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Is Superior Local Processing in the Visuospatial Domain a Function of Drawing Talent Rather Than Autism Spectrum Disorder?

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This study challenges the prevailing assumption that superior local processing is specific to autism spectrum diagnosis and suggests instead that such processing skill is a function of realistic drawing talent. Fifteen children with autism spectrum disorder (ASD) and 15 without ASD made an observational drawing scored for level of drawing realism and completed 2 tasks that allowed for the assessment of a local processing bias: the Block Design Task in unsegmented and segmented form at three levels of perceptual cohesiveness (minimal, intermediate, and maximal), and the Group Embedded Figures Test. Drawing realism score, not ASD diagnosis, predicted performance on the unsegmented version of the Block Design Task and on the most difficult items—the unsegmented maximally cohesive items. Accuracy on the Group Embedded Figures Test was also more strongly associated with level of drawing realism than ASD diagnosis. Thus, the superior local processing seen in ASD may be due to the drawing talent so often present in those with ASD.

Keywords: autism, local processing, giftedness, drawing

Individuals with autism spectrum disorder (ASD) show a local processing bias—a tendency to focus on the details rather than the overall shapes of objects. Although the local processing bias has been demonstrated in several domains (auditory, perceptual, verbal, and visuospatial), a large body of research has focused on the local processing bias in the visuospatial domain.

Evidence for superior visuospatial local processing in individuals with ASD comes from their reported performance on a variety of tasks requiring finding parts within wholes. Embedded figures that have been camouflaged in a complex scene are more rapidly detected by individuals with ASD (Edgin & Pennington, 2005; Jolliffe & Baron Cohen, 1997; Mottron, Burack, Iarocci, Belleville, & Enns, 2003; Shah & Frith, 1983). Globally impossible figures are copied more quickly: Individuals with ASD focus on the individual local parts of the figure and do not use their global schema of the figure when copying (Mottron, Belleville, & Ménard, 1999).

Among the visuospatial superiorities in individuals with ASD, the most replicated is related to performance on the Block Design Task. ASD individuals with normal intelligence excel on the Block Design subtest of the Wechsler Intelligence Scale for Children (3rd ed.; WISC–III; Caron, Mottron, Berthiaume, & Dawson, 2006; Pellicano, Maybery, Durkin, & Maley, 2006; Siegel, Minshew, & Goldstein, 1996), a task that requires reconstruction of a two-dimensional red-and-white geometric design by constructing the design out of three-dimensional blocks. The unsegmented version of this task requires segmenting the parts of the design mentally in order to match each part to a block. It is on this version that ASD participants excel. The segmented version of this task separates each part of the design spatially so that no mental segmentation is required. On this version, non-ASD individuals perform as well as those with ASD (Shah & Frith, 1993), although a ceiling effect may be implicated (Plaisted, 2001). The fact that ASD participants are superior on the unsegmented version shows that individuals with ASD have a superior ability to segment mentally the parts of the block design—an instance of superior local processing.

Caron et al. (2006) studied individuals with ASD whose IQ scores peaked on the Block Design Task and compared them with individuals with ASD without a Block Design peak. They also included two groups of non-ASD individuals, ones with and without a Block Design peak. The participants were given a modified Block Design Task in which items varied in perceptual cohesiveness—minimal, intermediate, and maximal. The minimally cohesive items are easily solvable because the edges that separate contiguous blocks co-occur with a color change from red to white or vice versa, making it easy to see each block as a unit. Participants can thus match each square to a block. They do not need to analyze a whole into its parts, as the parts clearly emerge from the figure to be reproduced. The maximally cohesive items are the most difficult because the edges that separate contiguous blocks never co-occur with a color change, making it difficult to see the contribution of each block as a unit. Maximally cohesive items require mental segmentation of the design into its components (the blocks), overriding the color boundary cues. On the intermediate items, only about half of the edges between contiguous blocks are the same color. The more cohesive the items, the more mental segmentation required.

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On the unsegmented version, ASD participants (with and without a Block Design peak) took less time when copying the highly cohesive designs than did non-ASD participants (with and without a Block Design peak). This superior ASD performance was eliminated on the segmented version, which allowed everyone to use a local strategy, further evidence that the local processing bias is specific to ASD.

However, not all individuals with ASD show a local processing bias. In a sample of over 100 high- and low-functioning ASD children, Charman et al. (2011) found no evidence of a Block Design peak. The researchers also found no evidence of a peak in a subset of high-functioning children with ASD (IQ $>$70). Other researchers have found that individuals with ASD performed less accurately than a matched group of typically developing children on the Block Design Task and Embedded Figures Test (although the difference in performance was not statistically significant; Kaland, Mortensen, & Silk, 2007). Still other researchers have found no differences in construction time on the Block Design Task between individuals with ASD and a matched control group (de Jonge, Kemner, Naber, & Van Engeland, 2009). They were also no differences between the two groups on the unsegmented and segmented versions of the tasks. However, the ASD group made fewer errors on the Block Design Task than did the group without ASD.

Researchers have also failed to find superior local processing on tasks that require finding parts within wholes. Chen, Lemonnier, Lazartigues, and Planche (2008) found no difference in performance between an autistic and nonautistic group on the Children's Embedded Figures Test (see also Kaland et al., 2007). And Hoy, Hatton, and Hare (2004) found no difference in performance between an autistic and nonautistic group on a visual illusions task. The failure to find superior local processing suggests that the local processing bias may not be found in all individuals with ASD and may therefore be due to some factor other than ASD diagnosis.

Further, there is evidence that a local processing bias is not exclusive to individuals with ASD (Pring, Hermelin, & Heavey, 1995). Two autistic groups (drawing "savants" and those without drawing talent) and two nonautistic groups (gifted child artists and those without drawing talent) were given two tasks requiring mental segmentation. Participants completed a jigsaw puzzle (in which parts had to be arranged to form a whole) as well as the Block Design Task. On both tasks, the art talented groups (with and without autism) performed better than the nontalented groups (with and without autism), suggesting that the kind of local processing skill that this task requires may not be associated with ASD diagnosis but rather with drawing talent. It seems reasonable to conclude that local processing is required for realistic drawing as well as for successful completion of the Block Design items: Both kinds of activities require mentally segmenting an image into its parts.

With a non-ASD population, it has been demonstrated that realistic drawing talent predicts children's mental segmentation abilities on the Block Design Task (Drake, Redash, Coleman, Haimson, & Winner, 2010), again suggesting that a local processing strategy is seen in typically developing children talented in realistic drawing. Children completed an observational drawing that was scored for level of drawing realism as well as a version of the modified Block Design Task from Caron et al. (2006) and the Group Embedded Figures Test (Witkin, Oltman, Raskin, & Karp, 1971). Level of drawing realism predicted performance on both tasks, and this effect occurred independently of verbal IQ, age, and years of art lessons.

The goal of the current study was to examine two predictors of superior local processing—level of drawing realism and ASD diagnosis. This study included children with and without an ASD diagnosis, with both groups showing a high degree of variability in level of realistic drawing talent. Children completed an observational drawing task along with Caron et al.'s (2006) modified Block Design Task, in which items are presented in both unsegmented and segmented form at three levels of perceptual cohesiveness, and the Group Embedded Figures Test. In both tasks, children must visually analyze an image. In the Block Design Task, children must mentally segment an image into its parts, whereas in the Embedded Figure Test, children must focus on the details and avoid the overall design of the image. In the drawing task, children must avoid their overall schema of the object and focus on the local components to capture the detail of the object in their drawing.

The following three hypotheses were tested:

Hypothesis 1: Greater accuracy on the unsegmented version of the Block Design Task should be associated with level of drawing realism rather than ASD diagnosis.

Hypothesis 2: Greater accuracy on the unsegmented maximally cohesive items should be associated with level of drawing realism rather than ASD diagnosis.

Hypothesis 3: Greater accuracy on the Group Embedded Figures Test should be associated with level of drawing realism rather than ASD diagnosis.

Method

Participants

Two groups participated in the study: those with and without an ASD diagnosis. Eighteen ASD children between the ages of 5 and 13 years were recruited through the Interactive Autism Network (IAN) Research Database at the Kennedy Krueger Institute and John Hopkins Medicine, sponsored by the Autism Speaks Foundation. All of the ASD children were high functioning and had previously been diagnosed with ADS based on the *Diagnostic and Statistical manual of Mental Disorders* (4th ed., text. rev.; *DSM–IV–TR*; American Psychiatric Association, 2000). We did not restrict the ASD population to any particular subgroup due to the lack of agreement among researchers and clinicians in subgroup diagnosis (Daniels et al., 2011). Only those ASD children with a verbal IQ of at least 85 and who were not diagnosed with attention-deficit hyperactivity disorder ($n = 15$) were included in the final analyses. Each of the 15 ASD children was matched to a control child on the basis of age, gender, and verbal and nonverbal IQ. Control children were recruited through after-school art studios in the greater Boston area and a local children's museum. As shown in Table 1, across groups, there were 24 boys and 6 girls, ranging in age from 5.1 to 13.2 years ($M_{age} = 9.0$ years, $SD_{age} = 1.10$). This wide age range was necessary, given the difficulty of recruiting individuals with ASD, and is consistent with previous research with ASD populations (Shah & Frith, 1983, 1993).

Table 1
Descriptive Characteristics by Group

	ASD		Non-ASD			
	M	*SD*	*M*	*SD*	$F(1, 28)$	*p* value
Age	9;1	2;1	8;10	1;9	.181	.674
SES (out of 6)	4.3	1.1	4.5	0.69	.341	.564
Verbal IQ	102.7	13.0	105.1	9.8	.584	.584
Nonverbal IQ	100.7	12.5	107.7	14.0	.160	.160
Years of art lessons	0.33	0.89	0.57	0.86	.525	.475
Drawing score (out of 1.0)	0.31	0.33	0.47	0.29	1.759	.196

Note. ASD = autism spectrum disorder; SES = socioeconomic status.

Materials and Procedure

Children were seen individually by one experimenter at the child's after-school art program, home, or in our laboratory for about 90 min, with breaks provided as needed. Parents provided informed consent for the study and children ages 7 and older provided assent. Tasks were administered in the following order: Block Design Task, Drawing Realism Task, Group Embedded Figures Test, and Kaufman Brief Intelligence Test-II.

Block Design Task. Caron et al.'s (2006) modified version of the Block Design Task was administered. This task requires the participant to copy a red-and-white geometrical design using blocks with two white sides, two red sides, and two sides diagonally split with red and white. The items vary in perceptual cohesiveness (minimal, intermediate, and maximal) and number of blocks (4, 9, and 16). The task was presented first in traditional unsegmented form and then in segmented form with the units of the design separated from one another by one third of the width of each unit (Shah & Frith, 1993; see Figure 1 for an unsegmented and segmented version at the three levels of cohesiveness). The unsegmented version was always administered first in order to avoid a facilitation effect (Caron et al., 2006; Shah & Frith, 1993). Time limit differed by number of blocks to be used: 120 s, 180 s, and 240 s for 4, 9, and 16 blocks, respectively. Participants were presented with nine unsegmented items and nine segmented items. For the unsegmented and segmented designs, three items were presented at each level of cohesiveness (three minimal, three intermediate, and three maximal). Participants received one point for each design correctly constructed. A design that was correctly completed after the time limit was recorded as incorrect.

For each matrix size and each presentation form (segmented, unsegmented), a motor-skill control item was administered in which the participant had to use red blocks to copy an all-red design, allowing for the control of motor skill.

Group Embedded Figures Test. The Group Embedded Figures Test (Witkin et al., 1971) was administered. In this task, one must identify (by tracing) a smaller geometric shape embedded within a larger figure. The test consists of seven control items followed by 18 test items. Children were instructed to trace the shape completely and erase all mistakes. A point was given for each correctly traced item, with a maximum score of 18. The timing administration of the Group Embedded Figures Test was modified. In adult samples, participants are given a set time to complete the items. In our sample, children were given unlimited time to complete each item. Response times were recorded from the time the item was presented until the child successfully traced the item or gave up. Because tracing ability may be related to drawing talent, the control items were included as a predictor in the Group Embedded Figures Test analyses. As reported later, performance on the control items proved unrelated to tracing ability.

Drawing Realism Task. Children were given a 9- × 11-in sheet of white paper and a sharpened pencil with an eraser and were asked to draw a still life consisting of a corkscrew and six connected transparent cylinders, one of which contained a branch of dried leaves (see Figure 2). These objects were chosen because they were difficult to draw: The leaves were irregular and organically shaped; the corkscrew was a complex object; and the way in which the cylinders connected and occluded one another was challenging. These objects were placed in the same position for each participant. The drawing paper was placed directly in front of the participant and the objects were placed on a piece of same-sized white paper about two inches to the left of the participant's sheet of drawing paper. Participants were instructed to look at the "still life" and draw what they saw for up to 15 min. All participants completed the drawing within this time frame.

Drawings were rated independently by two coders for elements that were characteristic of artistically gifted drawings (Milbrath, 1998; Winner, 1996). These elements require the skill of focusing on the local elements of the still life—the parts—rather than the overall global forms. Drawings were scored for the following elements: (a) use of line to indicate edge rather than use of line to stand for object (e.g., drawing the curlicue of the corkscrew or the stem of the leaves with two lines rather than just one); (b) detail (e.g., drawing square-shaped rather than rounded gears on the corkscrew; drawing at least one organically shaped [irregular] leaf rather than a general circle for a leaf); (c) foreshortening (e.g., shortening the base of the corkscrew; drawing the tops of the cylinders as ellipses rather than circles); and (d) occlusion (e.g.,

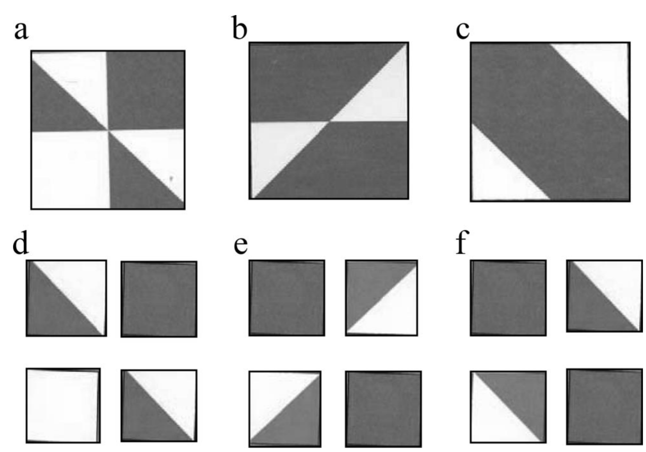

Figure 1. Items in the Block Design Task used by Caron et al. Images a–c are unsegmented designs at the three levels of cohesiveness: (a) Unsegmented Minimally Cohesive Item; (b) Unsegmented Intermediate Cohesive Item; (c) Unsegmented Maximally Cohesive Item. Images d–f are segmented designs at the three levels of cohesiveness: d) Segmented Minimally Cohesive Item; (e) Segmented Intermediate Cohesive Item; and (f) Segmented Maximally Cohesive Item. Printed with permission from Laurent Mottron.

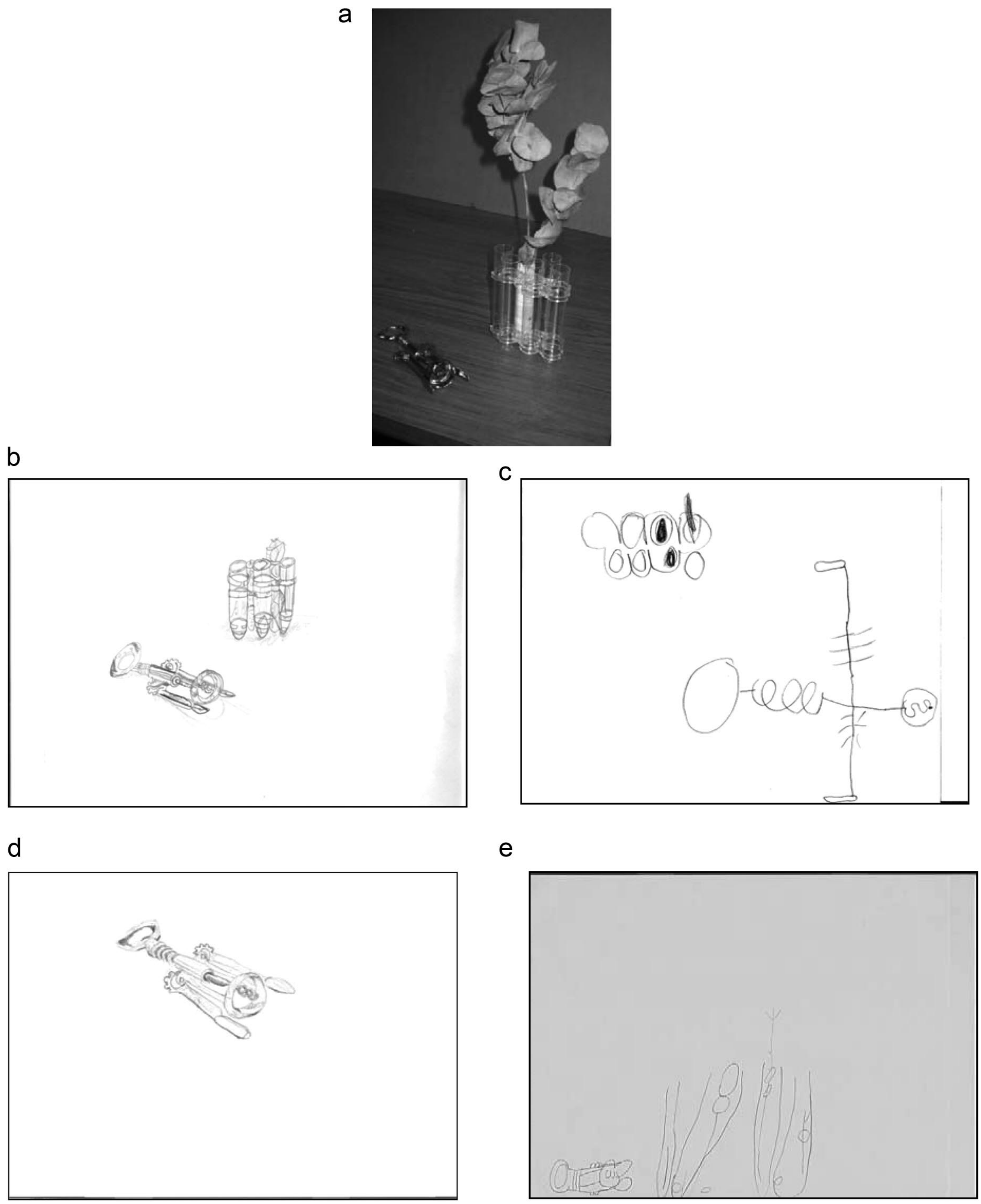

Figure 2. Still life model (a); drawings by two ASD children, one with a perfect drawing score of 1.0 (b) and another with a score of 0.0 (c), and by two non-ASD children, one with a perfect drawing score of 1.0 (d) and another with a score of 0.0 (e).

drawing one part of the corkscrew occluded by a part in front; drawing the back row of cylinders occluded by the front row).

One point was awarded for each element successfully drawn, for a total possible score of 8 (four characteristics × two objects [corkscrew and vase with leaves]). For each participant, a proportion score was calculated by dividing the number of correct elements drawn by the total number of elements drawn (8). Participants received a continuous score ranging from 0% to 100%. Two coders scored all the drawings and interrater reliability was calculated at $\Phi = .89$. Coders resolved disagreements by reviewing the drawings and coming to a consensus. Figure 2 shows drawings by two ASD children, one with a perfect drawing score of 1.0 and another with a score of 0.0 (top), and by two non-ASD children, one with a perfect drawing score of 1.0 and another with a score of 0.0 (bottom).

Kaufman Brief Intelligence Test-II. The verbal and nonverbal sections of the Kaufman Brief Intelligence Test-II (Kaufman & Kaufman, 2004) were administered and age-scaled scores were computed. This test was administered to ascertain that there were no IQ differences between the ASD and non-ASD groups that might explain group differences in performance.

Socioeconomic status (SES). SES was assessed with the use of a written questionnaire given to parents, asking about each parent's highest level of education. Following Norton et al. (2005), parents were classified into one of six categories: 1 = some high school; 2 = high school graduate or GED; 3 = some college, associate's, or vocational degree; 4 = college graduate; 5 = master's degree; and 6 = doctoral degree. Children received an SES score based on the average parental score; for those with single parents, only one score was used.

Years of art lessons. Parents were asked to indicate, on a questionnaire, the number of years of art lessons their child had taken outside of school.

Results

Preliminary Analyses

One-way ANOVAs by group (2) were performed on age, SES, drawing score, years of art lessons, and verbal and nonverbal IQ (see Table 1). There were no group differences in any of these variables ($p > .138$); these variables were therefore not included in the main analyses. The groups did not differ by gender, $\chi^2 = .240$, $p = .624$. The distribution of drawing talent scores for the ASD group was similar to that for the non-ASD group, $p = .725$. Because 83% of the sample had less than one year of formal art lessons, number of art lessons was not included in subsequent analyses.

Block Design Task

Mean accuracy scores and standard deviations for the Block Design Task are presented in Table 2. There was no main effect of group for accuracy or construction time on the motor-skill control items in which participants copied "designs" consisting of only red blocks. Thus, motor skill was not entered as a covariate in subsequent analyses.

Because there was more than one version of the Block Design Task, a binomial test was conducted to assess which version was more difficult. Participants who performed equally well on both versions of the task were excluded from the binomial analyses.

As expected, a binomial test showed a larger proportion of the children scoring higher on the segmented than the unsegmented version of the Block Design Task, 1.0 versus 0.0, $p < .001$. Regression analyses were then conducted to examine whether drawing realism score and/or ASD diagnosis (0 = ASD, 1 = non-ASD) predicted performance on the more difficult items—the unsegmented items (see Table 3). As hypothesized, drawing realism score ($\beta = .424$, $p = .022$) and not ASD diagnosis ($p = .445$) predicted performance on the unsegmented items.

Table 2
Mean Accuracy and Standard Deviations by Group on the Block Design Task and Group Embedded Figures Test

	ASD		Non-ASD	
	M	*SD*	*M*	*SD*
Block Design Task				
Minimal cohesiveness segmented	2.5	0.8	2.9	0.4
Minimal cohesiveness unsegmented	2.7	0.6	2.6	0.6
Intermediate cohesiveness segmented	2.5	0.7	2.5	0.7
Intermediate cohesiveness unsegmented	1.7	1.2	2.3	0.8
Maximal cohesiveness segmented	2.5	1.1	2.8	0.4
Maximal cohesiveness unsegmented	1.6	1.1	2.1	0.9
Group embedded figures test	5.1	5.0	7.3	5.8

Note. ASD = autism spectrum disorder.

As expected, a binomial test showed a larger proportion of the children scoring higher on the unsegmented minimally cohesive than the unsegmented maximally cohesive version of the Block Design Task, 0.84 versus 0.16, $p = 004$. Regression analyses were then conducted to examine whether drawing realism score and/or ASD diagnosis (0 = ASD, 1 = non-ASD) predicted performance on the more difficult items, the unsegmented maximally cohesive items (see Table 3). As hypothesized, drawing realism score ($\beta = .455$, $p = .013$), and not ASD diagnosis ($p = .387$), predicted performance on the unsegmented maximally cohesive items.

Group Embedded Figure Test

Drawing Realism score, ASD diagnosis, and accuracy on the control items were regressed onto the Group Embedded Figures Test accuracy scores (see Table 3). As hypothesized, accuracy on the Group Embedded Figures Test was predicted by the Drawing Realism score ($\beta = .685$, $p < .001$), but not by ASD diagnosis ($p = .381$) or accuracy on the control items ($p = .281$).

Discussion

The goal of the current study was to determine whether superior local processing in the visuospatial domain is a function of drawing talent versus ASD diagnosis. This study included two groups of children with and without an ASD diagnosis. Children in each group varied in level of realistic drawing talent. Children drew a complicated still life, which was scored for level of drawing realism, and then completed two local processing tasks. Results provide support that the local processing bias is associated with skill in drawing realism rather than ASD diagnosis, as has been previously assumed.

Consistent with the first hypothesis, children with higher drawing realism scores copied more unsegmented items correctly than did children with lower drawing realism scores. This occurred regardless of diagnosis. Consistent with the second hypothesis, children with higher drawing realism scores copied more unsegmented maximally cohesive items. This conclusion is consistent with Pring et al. (1995), who found that art talent rather than ASD diagnosis predicted superior performance on a puzzle task, and

Table 3
Regression Coefficients for Accuracy Block Design Task and Group Embedded Figures Test

	Block Design Task		
Predictors	Unsegmented	Unsegmented maxiamlly cohesive	GEFT
Drawing realism score	.424*	.455*	.685**
ASD diagnosis	.135	.150	.149
GEFT control items	—	—	.187
$F(df_1, df_2)$	3.948 (2, 27)	4.812 (2, 27)	10.699 (2, 24)
R^2	.226*	.263*	.498**

Note. ASD = autism spectrum disorder; GEFT = Group Embedded Figures Test.
* $p < .05$. ** $p < .001$.

with Drake et al. (2010), who showed that superior local processing found in ASD is also found in typically developing children talented in drawing realistically.

Finally, the third hypothesis was supported. Those more skilled in drawing were able to detect a simple shape in a complex pattern with greater accuracy on the Group Embedded Figures Test. Once again, this suggests that ASD and non-ASD children with a higher score in observational drawing show the same kind of superior local processing and visual analysis skills.

Children with a superior ability to draw realistically, whether typically developing or diagnosed with ASD, have a superior ability to mentally segment a complex design into its local features. And, in this study, realistic drawing talent proved a stronger predictor of mental segmentation skill (superior local processing) than did ASD diagnosis. Our findings show that superior local processing in the visuospatial domain is not specific to ASD diagnosis, as has been previously thought, but may be a function of the kind of drawing talent that allows a young child without any drawing training to depict a three-dimensional scene on a flat sheet of paper in a realistic manner.

Although the two tasks used assessed children's ability to decompose an image mentally into its component parts, the tasks were not identical. In addition to mental segmentation, the Block Design requires the ability to reconstruct the image using fine motor skills. In contrast, the Embedded Figures Test requires no reconstruction. Nonetheless, there was a strong association between these two tasks ($r = .611$, $p < .001$), supporting the claim that they both require mental segmentation.

Because many individuals diagnosed with ASD have above-average spatial and drawing abilities, previous reports showing an ASD local processing bias may have been due to a higher incidence of drawing talent in the ASD groups compared with the control groups tested. Recently it has been reported that the incidence of drawing talent in a non-ASD population is about 13% (Drake & Winner, 2012). In this study, 153 children were asked to draw with their nondominant hand, and two experts in drawing giftedness then selected those children who were about average for their age. The estimate of 13% is much higher than reported by Vital, Ronald, Wallace, and Happé (2009) for ASD children. In this study, only 6% of those with ASD (out of a sample of over 6,000 8-year-olds) were reported to have drawing/art talent. However, the discrepancy between Vital et al.'s (2009) study and the study by Drake and Winner (2012) may be due to the fact that in the latter study drawings were actually identified for talent (by comparing children's drawings with same age peers and selecting those that were above average for their age group), whereas in Vital et al.'s (2009) study, talent was based on parental reports. Parents may not know what average drawings look like at different ages and thus may not realize that their child has an advanced ability to draw.

Future research should investigate the comparative frequency of drawing talent in ASD and typical populations by administering the same kind of drawing task to both populations. Future research should also determine the generality of the local processing effect associated with drawing talent by examining performance on a wide range of local processing tasks, designing the studies like the present one so that artistic talent can be pitted against ASD diagnosis. It would also be important to determine whether enhanced performance on the converse kinds of tasks—ones that depend upon global processing—may only be found among individuals with drawing talent but without an ASD diagnosis. Artists have been known to draw the overall shape of an object before drawing in the details, and, therefore, it would seem likely that the ability to process stimuli globally would be related to the ability to draw realistically.

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