Superior Visual Analysis and Imagery in an Autistic Child with Drawing Talent

Jennifer E. Drake\textsuperscript{1} and Ellen Winner\textsuperscript{1, 2}

\textsuperscript{1}Boston College

\textsuperscript{2}Project Zero, Harvard Graduate School of Education

Invited article to appear in \textit{Imagination, Cognition, and Personality}

Corresponding Author:
Jennifer E. Drake
Department of Psychology
Boston College
Chestnut Hill, MA 02467
Electronic mail: drakejc@bc.edu
Abstract

Two opposing theories have been proposed to account for the strong visuo-spatial performance often seen in individuals with autism. According to the weak central coherence account, individuals with autism show a local processing bias. They have a superior grasp of the local details of a visual display but fail to grasp global aspects of the display (Happé & Frith, 2006). According to the enhanced perceptual functioning account, individuals with autism have superior local processing as well as intact global processing (Mottron & Burack, 2001). We report a case study of J.G., a 10-year old child of normal intelligence diagnosed with autism. He experienced expressive language delay, but showed special talents in both drawing and visual imagery. Our tests revealed that J.G. had superior local but poor global processing. This pattern of performance provides stronger support for weak central coherence than for enhanced perceptual functioning.
Superior Visual Analysis and Imagery in an Autistic Child with Drawing Talent

Striking realistic drawing talent has been reported in a small percentage of individuals with “savant syndrome,” those individuals diagnosed with autism who exhibit a disproportionate ability in one domain (e.g., music, mental calculation, realistic drawing) (Rimland & Fein, 1988; Ropar & Mitchell, 2002; Sacks, 1995; Selfe, 1977; Sheppard, Ropar, & Mitchell, 2007). Superior ability in drawing, even though not at the savant level, has also been reported in individuals with autism spectrum disorder (ASD) (Vital, Ronald, Wallace, & Happé, 2009). In 1978, Rimland sampled 5,400 children with autism and found that 10% had special abilities -- including music, mental calculation, and realistic drawing. Based on a sample of over 6,000 8-year olds, Vital et al. (2009) found that 6% of those with ASD have drawing/art talent. These special talents in individuals with ASD are independent of any kind of general intelligence measured by verbally mediated tests (Lincoln, Courchesne, Kilman, Elmasian, & Allen, 1988; O’Connor & Hermelin, 1988) but may be related to non-verbal intelligence (Dawson, Soullière, Gersbacher, & Mottron, 2007).

Individuals with autism often display other kinds of visuo-spatial talents as well. They perform at superior levels on “local” visuo-spatial tasks that require finding parts within wholes. The local processing tasks on which individuals with autism excel include the Embedded Figures Task (Edgin & Pennington, 2005; Jolliffe & Baron Cohen, 1997; Mottron, Burack, Iarocci, Belleville, & Enns, 2003; Shah & Frith, 1983), in which one must find a small part hidden in a larger pattern, and the Block Design Task (Caron, Mottron, Berthiaume, & Dawson, 2006; Pellicano, Maybery, Durkin, & Maley, 2006; Shah & Frith, 1993; Siegel, Minshew, & Goldstein, 1996), in which one must use blocks to copy a two-dimensional pattern. Performance on the
Block Design Task is sharply facilitated for everyone when the task is presented in segmented form so that it is clear which block corresponds to each part of the pattern to be copied (as shown in Figure 1), but this effect is much stronger for non-autistic than for autistic individuals (Caron et al., 2006; Shah & Frith, 1993). The lesser facilitation of external segmentation cues for those with autism suggests a superior ability to mentally segment (consistent with a local processing bias). Individuals with autism are also less likely to succumb to visual illusions than are non-autistics (Happé, 1996): they fail to integrate the figure with the context (ground), and it is the context that induces the illusion. Thus failure to see the illusion is indicative of local processing. Another study also showed that these individuals excel at copying “impossible figures” (Mottron, Belleville, & Menard, 1999). Impossible figure are ones that cannot be constructed three dimensionally. Each part is coherent, but the parts are inconsistent with one another. A focus on each part masks the drawing’s impossibility, which is revealed only when one perceives the figure as a whole.

Attending to the details of a display could lead to realistic rather than schematic drawings. Consistent with this claim, it has been shown that individuals with autism use a local drawing strategy, focusing on details rather than the overall shapes of objects and layout of shapes on a page (Mottron & Belleville, 1993; Mottron et al., 1999). Evidence that the tendency to analyze a pattern into its parts is associated with realistic drawing skill in savants comes from a report of the strategy used by E.C., a strategy referred to as “construction by local progression” (Mottron & Belleville, 1993, p. 29). E.C. did not draw the global shape of a figure first but instead began his drawings with a detail, adding contiguous elements, and often using an even more extreme local strategy -- moving on to an adjacent part before completing a part already begun. Each new line was in spatial contiguity with the preceding one – as if he were drawing
shapes like tracing a pattern, rather than using lines primarily to reveal the representational meaning of what he was drawing.

The ability of individuals with autism to focus on the parts and ignore the whole is not in dispute, as the performance of autistic individuals on local processing tasks is consistently high. Some have argued that this local processing strength is at the expense of the ability to grasp the whole and that these individuals lack “global processing” (Happé & Frith, 2006). According to this view, individuals with autism have “weak central coherence.” Mottron and his colleagues, however, have suggested that the local processing strength seen in autism exists alongside intact global processing (Mottron & Burack, 2001). According to this view, individuals with autism have “enhanced perceptual functioning.”

We report here a case study of an autistic child J.G., with exceptional realistic drawing talent much like that displayed by E.C. as an adult. J.G. has exceptional visual memory and visual imagery, and a superior ability to analyze an image into its parts and focus on the details. He does not, however, demonstrate unusual global strengths in the one difficult test we administered of the ability to perceive the whole of a display. Thus, he performed similarly to E.C. – showing superior local processing and poor global processing.

Case Report

*Social and clinical history.* J.G. is a right-handed male, age 10 years, 8 months. J.G. was born full-term by an emergency cesarean section after 36 hours of labor. He weighed eight pounds at birth and was healthy. From three weeks to about three to four months, J.G. cried constantly. He could not be consoled by his parents, a behavior his parents attributed to colic. At that time, his parents noticed that he did not smile and seemed more rigid than other children his age. As an infant, he turned away from his parents and resisted being hugged.
Around 18-20 months, J.G. developed a severe case of pica. He ate clothing, blankets, and stuffed animals. He picked fuzz off any material and ate it. His parents removed any fuzzy materials but then he began eating paper and biting his hand. At this time, he also exhibited toe-walking, hand-flapping, and head-banging behaviors and habitually hit his knee and fists and pulled forcefully on his ear. At age 2;3, J.G. was diagnosed with autism.

*Language development.* J.G. showed normal development of receptive language but was delayed in expressive language skills. At 18 months, he could only produce a few monosyllabic utterances. As has sometimes been reported in autistic children, J.G. developed his own language that involved clucking sounds. When he began using words, he often pronounced only the first sound of the word. At age 2;6, he began using sentences, but he often relied on gesture and non-linguistic sounds to communicate his needs.

*Neurocognitive assessment.* At age three, J.G. was administered the Differential Ability Scales (DAS). He received a global cognitive ability score of 131 indicating superior to very superior cognitive abilities. His capacity to understand spoken language including syntax, prepositional and relational concepts, and vocabulary was very superior. J.G. scored in the superior range for early number concepts and block building. His expressive vocabulary was above average.

*Visual imagery & memory.* One of J.G.’s most unusual traits is his capacity for generating visual images. He reports that he can project any image that he has memorized onto a visual field. He not only sees the image in his mind but can project it anywhere, at anytime, for any duration of time so that he has the experience of actually looking at the image. J.G. knows these images are mental rather than external.
His striking visual memory can also be seen in his verbal descriptions of things he has seen. He has memorized several entire life sciences textbooks and the *Kaufman Field Guide to Birds of North America* which includes images of birds as well as detailed descriptions of their features. Prompted by the name of any bird in this guide, he can describe the bird in great detail as if he were looking right at it. Below is an excerpt from a verbatim description J.G. gave at age 10 of an Elegant Trogon bird (which can be seen in Figure 2):

“Trogons are mostly tropical birds from Mexico central and northern South America. Stocky, kind of unrelated to most birds, slightly related, more closely related to King Fishers than most. Usually have short stubbed bills, a roundish head, chubby round body, long black and white tail, and short black legs. There are two species that will reside in Southern Arizona scarcely during the summer. The more common and famous is the Elegant Trogon. The male has a red belly, white upper stripe normally, black wings, black back, black head, and black tail, shines with green gloss, has a bright short yellow beak. In females, green, glossy green is replaced by dark grey with white spots by eyes. Very pale red chest.”

*Realistic drawing.* J.G. loves to draw and has had no formal art lessons. As has been reported for drawing savants (Selfe, 1977), J.G. has certain subjects that he focuses on: he prefers to draw animals such as his favored birds from the *Kaufman Field Guide to Birds of North America* (Figure 3 shows a creature drawn at age five; Figure 4 shows dinosaur skeletons drawn at age seven; Figure 5 shows a jaguar drawn at age nine; and Figure 6 shows ducks and geese from the Anatidae family drawn at age 10). He sometimes draws directly from pictures but also often draws from memory.

Experimental Investigation
We administered a series of cognitive and visuo-spatial tests to assess J.G.’s profile of abilities. We compared his performance to a comparison group of 10 ASD children. The comparison group was comprised of 8 males and 2 females with a mean age of 8;6. They had a mean verbal IQ of 98 (SD = 11.8) and non-verbal IQ of 98 (SD = 12.3).

Verbal and non-verbal iq. The verbal and nonverbal sections of the Kaufman Brief Intelligence Test-II (Kaufman & Kaufman, 2004) were administered. The verbal section consists of two parts, a vocabulary test in which pictures of objects must be named, and a definitions test in which a word with missing letters must be deciphered after hearing its definition. The nonverbal section consists of matrices to be completed by selecting the correct design or representation. J.G.’s composite IQ was 122 (verbal IQ = 125; non-verbal = 115). The mean score of 10-year olds on the K-BIT for verbal IQ is 99.6 (SD = 13.5) and non-verbal IQ is 100.4 (SD = 16.8). Thus his verbal IQ was almost two standard deviations above the mean and non-verbal IQ was one standard deviation above the mean.

Visual memory. J.G.’s visual memory was assessed by the Shape Memory test from the ETS Service Kit of Factor-Referenced Cognitive Tests (Ekstrom, French, Harman, & Dermen, 1976). He was presented with a page of geometric shapes and asked to “study the shapes and their relation to each other for four minutes” (see Figure 7). He was then presented with 32 smaller pictures each containing a part of the original design or a part that had been altered and was asked to indicate “if the shapes are the same and have the same position in relation to each other as on the study page”. The average score of adult naval recruits on this task was 21.4 out of 32. J.G. received an equivalent score, getting 20 out of 32 pictures correct. Thus, J.G. performed at an adult level on this test.
**Drawing ability.** To assess level of drawing talent, we asked J.G. to draw a still-life from observation. The still-life was difficult to draw: it consisted of two complex objects -- a corkscrew and a vase made up of six connected transparent cylinders, one of which contained a stalk of dried leaves (as shown in Figure 8). He was given a sharp pencil with an eraser and a 9x11” sheet of white paper. His drawing was scored for level of realism using a detailed, reliable, and valid scoring system that we have used in other research (Drake, Redash, Coleman, Haimson, & Winner, 2010). Scores on this task can range from 0.0 to 1.0. J.G. drew the still life hyper-realistically and included many of the characteristics of drawings by precocious realists--line as edge, detail, modeling, occlusion, and foreshortening. His drawing received a perfect score of 1.0 for realism. In contrast, a comparison group of 10 ASD children obtained an average score of only 0.29 (Drake & Winner, 2010). Figure 8 J.G.’s drawing and a drawing by a non-autistic child from Drake et al. who also received a 1.0.

To determine whether J.G. used the kind of local proximity strategy described in ASD individuals by Mottron and Belleville (1993) and Mottron et al. (1999), we examined videotapes of J.G.’s observational drawing. We assessed whether J.G. first drew the global shape and then altered the global shape by modifying it and adding details, or whether he drew the still life part by part. J.G. used the same kind of extreme local strategy used by the savant, E.C., which Mottron and Belleville (1993) refer to as the strategy of construction by local progression. He did not sketch in the overall shape but rather drew part-by-part. Thus, for the corkscrew, J.G. began at the top and worked his way down to the base.

We also administered a copy task to determine whether J.G. drew local features before global ones. We asked J.G. to copy four line drawings – two objects and two non-objects taken from Mottron et al. (1999). Nonobjects were created by decomposing the objects features (i.e.,
lines, curves) and regrouping the features into a new two-dimensional design (Figure 9). He was given a pencil without an eraser and had three minutes to copy each picture. We videotaped the copying and then scored drawings for graphic hierarchization using a system developed by Mottron et al. (1999). Graphic hierarchization was assessed by calculating the mean proportion of local and global features copied during the first third set of features copied, followed by the second third, and by the last third. In Figure 9, lines labeled with a “G” are global features and lines labeled with a “L” are local features. J.G. copied the line drawings with an accuracy rate of 92.5%.

We compared J.G.’s sequence of copying to a group of eight ASD children of a similar age (Drake & Winner, 2010). When copying objects J.G. drew more local features as he began his drawing than did children in the ASD comparison group. In the first third of the task, 75.8% of the features J.G. copied were local vs. 67.3% for the comparison group. When copying non-objects, J.G. drew more global elements in the first third of the task (71.4%) than did the ASD group (49.4%). Thus, J.G. copied local elements in the first third of his drawing when the line drawings were familiar objects but coped global elements first when the line drawings were unfamiliar.

Local processing. J.G. was given three tasks that assessed local processing: the Block Design Task, the Group Embedded Figure Test, and Visual Illusions.

First, J.G. was asked to complete a modified version of the Block Design Task in unsegmented and segmented form (Caron et al., 2006). In the unsegmented version, the patterns do not reveal their internal parts, and hence require mental segmentation and focus on the parts to complete the task (Figure 10). In the segmented version, the patterns reveal their internal parts because the parts are separated from one another. We compared J.G’s performance to 10 other
children diagnosed with ASD of a similar age. J.G. copied 14 out of 18 unsegmented images correctly while the comparison group copied an average of 11 out of 18 unsegmented images correctly. J.G. copied 16 out of 18 segmented images correctly while the comparison group copied an average of 13 out of 18 segmented images correctly. Thus he performed somewhat better than the other ASD children, and showed a strong ability to segment mentally a complex image into its parts.

Second, J.G. completed the Group Embedded Figures Test where he was asked to identify a simple shape embedded within a larger figure (Witkin, Oltman, Raskin, & Karp, 1971) (Figure 11). To succeed requires that one avoid the global pattern and focus on the local details. J.G. was able to detect 9 out of 18 figures while the comparison ASD group detected an average of only 4.4 out of 18 figures. Thus J.G. was clearly superior to the other ASD group and was skilled at zeroing in on the relevant “part” and ignoring the context.

Finally, a visual illusions task was administered. J.G. was presented with six two-dimensional visual illusions and was asked questions about each one to determine whether he perceived the illusion. For example, for the image in Figure 12 he was asked “Are these two lines straight or curvy?” In order to determine that the lines are straight, one must focus on the two lines and ignore the background. We compared J.G.’s performance on the visual illusions to autistic and non-autistic children studied by Happé (1996). J.G. succumbed to three of the six illusions while autistic and non-autistic children in Happé’s study succumbed to a mean of 2.24 and 4.09 illusions, respectively. Thus, J.G. showed the same resistance to illusions shown by Happé’s autistic children that results from focusing on the figure and ignoring the ground, or context.
Global processing. J.G. was given one task that assessed global processing strength -- he was asked to classify drawings as depicting figures that were either possible or impossible. The image on the left in Figure 13 is an impossible figure. To recognize this as impossible, something that could not be built, requires that one focus on the whole image simultaneously. Focusing on each part sequentially will not reveal the inconsistencies between parts and thus will not reveal that this is an impossible figure. J.G. was presented with 11 possible and 11 impossible figures (taken from Schacter, Cooper, & Delany, 1990; Von Karolyi, Winner, Gray, & Sherman, 2003) and presented on a laptop computer. J.G. identified 10 of the 11 of the possible figures correctly. These are the foils. The key items are the impossible ones, and he correctly identified as impossible only 2 out of 11 impossible figures. Thus, he failed to integrate the local elements into a global whole and demonstrated inferior global processing. J.G. performed similarly to E.C. on this task (Mottron & Belleville, 1993). When presented with impossible figures for 100 milliseconds, E.C. correctly identified only three of the 12 impossible figures; a comparison group of typical adults in Mottron and Belleville’s study correctly identified an average of 7.33 out of 12 impossible figures.

Discussion

The current case study sought to examine whether J.G., an autistic child with exceptional strengths in drawing and visual imagery, had visuo-spatial skills in line with weak central coherence or enhanced perceptual functioning. We administered several visuo-spatial and cognitive tasks and assessed J.G.’s drawing ability. J.G demonstrated superior performance on local processing tasks, along with poor performance on the global processing task similar to that of E.C. (Mottron & Belleville, 1993).
The parental reports of J.G.’s extraordinary visual memory was confirmed experimentally on the Shape Memory test, where he performed similarly to a sample of adults. While not classified as such, this test might also be considered a measure of local processing since to determine whether one has seen a pattern before one must notice whether small details have been altered.

On the observational drawing task, J.G. exhibited the same drawing strategy as E.C (Mottron & Belleville, 1993). J.G. used E.C.’s strategy of “construction by local progression”. He moved onto an adjacent part before completing the part already begun.

On the copying task, J.G. also demonstrated a local strategy when copying familiar objects: more local features were copied in the first third of the task. The comparison group of ASD children performed the same way. When copying non-objects, J.G. copied more global than features in the initial stages of the drawing, while the comparison group copied more local than global features initially. J.G.’s performance is in contrast to what has been found with adults with ASD: Mottron et al. (1999) reported that adults with autism showed this same bias towards copying local features early on but they did so equally when copying objects and non-objects.

J.G. demonstrated superior local processing on the Block Design Task. His accuracy was superior to the comparison group of ASD children. He also demonstrated local processing skill on the Group Embedded Figure Test. In comparison to the ASD group, J.G. demonstrated superior performance: he was able to detect a simple shape in a complex pattern with greater accuracy. Once again, this suggests that autistic children with high levels of drawing realism have superior local processing in the visuo-spatial domain.

J.G.’s response to visual illusions was in the middle of the autistic range obtained by Happé (range = 1-5). Like those autistic children studied by Happé, J.G. succumbed to fewer
visual illusions than did a typical sample. Thus, J.G. failed to integrate the parts of the illusion into a whole, which would have induced the illusion.

While J.G. demonstrated superior local processing, he also demonstrated inferior global processing. When asked to detect whether a figure was impossible or possible, he responded that almost all the images were possible. He failed to integrate the local elements into a global whole. This is consistent with work by Rodgers (2000) who found that adults with Asperger’s syndrome made more errors in identifying impossible figures than did a control group of undiagnosed adults. Participants were presented with possible and impossible figures simultaneously and were asked to indicate which figure was impossible. The presence of the comparison figure (the possible figure) facilitated the Asperger group’s performance: they performed better than E.C. (studied by Mottron and Belleville [1993]) who was presented with figures sequentially. However, the Asperger’s group made significantly more errors than did the control group.

Taken together, our findings suggest that J.G. has weak central coherence in the visual domain: he demonstrates superior performance on local processing tasks, along with poor performance on the global processing task. As reported earlier, J.G. had a much higher drawing score than did the comparison group. The combination of superior local processing and exceptional realistic drawing ability that we found in J.G. suggests that local processing and realistic drawing skill are related. We have also demonstrated a correlation between these two skills in a typical population of children (Drake et al., 2010). Similarly, Pring et al. (1995) has reported that gifted autistic and non-autistic artists focus on the local elements of a complex design. Thus, superior skill in realistic depiction, whether found in an autistic or a non-autistic individual, is linked to a strong ability to focus on parts. What is not yet known is whether
superior skill in realistic depiction in non-autistic individuals co-exists with weak global processing, as it does for J.G.
References


Figure Captions

1. Unsegmented (left) and segmented (right) item from the Block Design Task
2. Picture of an Elegant Trogon
3. Drawing of a creature, age 5
4. Drawing of dinosaur skeletons, age 7
5. Drawing of a Jaguar, age 9
6. Drawing of ducks and geese from the Anatidae family
7. Shape memory study and test items
8. Still-life model, J.G.’s drawing (left), drawing by typical child with realistic drawing skill (right)
9. Copying task stimuli and scoring procedure. Each figure is identified by a letter that corresponds to a local or global feature
10. Minimally (left) and maximally (right) cohesive block design in unsegmented and segmented versions
11. Control item, complex figure, and simple shape from the Group Embedded Figure Test
12. Example of a visual illusion
13. Example of a possible and impossible figure
Ducks and Geese
Family: Anatidae

Dabbling Ducks

Mallard
- Mallard x American Black Duck Hybrid
- Subspecies: American Mallard

Duck Range

Northern Pintail

Goose Range

Gadwall

American Wigeon

Eurasian Wigeon Hybrid

American Wigeon x Eurasian Wigeon Hybrid

Wing patterns same as American Wigeon

Green-Winged Teal
- American Race
Study Item

Test Items

I. Y N  II. Y N  III. Y N
Control Item Complex Figure

Test Item Complex Figure

Simple Shape
Are these two lines straight or curvy?

**Hering illusion**
Possible Figure

Impossible Figure