latter, it is worth mentioning, for instance, that Jolliffe and Baron-Cohen (1997), who, alike our study, examined adults with HFA and Asperger syndrome found their groups to significantly outperform a normative control sample on the EFT. By contrast, even though the normative control samples in our and the Jolliffe and Baron-Cohen study had almost identical performance times on the EFT, our HFA sample showed considerably slower EFT-performance (about 15 sec./item) than the autism and Asperger syndrome sample recruited by these authors. Finally, compared to the administration of standardized tests such as the EFT or the BD, there is apparently the possibility of a variation in findings due to the procedure chosen for assessing gestalt perception and visual illusion susceptibility.

Future studies should collect larger samples of individuals affected by an autism spectrum disorder at different age ranges applying a comprehensive battery of standardized and experimental tasks of gestalt and local-global processing. Those should be related to neurobiological measures, as the physiological basis for of gestalt perception and local-global processing is largely unknown in autism, although there is some vague consensus that it could be a behavioural expression of disconnectivity between crucial brain regions (Wickelgren, 2005). Recent studies on gestalt processing in schizophrenia showed that alterations in visual gestalt processing (Uhlhaas, Silverstein, & Philips, 2005) were related to reduced gamma-band phase synchrony and reduced spectral power in the gamma- and beta-band, suggesting a functional role of synchronous oscillatory activity in gestalt cognition.

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