Artists Have Superior Local and Global Processing Abilities but Show a Preference for Initially Drawing Globally

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Abstract

The attentional demands of drawing require both local processing of an object's details and global processing of its overall structure. In this study, we examined the extent to which artists have superior local and global processing skills, how these skills relate to artists' ability to draw realistically and to autistic-related traits, and whether artists initially take a local or global approach to drawing. Forty first-year college art students and 41 non-art students completed two tasks assessing local processing and two tasks assessing global processing. Participants completed two drawing tasks that assessed their ability to draw realistically, two copying tasks that assessed whether they showed a preference for initially copying the local or global aspects of an object, and the Autism-Spectrum Quotient that assessed autistic-related traits. We found that art students outperformed non-art students on both the local and global processing tasks and that drawing ability was related to performance on these tasks. We also found that art students were more likely than non-art students to initially copy the global features in their drawings. Finally, we found that art students did not exhibit more autistic-related traits than non-art students and that the number of autistic-related traits was unrelated to performance on the local and global processing, drawing, or copying tasks. These results suggest that art students have an attentional flexibility that allows them to process information at a local and global level but that they have a preference for initially drawing globally.

Keywords: artists, drawing, local processing, global processing, visuo-spatial

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Drawing from observation is a complex task that requires analyzing what is actually seen, rather than what is expected or known. To create a realistic drawing, artists must focus on the essential aspects of a three-dimensional scene and translate those into a recognizable depiction on a two-dimensional surface (Gombrich, 1960). The attentional demands of drawing are multi-faceted, requiring local processing of an object's details as well as global processing of its overall structure. At the local level, attending to details and breaking a whole into its parts may be particularly important when creating a realistic drawing (Happé & Vital, 2009). At the global level, artists must assess proportions and spatial relationships between important details and integrate this information to convey a convincing sense of an object's structure (Chamberlain & Wagemans, 2015). It seems plausible that both local and global processing are necessary for skilled realistic drawing. But how exactly do artists and non-artists differ in local and global processing skills? And do artists' dynamic drawing strategies show a general bias toward favoring local versus global features, compared to non-artists?

A large and varied research literature has examined aspects of local and global perceptual processing and is relevant to understanding the nature of artists' perceptual expertise and drawing skill (see Chamberlain & Wagemans, 2016; Kozbelt & Ostrofsky, 2018). These studies have explored performance on relevant perceptual tasks, their correlations with realistic drawing ability, comparisons between and among special populations, and case study reports. As detailed below, substantial evidence linking local processing advantages with realistic drawing skill has been found among artistically gifted children (Drake, Redash, Coleman, Haimson, & Winner, 2010; Drake & Winner, 2018), adult artists (Chamberlain, McManus, Riley, Rankin, &

Brunswick, 2013; Chamberlain & Wagemans, 2015), and – perhaps most convincingly – among autistic savants (Mottron & Belleville, 1993). Evidence linking global processing with realistic drawing skill is more mixed, though still suggestive of potential artist advantages. We now detail the evidence for both kinds of processing and their relevance to skilled realistic drawing.

Evidence of Superior Local Processing Among Autistics and Artists

Superior local processing ability in the visuo-spatial domain has been explored and documented in two distinct populations: autistics and artists. The evidence among autistics is particularly strong. For instance, when presented with visual stimuli in prior research, autistics have demonstrated increased focus on details rather than on the overall shape or layout of objects on a page (Mottron & Belleville, 1993; Mottron, Belleville, & Ménard, 1999), an ability that allowed them to excel on tasks that require finding parts within a whole (Wang, Mottron, Peng, Berthiaume, & Dawson, 2007). Superior local processing in autistics has been most reliably replicated on the Block Design Task (e.g., Caron, Mottron, Berthiaume, & Dawson, 2006; Shah & Frith, 1993), where an image must be mentally segmented into its parts, and the Embedded Figure Test (Edgin & Pennington, 2005; Mottron, Burack, Iarocci, Belleville, & Enns, 2003; Shah & Frith, 1983), where a simple shape embedded within a more complex figure must be detected.

There is also some evidence to suggest that the superior local processing ability exhibited by autistics may be related to the ability to draw realistically. For example, Pring, Hermelin, and Heavey (1995) compared performance of four groups – autistics with and without drawing talent and non-autistics with and without drawing talent – on the Block Design Task and a jigsaw puzzle that required local processing. Those with drawing talent (irrespective of diagnosis) outperformed those without drawing talent on both tasks. However, the relationship between superior local processing and drawing ability may also be dependent on the difficulty of the local processing task used. For instance, whereas Pring, Ryder, Crane, and Hermelin (2010) found that savants outperformed an autistic group and another group with mild/moderate learning disabilities (MLD) on the Children's Embedded Figures Test, there was no difference between the savants and two non-autistic groups with and without artistic talent. The authors noted that they used the children's version of the Embedded Figures Test that may have been more suitable for those with below average IQ (i.e., the MLD group). Thus, this task may have failed to discriminate between those with and without artistic talent who have average or above-average IQs.

Superior local processing is not exclusive to those with an autism diagnosis; it has also been found in non-autistics with high autistic-related traits or those who draw hyper-realistically. Higher scores on the Autism-Spectrum Quotient (Baron-Cohen, Wheelwright, Skinner, Martin, & Clubley 2001) have been related to superior performance on the Embedded Figures Test (Grinter, Van Beek, Maybery, & Badcock, 2009) and the unsegmented version of the Block Design Task (Stewart, Watson, Allcock, & Yaqoob, 2009). These findings are consistent with the view that autistic-related traits are normally distributed in the general population and that the extreme high end of the distribution represents an autism diagnosis (Constantino & Todd, 2003; Mandy & Skuse, 2008), entailing that individuals with subclinical autistic-related traits might also show superior local processing associated with an autism diagnosis. Others have shown that superior local processing abilities are related to the ability to draw realistically. In one sample of children, drawing ability predicted performance on the Embedded Figures Test and unsegmented version of the Block Design Task, independent of age, IQ, and years of visual arts lessons (Drake et al., 2010). Additionally, these researchers found that a higher drawing accuracy score was associated with a higher score on the repetitive behavior and interests scale of the Childhood Asperger Syndrome Test (a subscale of the autism diagnosis). Moreover, in an adult non-artist sample, drawing ability but not autistic-related traits predicted performance on local processing tasks (Drake & Winner, 2011). Finally, a similar result has been found for autistic and non-autistic children: drawing ability, but not autism diagnosis, predicted performance on local processing tasks (Drake, 2013).

Some initial research has shown that adult artists also exhibit superior local processing abilities compared to non-artists. For instance, art students outperformed non-art students on the Block Design Task (Ryder, Pring, & Hermelin, 2002) and Embedded Figures Test (Chamberlain et al. 2019; Kozbelt, 2001; Ryder et al., 2002). Another study found an association between drawing experience and reduced holistic processing of faces in art students in a composite face task (Zhou, Cheng, Zhang, & Wong, 2012). Chamberlain et al. (2019) also found that art students outperformed non-art students on a Mental Rotation Task, which requires the ability to locate the precise location of an object's parts in order to match an oriented stimulus on a screen. Performance on the Mental Rotation Task was positively correlated with performance on the Embedded Figures Test (a local processing task) but negatively correlated with performance on a visual illusions task (a global processing task). This suggests a possible link between the Mental Rotation Task and local processing skill.

Other researchers have failed to find an artist advantage on the Embedded Figures Test. Instead, these researchers observed that observational drawing accuracy may be a greater determinant of local processing ability than being an artist, per se. For example, one study found no differences between art students and non-art students on the Embedded Figures Test and Block Design Task (Chamberlain, McManus, Riley, Rankin, & Brunswick, 2013). However, positive correlations were found between the two local processing tasks and drawing accuracy within each group – and more so among the art students. Another study found (somewhat surprisingly) that non-art students outperformed art students on the Embedded Figures Test, but performance on that task was still predicted by drawing ability (Chamberlain & Wagemans, 2015). This echoes findings of Drake (2014), who showed that performance on the Embedded Figures Test positively predicted drawing ability in non-autistic children.

Global Processing in Autistics

Overall, there is substantial evidence indicating that autistic individuals and non-autistic artists have perceptual advantages in local processing that are associated with realistic drawing ability. What do local processing advantages imply about global processing ability in either group? In the autism literature, two opposing theories have been proposed to account for their superior local processing skills (often referred to as a *local processing bias*). One view argues that the local processing bias occurs at the expense of the ability to grasp the whole and that autistics lack a "global bias" (Happé & Frith, 2006). In this view, autistics have "weak central coherence" (Frith, 1989) and thus prefer processing stimuli locally rather than globally (e.g., Bölte, Holtmann, Poustka, Scheurich, & Schmidt, 2007; Deruelle, Rondan, Gepner, & Fagot, 2006; Plaisted, Swettenham, & Rees, 1999). The alternative view, advanced by Mottron and colleagues, suggests that the local processing bias found in autistics exists alongside intact global processing (Mottron & Belleville, 1993; Mottron et al., 1999). In this view, autistics have "enhanced perceptual functioning." By default, then, autistics prefer processing local over global elements and will not use a global strategy if it is detrimental to their performance, but this does not deprive them of the ability to see the global whole (Mottron, Dawson, Soulières, Hubert, & Burack, 2006). Indeed, a meta-analysis showed that autistics were able to process visual stimuli at the global level but that autistics processed global stimuli slower than non-autistics (Van der Hallen, Evers, Brewaeys, Van den Noortgat, & Wagemans, 2015).

Global Processing and Drawing Ability

The evidence suggesting that autistics' local processing advantages may not interfere with their global processing implies that visual artists may also excel at global processing in being able to focus on the overall form of objects as they draw. However, the question of possible artist advantages in global processing is far less explored than its local processing counterpart. While there is some extant evidence suggesting a possible association between drawing ability and global processing, findings thus far are inconsistent within and across tasks. For example, Kozbelt (2001) found that art students outperformed non-art students on the Out-of-Focus Pictures and Gestalt Completion Tasks, which require integrating degraded visual patterns into a whole, in order to identify objects shown in blurry or fragmented images. However, other studies (e.g., Chamberlain et al., 2019; Drake, Simmons, Rouser, Poloes, & Winner, 2021) have found no difference between art students and non-art students on a different version of the Out-of-Focus Pictures Task. In addition, Chamberlain and Wagemans (2015) found similarly mixed results on the performance of art students and non-art students on two global processing tasks. Specifically, art students were better able to determine the global direction of a moving series of objects in a Coherent Motion Task, but they were no better than non-art students at integrating information to determine the object depicted in a two-tone image, a finding consistent with later studies (Chamberlain et al., 2019; Drake et al., 2021)

Artists' eye movements while drawing may be another indication of a link between artists' drawing ability and global processing strengths. One study found that drawing training and drawing accuracy were related to the ability to integrate local details into a global whole across eye movements (Perdreau & Cavanagh, 2013). Another study compared eye movements between artists and non-artists in a free viewing phase and drawing task. Whereas both groups showed similar eye movements in the free viewing phase, artists were found to use a more global eye movement distribution than non-artists during the drawing phase (Park, Williams, & Chamberlain, 2021).

In sum, while the evidence for a global processing advantage relevant to drawing skill is not as firm or consistent as the evidence for local processing, this need not imply that global processing is less important for artists or for realistic drawing ability. Fewer studies assessing global processing skills in artists have been conducted, and assessment methods for global processing may simply be less well developed than those for local processing. There is also evidence suggesting that global processing characterizes how artists inspect images, especially visual art (Nodine, Locher, & Krupinski 1993; Pihko et al., 2011; Vogt & Magnussen, 2007; Zangemeister, Sherman, & Stark, 1995). Therefore, both local and global modes of processing may simply be part of a larger toolbox of perceptual knowledge and skills that artists possess (see Kozbelt & Ostrofsky, 2018). Along these lines, Chamberlain and Wagemans (2015) found that art students were better able to switch between local and global features on a Navon Task, as evidenced by reduced reaction time when shifting between trials that required either focusing on local elements or a global configuration. This suggests that artists need not have a consistent and default attentional bias towards either local or global features. Rather, artists may have an attentional flexibility that allows them to easily switch between these two types of features, both of which seem important for realistic depictions (see also Ostrofsky, Kozbelt, & Seidel, 2012). This attentional flexibility might also be important for more creative aspects of artistic activities, in addition to technical skill (Chamberlain, Heeren, Swinnen & Wagemans, 2018).

Dynamic Local and Global Processing Strategies in Drawing and Copying Tasks

Instead of static individual-difference conceptions of local and global processing skill, a more informative focus may require a more dynamic approach – specifically, how local and global modes of processing are strategically deployed throughout the time course of the activity of drawing. For example, do people who draw well tend to adopt a local or a global processing approach at the beginning of a drawing session, versus later on? Researchers have pursued this issue in several populations.

Some evidence comes from case studies of autistic artists, which have consistently demonstrated a local processing bias, by creating drawings part-by-part rather than sketching an overall outline. For instance, the savant E.C. was observed to use a strategy called "drawing by local progression" where he added contiguous parts rather than first drawing the overall form (Mottron & Belleville, 1993, p. 29). A similar strategy was used by the artist Stephen Wiltshire, who drew detail by detail as if he was tracing an image (Sacks, 1995). Nadia, an autistic child gifted in drawing, also exhibited a preference for drawing locally. "Nadia would sometimes use a detail that was already part of one figure as the starting point for a new drawing - which would then take off in another direction - as if she had lost track of the original context" (Humphrey, 1998, p.167). A focus on drawing details has also been found in non-autistic artists: the portrait artist Humphrey Ocean was found to draw ‘‘detail by detail, rather than in a more holistic manner" (Miall & Tchalenko, 2001, p. 38).

A preference for drawing locally is not limited to autistic artists: it has also been found in autistics without drawing talent. Some work has shown that autistics were more likely to initially copy local features of objects than non-autistic children (Booth, Charlton, Hughes, & Happé, 2003) and non-autistic adults (Mottron et al., 1999). This preference for copying local features also extends to copying local features on the well-known Rey-Osterrieth Complex Figure (Figure 1). Autistics were more likely to initially copy the local features of the figure than non-autistics (Cardillo, Menazza, & Mammarella, 2018). Other researchers (e.g., Jolliffe & Baron-Cohen, 1997; Kuschner et al., 2009; Ropar & Mitchell, 2001) have found no difference in copying strategies between autistics and non-autistics. However, this discrepancy may be due to the different scoring procedures used. Traditionally, the Rey is administered to participants twice – in a copy and delayed recall condition given 30 minutes after the copy condition. Results on both conditions are used to assess whether participants used a local or global approach to copying the figure. Researchers who have used this scoring procedure have found no difference in the approach used by autistics and non-autistics. More recent research argues that the copy condition *only* is a more accurate assessment of a local or global approach (Booth 2006; Lang et al., 2016) and this scoring procedure has resulted in autistics showing a preference for initially copying local features of the figure.

Among non-autistics, a preference for drawing locally may also be related to drawing talent. Children who had higher drawing accuracy scores were more likely to initially copy local features in a copying task than those children with lower drawing accuracy scores (Drake et al., 2010). However, this finding was not replicated in a non-autistic non-artist college student sample (Drake & Winner, 2011).

Current Study

Overall, we know of no empirical research to date that has directly examined local versus global processing in terms of the overall sequence of marks required to create a drawing or copy a visual stimulus like the Rey-Osterrieth Complex Figure in artists and non-artists. The aim of the current study was to compare local and global processing skills in art and non-art students, to examine whether art students initially draw locally or globally, and to examine whether performance on these tasks might be related to artists' superior drawing abilities. Understanding how artists and non-artists dynamically approach drawing tasks, by deploying local and global processes as needed, would be useful for characterizing the nature of these processes and their relevance to skilled artistic drawing. Ideally it would also complement existing research on local and global processing abilities among artists and non-artists.

The current study had four aims. First, we sought to compare local and global processing skills in art students and non-art students via a suite of standard visuo-spatial tasks that emphasize one or the other modes of processing. Second, we compared whether art students and non-art students initially took a local or global approach to copying visual stimuli. Third, we assessed whether there was a relationship between local and global processing and realistic drawing ability and whether an initial preference for a local or global strategy (as measured by the copying tasks) was related to drawing accuracy. Finally, we examined whether art students would self-report more autistic-related traits than non-art students. We assessed whether the presence of more autistic-related traits would be related to performance on the local tasks (as has been reported in previous studies with autistic individuals; Grinter et al., 2009; Stewart et al., 2009) and whether more autistic-related traits would be related to a local approach when drawing. Since previous research has found that art students have higher non-verbal IQs than non-art students (Chamberlain et al., 2019), we assessed non-verbal IQ to determine whether it should be controlled for in our analyses.

Consistent with previous findings, we hypothesized that art students would outperform non-art students on both the local and global tasks and that art students would have higher accuracy scores on the drawing and copying tasks than non-art students. Since both local and global skills are, in principle, important for drawing, we tested two competing hypotheses on which approach art students initially used in the copying tasks. The first possibility is that art students by default would favor an initial local approach in the copying task, echoing what has been reported in autistics and artistically gifted children and artists (e.g., Booth et al., 2006; Drake et al., 2010, Mottron et al., 1999, Zhou et al., 2012). The second possibility is that art students initially favor a global approach, at least in certain copying tasks where that strategy may be more effective or efficient. A reliance on global processing may also be evident if artists do not have a systematic attentional bias and can easily switch between the local and global aspects of a stimulus (Chamberlain & Wagemans, 2015), or if artists operate using larger perceptual chunks as a function of their expertise (Kozbelt & Ostrofsky, 2018). Such behavior differs from that of autistics, but it would suggest that art students have an attentional flexibility that allows them to excel at processing information both locally and globally, as needed, while still demonstrating that they favor a global approach initially in the copying task. Finally, we hypothesized that art students would exhibit more autistic-related traits than non-art students, specifically those that may be related to their drawing ability (e.g., attention to detail), that more autistic-related traits would be related to performance on the local processing tasks and preference for taking a local approach to drawing.

Methods

Participants

The art students were 40 college first-year art and design majors (31 females, 9 males; ages 18-21 years, M_{age} = 18.2, SD_{age} = 0.5) who were recruited from the Pratt Institute in Brooklyn, NY. The Pratt Institute is a highly selective art and design school where students must be accepted for admission based on their artistic and drawing skills. While first year art students were all required to take a foundational drawing course, they represented the following majors: film (n = 6), illustration (n = 6), fine art (n = 5), graphic design (n = 5), animation (n = 4), interior design (n = 4), industrial design (n = 3), photography (n = 3), advertising (n = 1), education (n = 1), art direction (n = 1), and undecided (n = 1). Art students each received $40 for participation. The non-art students were 41 undergraduate students (30 females, 11 males; ages 19-24 years, M_{age} = 21.7, SD_{age} = 6.4) who were recruited from an undergraduate subject pool at a large, public, urban university and received course credit for their participation. A one-way ANOVA revealed that art students were younger than non-art students, F (1, 79) = 11.799, p = .001, d = -0.77.[1] None of the non-art students were majoring or minoring in art.

The art student group was: 37.5% Asian, 35.0% Caucasian, 20.0% Other, 5.0%, Hispanic or Latino, and 2.5% Black or African American. The non-art student group was: 31.7% Caucasian, 19.5% Asian, 19.5% Other, 14.6%, Black or African American, and 14.6% Hispanic or Latino. The gender and racial composition of the two groups did not differ, X^2 (1, n = 81) = 0.204, p = .651 and X^2 (4, n = 81) = 7.728, p = .102, respectively.

Materials and Procedure

Participants were tested individually in a quiet room in a single session that lasted no more than 1.5 hours. We administered the questionnaires and tasks in the order described below. The questionnaires and drawing and copying tasks were completed with paper and pencil. All other tasks were completed on a laptop computer that was placed at an arm's distance from the participant. The college's institutional review board approved the study, and all participants provided written informed consent. Table 1 presents a detailed overview of the visuo-spatial, drawing, and copying tasks.

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[1] When we included age as a covariate in subsequent analyses, our results did not change.

Demographic Questionnaire. Participants were asked to report their age, gender, race, handedness, academic major, and years of art training.

Autistic-related Traits. To assess sub-clinical traits associated with autism, we administered the Autism-Spectrum Quotient (AQ; Baron-Cohen et al., 2001). The AQ is a 50-item self-report measure that assesses five areas: Social Skills, Attention Switching, Attention Detail, Communication, and Imagination. For each item, participants must respond whether they “strongly disagree,” “disagree,” “agree,” or “strongly agree” with the statement. Participants received 1 point for endorsing the autistic-related trait as either mildly or strongly. In order to reduce a response bias, half of the items endorsing autistic-related traits resulted in a disagree response and the other half an agree response. The AQ yields a score from 0 to 50, with a higher score indicating more autistic-related traits. A score of 32 or above represents clinically significant autistic-related traits.

Non-verbal IQ. To assess non-verbal IQ, we administered the shortened version of the Raven’s Advanced Progressive Matrices Task (RAPM; Arthur, Tubre, Paul, & Sanchez-ku, 1999). Participants were presented with a visual pattern on a computer screen. The pattern was presented in a 3×3 grid that consisted of eight smaller images and one missing image. Below the grid, participants were presented with four answer choices and were asked to select the choice that would best complete the visual pattern. Participants first completed one practice item where they received feedback on their response and then completed 12 test trials without feedback. Participants had 15 minutes to complete the test trials and both accuracy and reaction time were recorded. The RAPM has been validated and normalized and has been found to be a valid predictor of non-verbal IQ (Arthur et al., 1999).

Visuo-spatial Tasks. Accuracy and reaction time were recorded for each task and accuracy and reaction time for each task were assessed for skewness and kurtosis. To assess local processing, we administered two tasks: 1) the Embedded Figures Test, which assesses the ability to avoid context and focus on details and is a passive perceptual task that does not require motoric coordination; and 2) the Mental Rotation Task, which assesses the ability to focus on the precise location of a pair of objects and has been found to be associated with performance on local processing tasks (e.g., Embedded Figures Test) but not global processing tasks (e.g., visual illusions), suggesting that it specifically taps local processing abilities. To assess global processing, we also administered two tasks: 1) the Out-of-Focus Pictures Task, which assesses the ability to integrate degraded visual information into identifiable objects; and 2) the Coherent Form task, which assesses lower level Gestalt grouping (good continuation) and thus should not be subject to top-down effects. The Coherent Form task is similar to the Embedded Figures Test in that both present simple geometric patterns rather than familiar objects.

Mental Rotation. Mental rotation skills were assessed using a computerized version of the Mental Rotation Task (MRT: Hunt, Davidson, & Lansman, 1981; Shepard & Metzler, 1971). This task assesses the ability to mentally rotate objects by focusing on the parts of the object rather than the whole. Participants were presented with a pair of drawings of three-dimensional block constructions (black lines on white backgrounds). Participants were asked to indicate whether the pair of drawings was the same objects presented from two different angles (by pressing the S key on the computer) or two different objects (by pressing the D key on the computer). They completed five practice trials where they received feedback followed by 16 test trials without feedback. Participants had 3 min to complete all the test trials.

Embedded Figures. The Embedded Figures Test assesses the ability to identify a small geometric shape embedded within a larger figure. We administered a modified version of the Embedded Figures Test (Witkin, 1950) that has been validated and used in previous research (e.g., Chamberlain et al., 2019; Chamberlain & Wagemans, 2015). Participants were presented with a complex two- or three-dimensional pattern and a simple two-dimensional target shape (all involving black lines on white backgrounds). Each image was presented for 12s and participants were asked to indicate whether the target shape was present (by pressing the J key) or absent (by pressing the F key) in the complex pattern. Participants completed six practice trials where they received feedback on their response and 40 test trials without feedback. The test trials were presented in a random order and contained an equal number of present and absent trials.

Out-of-Focus Pictures. The Out-of-Focus Pictures Task (Kozbelt, 2001) assesses the ability to integrate information given to identify the object represented in an image. Participants were presented with 10 gray scale pictures in a random order on a laptop computer that varied in level of blurriness. The pictures were taken from Schooler and Melcher (1994) and consisted of animals, scenes, and objects. Each picture was presented for up to 30s, and participants were instructed to press the space bar when they were ready to identify what was in each picture. After pressing the space bar, participants were given an additional 15s to type their free response before moving on to the next picture. Participants first completed two practice items and were given feedback and then preceded on to 10 test items without feedback. Responses were coded for accuracy independently by two raters, inter-rater reliability r (79) = .939, $p < .001$. Responses that named an exemplar or the class of the object (e.g., tulip or flower) were scored as correct.

Coherent Form. To assess global processing, we administered the Coherent Form Task, which was developed specifically for the current study as a complementary task to the Embedded Figures Test, by testing Gestalt grouping through good continuation. This task assessed participants' ability to cohere local line orientations into a global shape. In this task, participants viewed 150 randomly oriented white line segments on a black background. The orientations of line segments in one location of the image (either at the top, bottom, left, or right side of the image) were manipulated so that they formed the contour of a series of concentric circles. Participants were asked to identify which of four locations on the image (top, bottom, left, right) contained the circular arrangement of line segments. The orientations of the individual line segments that formed the contour of these concentric circles were randomly jittered from the overall contour orientation to form a series of contour coherence levels, from 0% (orientation of all lines jittered) to 56% (56% of lines with orientation alignment along the contour) in increments of 8% (i.e., 0, 8, 16, 24, 32, 40, 48, 56). Therefore, in trials in which there was high alignment of the line segments (56%), the location of concentric circular shape would be easy to detect, whereas in trials in which the line segments were completely misaligned (0%) the location of the concentric circular shape would be more difficult to detect. Stimuli were developed using the GERT toolbox for MATLAB, which is designed for the construction of perceptual grouping displays (Demeyer & Machilsen, 2012), and the stimuli were extensively piloted before inclusion in the current study so that the task adequately reflected individual differences in grouping through good continuation.

In each trial, participants were presented with the image for 250ms followed by a fixation cross. Then, participants were asked to indicate whether the circular arrangement of line segments was up, down, left, or right of the fixation cross using the arrow keys on the computer. They had 10s to provide their response. Participants completed five practice trials where they received feedback and 64 test trials without feedback. Figure 2 shows example stimuli at different contour coherence levels used in the task.

When giving their responses, some participants (n = 17) anticipated the fixation cross resulting in a negative reaction time for that trial. In the case of 12 of our participants, this occurred for fewer than 10% of a participant's trials (M = 2.1 trials with negative reaction times). For these participants, we removed the negative reaction times and recomputed their average reaction time score. In the case of five of our participants, this occurred for a majority of their trials (M = 19.6 trials with negative reaction times), and thus we removed these participant's reaction time scores from the reaction time analyses.

Drawing and Copying Tasks.

Still-life. To assess drawing ability of objects in three-dimensions, we administered an observational drawing task developed by Chamberlain et al. (2019). Participants were given an 8.5-in. x 11-in. piece paper and a sharp pencil with an eraser and asked to draw a still-life that consisted of common objects (i.e., cup, bowl, fork, bag). Participants were given 10 min to draw the still-life as accurately as possible. They were instructed that if time allowed, they could add details and shading. Figure 3 presents a picture of the still-life as well as a drawing by an art student and a non-art student.

Face Drawing. To assess drawing ability when drawing in two-dimensions, we presented participants with a picture of a face on a laptop computer. Participants were given an 8.5-in. x 11-in. piece paper and a sharp pencil with an eraser and asked to draw the face as accurately as possible. As in the observational drawing task, participants were given 10 min to complete the drawing and were instructed to add details and shading only if time allowed. Figure 4 presents a picture of the face as well as a drawing by an art student and a non-art student.

Copying Task. To assess whether participants showed a preference for copying local or global features of an object, we administered a copying task developed by Mottron et al. (1999).

In this task, participants were asked to copy eight line drawings – four of objects and four of non-objects. The non-objects were created by deconstructing the object's features (e.g., lines, curves) and regrouping the features into a two-dimensional design (Figure 5). Participants were given a pencil without an eraser and were instructed to copy the drawings as quickly and as accurately as possible. They were given a maximum of 3 min to copy each drawing. As participants worked, their drawings were videotaped and copy times recorded.

Each drawing was assessed for accuracy and graphic hierarchization (sequencing of items copied). To assess accuracy, two raters scored each drawing for the percentage of local and global features omitted. Inter-rater reliability for accuracy was as follows: local features r (79) = .953, $p < .001$ and global features r (79) = .888, $p < .001$. Following Mottron et al. (1999), graphic hierarchization was assessed by calculating the percentage of local and global features copied during the first third of features copied. Two raters viewed the videos and recorded the sequence of local and global features copied taking into consideration any omitted features. For example, if a participant successfully copied 36 out of 39 features, the first third would consist of 12 features. We then calculated the percentage of local and global features copied among these 12 features. Inter-rater reliability for graphic hierarchization was as follows: local features r (79) = .948, $p < .001$ and global features r (79) = .939, $p < .001$.

Rey-Osterrieth Complex Figure. The Rey-Osterrieth Complex Figure (ROCF; Osterrieth, 1944) assesses participants' accuracy and preference for copying local and global elements of a complex figure (see Figure 1). The figure is made up of 18 elements that represent global elements (e.g., large rectangle) and local elements (e.g., circle with three dots). Participants were presented with the figure on a laptop computer and were given a sheet of paper and a pencil with no eraser. Participants were given a maximum of 4 min to copy the image as accurately as possible, and their drawing was videotaped.

We scored the drawings for accuracy and the sequencing of items copied. To assess accuracy, two raters scored the accuracy and placement of each of the 18 elements on a scale of 0 to 2 (Osterrieth, 1944). For example, a score of 2 represented an element that was both accurately drawn and correctly placed whereas a score of 0 represented an element that was inaccurately drawn, incorrectly placed, and unrecognizable. Participants received an accuracy score for each item and a total score was computed by summing the values for all the items, with scores ranging from 0 to 36. Inter-rater reliability for accuracy was r (79) = .835, $p < .001$.

To assess copying sequence, two raters viewed the video recordings and recorded the first six elements that were drawn (out of 18 elements). This gave us an indication of what was copied during the first third of the task and whether participants showed a preference for copying local or global elements. We used a scoring system developed by Booth (2006), that groups the elements into one of four categories: 1) global elements (e.g., large rectangle); 2) global internal elements (e.g., diagonal cross); 3) local perimeter elements (e.g., diamond); and 4) local internal elements (e.g., circle with three dots). Elements belonging to each of these categories received a weighted score based on their importance to the overall organization of the figure. The scoring was as follows: global elements = 4; global internal elements = 3; local perimeter elements = 1; and local internal elements = 0. For each participant, we recorded the first six elements copied and assigned these elements weights. We then calculated an average weighted score with a higher score indicating a preference for initially copying global elements and a lower score indicating a preference for initially copying local elements. Inter-rater reliability for the copying sequence was r (79) = .960, $p < .001$.

Results

Preliminary Analysis

A one-way ANOVA revealed that art students had a higher non-verbal IQ[2] (*M* = 7.6; *SD* = 2.2) than non-art students (*M* = 5.7, *SD* = 2.6), *F* (1, 75) = 10.929 *p* = .001, *d* = 0.86. Since non-verbal IQ may be related to performance on the visuo-spatial tasks, we controlled for non-verbal IQ in these analyses as well as the drawing accuracy analyses.

Autistic-related Traits

A one-way ANOVA compared the total number of autistic-related traits by group. Contrary to our hypothesis, there was no difference in the total number of autistic-related traits between art students (*M* = 19.2, *SD* = 5.2) and non-art students, (*M* = 18.3, *SD* = 5.9), *F* (1, 77) = 0.468, *p* = .496, *d* = 0.16. We next ran a MANOVA on the five autistic subscales (Social Skills, Attention Switching, Attention Detail, Communication, and Imagination) and found no differences between the two groups on these subscales, *p*s > .05. Thus, contrary to our hypothesis, art students did not score higher in attention to detail than non-art students.

Visuo-spatial Tasks

Preliminary Analysis. We first examined whether accuracy and reaction times on our tasks were normally distributed. Accuracy on the Mental Rotation Task showed significant skewness (*p* = .010) and reaction time on the Mental Rotation Task showed significant skewness and kurtosis (both *p* < .001). To correct skewness and kurtosis, a natural logarithmic transformation was performed on both these variables. Reaction time and accuracy data were normally distributed for all other tasks.

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[2] Due to computer issues, four of the art students' non-verbal IQ scores were missing.

Next, we examined whether accuracy and reaction time on our tasks were related, which would suggest a speed-accuracy trade-off (i.e., participants performing slower on a task in an effort to make fewer errors). We found a significant positive correlation between accuracy and reaction time on the Embedded Figures Test, r (79) = .274 p = .013, suggesting a relatively weak speed-accuracy trade off on this task. However, on the Mental Rotation Task (transformed variables), r (78)[3] = -.252, p = .024 and the Coherent Form Task r (73) = -.382, p = .001, we found the opposite of a speed-accuracy trade off, with increased accuracy associated with a decrease in reaction time. There was no relationship between accuracy and reaction time on the Out-of-Focus Pictures Task, r (79) = .087, p = .439. Since we did not find a speed-accuracy trade off, we analyzed accuracy and reaction time separately. We also analyzed the accuracy and reaction time trade-off separately for art students and non-art students and a similar pattern of correlations were found.

Finally, we examined whether there was an association among accuracy scores on the visuo-spatial tasks suggesting that performance on these tasks may be measuring similar constructs (Table 2). We also examined whether performance on these tasks was related to more autistic-related traits. The correlations were similar when analyzed separately for art students and non-art students. The tasks were moderately correlated with one another and non-verbal IQ. Performance on both the local and global processing tasks was unrelated to the total number of autistic-related traits and a similar pattern emerged for art and non-art students.

Accuracy. Table 3 presents the means and standard deviations for accuracy on the local and global processing tasks. To examine whether accuracy differed between art students and non-art students, we ran a MANCOVA controlling for non-verbal IQ. The art students

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[3] Due to computer issues, one of the art student's Mental Rotation scores was missing.

outperformed non-art students on all four of the tasks: Mental Rotation, F (1, 72) = 6.298, p = .014, n^2_p = .080, Embedded Figures, F (1, 72) = 5.736, p = .019, n^2_p = .074, Out-of-Focus Pictures, F (1, 72) = 11.216, p = .001, n^2_p = .135, and Coherent Form, F (1, 72) = 4.530, p = .037, n^2_p = .059. Thus, we found art students demonstrated superior performance on both the local and global processing tasks compared to non-art students.

Reaction Time. Table 4 presents the means and standard deviations for reaction time on the local and global processing tasks. To examine whether reaction differed between art students and non-art students, we again ran a MANCOVA controlling for non-verbal IQ. There were no differences in reaction time by group, ps > .05.

Drawing Tasks

Rating of Drawings. Following Chamberlain et al. (2019; Chamberlain, Kozbelt, Drake, & Wagemans, 2021), participants' drawings were rated for accuracy by 14 non-artist judges using a Consensual Assessment Technique (Amabile, 1982). Judges were asked to rate both the still-life and face drawing, counterbalanced by judge. For both drawings, judges were told that participants were given 10 min to make an accurate drawing of the still-life (or face) and if time allowed, they could add details and shading.

For the still-life, judges were presented with the still-life and the drawings in a random order. Judges were told that they would sort the drawings into seven piles from the "best" to the "worst" drawings and that the piles did not have to be equal in size. First, judges were asked to make three piles that represented drawings that were "good," "OK," and "bad." Next, judges were asked to sort the bad pile into "very bad" and "bad" drawings. Then, judges were asked to sort the good pile into "very good" and "good" drawings. Next, judges were asked to sort the OK pile into "pretty good," "OK," and "pretty bad" drawings. Finally, judges were asked to review the seven piles and make any necessary changes. The experimenter recorded the category the drawing was placed in with 1 = "very bad" and 7 = "very good." The same procedure was followed for the face drawing with the judges being presented with the picture of the face on a laptop computer.

The ratings from the still-life and face drawings were analyzed using a Rasch statistical analysis (Rasch, 1980; Wright & Masters, 1982) in WINSTEPS (Linacre & Wright, 1991). Rasch analysis is a statistical technique that takes into the consideration both the difficulty of each survey item as well as the strictness of each judge by constructing an interval-scale metric for the accuracy of each drawing. This metric is obtained through an iterative process that minimizes the residuals between each judged drawing and each survey item. This technique produces a logit or a log-odds ratio that represents the probability that a drawing would receive a high rating from a judge on accuracy. Three judges were removed from the analyses because of poor fit. Inter-judge reliability (equivalent to a Cronbach's alpha) was .98 for the still-life and .95 for the face.

Drawing Accuracy by Group. We found performance on the two drawing tasks was highly correlated, r (79) = .849, $p < .001$. To examine whether drawing accuracy scores differed between the two groups, we ran a MANCOVA with the Rasch logit accuracy scores on the still-life and face as the dependent variables, controlling for non-verbal IQ. Art students received a higher score on the still-life (M = 63.5, SD = 13.7) than non-art students (M = 34.0, SD = 17.1), F (1, 74) = 51.510, $p < .001$, $n^2_p = .410$; art students also received a higher score on the face drawing (M = 51.1, SD = 10.9) than non-art students (M = 30.2, SD = 15.4), F (1, 74) = 32.060, $p < .001$, $n^2_p = .302$. Thus, not surprisingly, art students outperformed non-art students on both drawing tasks.

To examine whether drawing accuracy was related to performance on the visuo-spatial tasks, we ran a series of partial correlations separately for art students and non-art students, controlling for non-verbal IQ (Table 5). For the non-art students, drawing accuracy was unrelated to the performance on the visuo-spatial tasks. For the art students, only performance on the Coherent Form Task was positively related to drawing accuracy on the face but not the still-life task. Perhaps, surprisingly, this suggests that art students' drawing accuracy was related to a focus on overall form (global) and not details (local).

Finally, we examined whether drawing accuracy was related to autistic-related traits by running a series of partial correlations separately for art students and non-art students, controlling for non-verbal IQ (Table 5). For both groups, we found that autistic-related traits were unrelated to accuracy on both drawing tasks (*p*s > .05).

Copying Tasks

Because the two copying tasks were scored differently, we analyzed each task separately.

Copying Task.

Accuracy. We first examined whether the percentage of local and global features omitted on the copying task were similar for objects and non-objects. We found that the percentage of local features omitted was similar for objects and non-objects, r (79) = .552 p < .001, as was the percentage of global features omitted for objects and non-objects, r (79) = .290 p = .009. We then analyzed the mean percentage of local and global features omitted collapsing the mean percentage for objects and non-objects. Next, to examine whether the percentage of omitted features on the task differed by group, we ran a mixed design ANOVA with feature (local, global) as the within-subject factor and group as the between-subject factor.

There was an effect of feature, F (1, 79) = 20.337, $p < .001$, $n^2_p = .205$: both groups omitted a greater percentage of local features (7.5%) than global features (5.5%). There was no effect of group F (1, 79) = 3.402, $p = .069$, $n^2_p = .041$, and no interaction between group and feature, F (1, 79) = 0.307, $p = .581$, $n^2_p = .004$.

Graphic Hierarchization. As with accuracy, we first examined whether there was an association between the features copied in the first third of the drawing for objects and non-objects. Following Mottron et al (1999), we examined the percentage of local and global features copied in the first third of the copying task. We found a significant correlation between the mean percentage of local features copied for objects and non-objects, r (79) = .347, $p = .002$; and the mean percentage of global features copied for objects and non-objects, r (79) = .347, $p = .002$. Thus, we analyzed the mean percentage of local and global features copied in the first third of the drawing collapsing the objects and non-objects.

Next, we examined whether the mean percentage of features copied in the first third of the drawing differed by group by running a mixed design ANOVA with feature (local, global) as the within-subject factor and group as the between-subject factor. There was an effect of feature, F (1, 79) = 13.219, $p < .001$, $n^2_p = .143$: both groups copied more global features (53.9%) initially than local features (46.3%). There was no effect of group F (1, 79) = 0.0, $p = 1.0$, $n^2_p =$ 0.0, and no interaction between group and element F (1, 79) = 0.788, $p = .378$, $n^2_p = .010$.

Rey-Osterrieth Complex Figure. First, we found no relationship between participant's accuracy and sequencing scores on the ROCF, r (79) = .187 $p = .095$. We next examined whether accuracy on the ROCF differed by group. A one-way ANOVA revealed no difference in accuracy scores between art students ($M = 22.7$, $SD = 3.4$) and non-art students ($M = 21.1$, $SD =$ 4.5), F (1, 79) = 2.979, $p = .088$, $d = .40$. However, a one-way ANOVA did reveal a difference in sequencing scores between art students (*M* = 2.5, *SD* = 0.33) and non-art students (*M* = 2.2, *SD* = 0.31), *F* (1, 79) = 11.867, *p* = .001, *d* = .94. Art students were more likely to initially copy global elements in the first third of their drawing than non-art students.

Relationship of Copying Tasks, Drawing Accuracy, and Autistic-related Traits

Finally, we examined whether drawing accuracy on the still-life and face were related to participants' taking a local or global approach to the copying task or ROCF. First, we examined whether sequencing on the ROCF and copying tasks were correlated. We found that the ROCF sequencing score was unrelated to the local, *r* (79) = .105, *p* = .351, and global copying sequencing scores, *r* (79) = -.105, *p* = .351. We next ran a regression analysis separately for the still-life and face drawings, with accuracy on the drawing task as the dependent variable and sequencing scores on the copying task and ROCF as the independent variables. For the copying task, we only entered the percentage of local features copied in the regression since the percentage of local and global features were not mutually exclusive and one variable could be predicted from the other.

For the still-life drawing, the ROCF sequencing score (*B* = .440, *p* < .001) and not the copying task sequencing score (*B* = -.066, *p* = .523) predicted drawing accuracy. A similar finding emerged for the face drawing: the ROCF sequencing score (*B* = .503, *p* < .001) and not the copying task sequencing score (*B* = -.067, *p* = .501) predicted drawing accuracy. Thus, participants that initially took a more global approach in the ROCF received higher accuracy scores on both drawing tasks.

Finally, we examined whether having more autistic-related traits was related to a preference for initially taking a local approach to drawing on the copying task or ROCF.

Autistic-related traits were unrelated to the percentage of local features initially copied on the copying task, *r* (79) = -.037, *p* = .748, or ROCF, *r* (79) = .132, *p* = .247.

Discussion

The aim of the current study was to compare local and global processing skills in art students and non-art students. We administered two tasks that assessed local processing skills (Mental Rotation Task and Embedded Figures Test), where participants must focus on the details of a visual array and disregard the overall context, and two tasks that assessed global processing skills (Out-of-Focus Pictures and Coherent Form Task), where participants must integrate visual details of an array into a larger whole. We asked participants to copy two visual stimuli, and we coded the sequence of their marks on the page to assess whether art students initially copied the stimuli part-by-part (suggesting a local approach) or initially copied the overall shape of the stimuli (suggesting a global approach). Finally, we examined not only whether performance on the local and global processing tasks might be related to drawing ability but whether initially taking a local or global approach to copying might also be related to the ability to draw realistically.

Consistent with our hypothesis, art students outperformed non-art students on both local processing tasks. These findings are consistent with previous research that has found an artist advantage on the Embedded Figure Test (Chamberlain et al. 2019; Kozbelt, 2001; Ryder et al., 2002) and Mental Rotation Task (Chamberlain et al., 2019). Also consistent with the research literature (Chamberlain et al., 2013; Chamberlain & Wagemans, 2015; Drake et al., 2010), we found that drawing ability was positively correlated with performance on Embedded Figures Test and the Mental Rotation Task, suggesting that local processing skills are important when drawing from observation (Happé & Vital, 2009). It is important to note that while the Mental

Rotation Task does require the ability to analyze the parts of two visual stimuli to determine whether the two objects presented are the same or different, the Mental Rotation Task is not officially categorized as a local processing task. However, previous research has found a positive relation between performance on the Mental Rotation Task and other measures of local processing such as the Embedded Figures Test (Chamberlain et al., 2019) and a negative correlation with global processing tasks such as visual illusions (Chamberlain et al., 2019). The current study found a positive (albeit weak) relation between performance on these two local processing tasks. This does not rule out the possibility that the Mental Rotation Tasks is tapping into local processing abilities, but the results would need to be replicated in future work.

Consistent with our hypothesis, we also found that art students outperformed non-art students on the two global processing tasks. Whereas some previous research has found mixed evidence for artists' superior performance on the Out-of-Focus-Pictures Task (e.g., Chamberlain et al., 2019), our findings are consistent with the work of Kozbelt (2001) who showed that artists outperformed non-artists on this task. Indeed, in this study, we used the same image set as the Kozbelt study and not the image set used in the Chamberlain et al (2019) study. It would be useful in future work to administer both image sets to artists and non-artists to determine whether one image set better discriminates between these two groups. We also found that art students outperformed non-art students on the Coherent Form Task. While we did find that the global processing tasks were positively correlated, the Coherent Form Task was designed and piloted for the current study. Therefore, findings should be replicated in future work to establish whether artists consistently perform better on this new task. As with the local processing tasks, we found performance on both drawing tasks were positively related with performance on the global processing tasks.

Contrary to our hypothesis, we did not find that art students had more autistic-related traits than non-art students nor did we find that art students scored higher on Attention Detail (a subscale on the Autism-Spectrum Quotient that might potentially be related to drawing). We also found that autistic-related traits were unrelated to drawing accuracy or initially taking a local approach in the copying task. Perhaps this finding should not be surprising, given that only limited research has found an association between autistic-related traits and drawing ability. For example, one study with non-autistic children, found that drawing ability was correlated with Restricted and Repetitive Interests and Behaviors (a subscale of the autism diagnosis) but not with the total number of autistic-related traits (Drake et al., 2010). However, a subsequent study with child drawing prodigies found no relationship between drawing ability and autistic-related traits (Drake & Winner, 2018).

Also contrary to our hypothesis, we also did not find that autistic-related traits were related to performance on the local processing tasks. There is evidence demonstrating that non-autistics with high autistic-related traits excel on local processing tasks (Grinter et al., 2009; Stewart et al., 2009) but whether these individuals also are talented in the ability to draw realistically remains unknown. Thus, there might be three groups of individuals who excel on the local processing tasks: autistics, artists, and non-autistic, non-artists who have high autistic-related traits.

In addition to comparing local and global processing abilities between art students and non-art students, we also examined how local and global processing methods are deployed during the act of drawing. Do art students tend to adopt a local or a global approach when initially copying a complex figure? First, we found that art students and non-art students did not differ in accuracy in the copying task and ROCF. The former finding is consistent with previous research that has shown no difference in copying accuracy between autistics and non-autistics (Mottron et al., 1999). Indeed, the number of omitted features in our study was consistent with Mottron et al., who reported an average of 7% omitted features, versus our sample with 6.7% omitted features. The latter finding is to some extent in contrast with previous research, which found that individuals with better representational drawing ability demonstrated an advantage in copying and recalling the ROCF (Chamberlain, McManus, Brunswick, Rankin, & Riley, 2015; McManus et al., 2010). However, this may point toward a specific association between memorizing complex patterns and drawing, rather than the broader category of artistic skill.

Compared to non-art students, art students' dynamic drawing strategies showed a general bias toward favoring global features in the initial phase of the drawing task. On the ROCF, artists copied more global features in the first third of the task than local features. On the copying task, both groups, copied more global than local features in the first third of the task. Both of these findings are in contrast to the work with autistics and artistically gifted children who both showed a bias toward initially copying local features. However, our findings for the ROCF are consistent with work showing that artists view visual art using a global approach (Nodine et al. 1993; Pihko et al. 2011; Vogt & Magnussen, 2007; Zangemeister et al. 1995) and a recent study that showed that artists make more global eye movements during a drawing task (Park et al. 2021). When viewing art, non-artists are more likely to focus on individual objects while artists are more likely to focus on the background and the relationships among objects (Pihko et al. 2011). It would be interesting to examine how autistics view visual art and whether or not this differs from artists. When given the option to view either the local or global aspects of a work of art, do autistics focus on the details or do they focus on the overall form?

Finally, we found that drawing accuracy scores on both our tasks were predicted by sequencing scores on the ROCF. That is, participants who were more likely to take a global approach in copying the ROCF also had higher drawing accuracy scores, suggesting that global processing plays an important role in the ability to draw realistically. That being said, these findings may be limited to the demands of the copying task where participants were asked to copy flat two-dimensional figures that consisted of simple lines and shapes. It is unclear how generalizable this global approach would be to drawing from observation or from imagination. Future research should examine whether artists use a global approach when drawing from observation and how this might relate to their local and global processing skills.

The current study has several limitations. First, it is important to note, that in order to assess local and global processing, we administered several visuo-spatial, drawing, and copying tasks. As a result, several analyses were conducted that inevitably increased the risk of Type I error. While the differences between the art students and non-art students were strong (as evidenced by the effect sizes), it would be important for future researchers to replicate this work. Another potential limitation of this work is the difference in compensation between the art students and non-art students. Aligned with previous research (Chamberlain et al., 2019; Drake et al., 2021), art students received monetary compensation whereas non-art students received course credit. It is possible that this difference in compensation may have contributed to the results with art students potentially more engaged in the study tasks than non-art students – though it seems unlikely that monetary compensation alone would confer meaningful artistic ability on a novice sample.

Our findings suggest that art students have an attentional flexibility that allows them to excel at processing information both at the local and global level but that they initially favor a global approach in a copying task. This is consistent with the work of others that have shown that artists can easily switch between the local and global aspects of a stimulus as evidenced by performance on the Navon task (Chamberlain & Wagemans, 2015). Future work should examine whether art students' skill in drawing is a result of superior local or global processing, or vice versa. Work with artistically gifted children (Drake & Winner, 2018) suggests that local processing abilities occur even before any formal arts training. Yet we also know that whereas art students have superior visuo-spatial skills at the beginning of their training compared to non-art students, art students' skills improve with training (Chamberlain et al. 2019; Chamberlain et al., 2021). It would be interesting to track the developmental trajectory of these skills to determine which generally comes first – skill in drawing from observation or skill in local and global processing. Previous research, including the current study, included first-year art students who were in the first semester of their training Thus, it is unclear the role that training played in their superior visuo-spatial skills. In fact, there is limited evidence to suggest that there is a causal relationship between drawing training and other visuo-spatial skills (Chamberlain et al., 2015).

This research adds to and complements existing research by demonstrating that art students have both superior local and global processing skills and that art students take a dynamically different approach to copying than non-art students. While both local and global skills are important for drawing from observation, our work shows that art students initially typically take a global approach to drawing. Perhaps, this is not surprising, since global drawing strategies are often taught in drawing classes. Art instructors often instruct their students to focus on the overall proportions of a drawing, to draw negative space, or to create an overall drawing using gesture. Nevertheless, this work underscores the importance of drawing and has implications outside of the art world including those in STEM fields. Drawing stimulates the act of seeing, which in turn promotes visual imagination and visual thinking (Arnheim, 1969).

Taken together, our work demonstrates both similarities and differences in perceptual skills between artists in our study and autistics as demonstrated in the previous research literature. Both art students and autistics have superior local processing skills. Art students consistently demonstrate superior global processing skills, while autistics demonstrate superior global processing skills when the task calls for it. These two groups also take different approaches when drawing or copying: autistics favor an initially local approach, drawing part-by-part, while and art students favor a global approach, first establishing the overall structure. Such distinctions point to nuances in perceptual processing abilities as well as in the dynamic, strategic use of such processes, which promise to sharpen our understanding of skilled drawing performance in special populations and in general.

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Table 1. Perceptual and Drawing Tasks Administered to Art Students and Non-Art Students

Task	**Skilled Assessed**	**Focus**
Visuo-spatial Tasks		
Mental Rotation	Local Processing	Identify the precise location of a pair of objects
Embedded Figures	Local Processing	Identify a small shape within a complex figure
Out-of-Focus Pictures	Global Processing	Integrate degraded visual information into identifiable known objects
Coherent Form	Global Processing	Assesses lower-level Gestalt grouping of geometric shapes
Drawing and Copying Tasks		
Still-life	Drawing Accuracy	Three-dimensional drawing ability
Face	Drawing Accuracy	Two-dimensional drawing ability
Copying Task	Local or global approach to copying	Copying objects and non-objects
Rey-Osterrieth Complex Figure	Local or global approach to copying	Copying a complex figure

Table 2. Correlations between performance on the visuo-spatial tasks, non-verbal IQ, and autistic-related traits

Measure	MRT	EFT	Out-of-Focus Pictures	Coherent Form	Autistic-related Traits
Non-verbal IQ	.127	.378**	.162	.252*	.164
MRT		.179	.026	.141	.093
Embedded Figures			.401**	.165	.044
Out-of-Focus Pictures				.286*	.050
Coherent Form					-.079

Note. n = 73. MRT = Mental Rotation Task; EFT = Embedded Figure Test. $*p < .05$ $**p < .01$

Correlations were performed with the transformed Mental Rotation variable.

Table 3. Means and Standard Deviations for Accuracy on the Visuo-Spatial Tasks by Art Students and Non-Art Students

Measure	**Highest Possible Score**	**Art Students**		**Non-Art Students**				
		M	*SD*	*M*	*SD*	*F*	*p* value	n^2_p
Mental Rotation	16	13.0	2.4	10.9	3.8	6.298*	.014	.080
Embedded Figures	40	15.9	2.2	14.3	2.1	5.736*	.019	.074
Out-of-Focus Pictures	10	4.9	1.2	3.7	1.4	11.216**	.001	.135
Coherent Form	64	36.3	10.3	29.9	9.5	4.530*	.037	.059

Note. All values are presented with non-verbal IQ controlled. Values presented for the Mental Rotation Task are untransformed.

Table 4. Means and Standard Deviations for Reaction Time on the Visuo-Spatial Tasks by Art Students and Non-Art Students

Measure	**Art Students**		**Non-Art Students**				
	M	*SD*	*M*	*SD*	*F*	*p* value	n^2_p
Mental Rotation	9.1	2.8	10.5	6.9	0.749	.390	.011
Embedded Figures	6.3	1.0	6.0	1.1	0.519	.474	.008
Out-of-Focus Pictures	9.4	2.3	9.9	2.7	3.332	.072	.047
Coherent Form	1.1	0.3	1.2	0.3	1.582	.213	.023

Note. Reaction Time is presented in seconds. All values are presented with non-verbal IQ controlled. Values presented for the Mental Rotation Task are untransformed.

Table 5. Correlations between the drawing tasks and performance on the visuo-spatial tasks and autistic-related traits

Measure	Still-life Drawing	Face Drawing
Art Students		
MRT	.139	.137
EFT	.130	.042
Out-of-Focus Pictures	.170	.048
Coherent Form	.331	.501**
Autistic-related Traits	-.063	-.108
Non-Art Students		
MRT	-.005	-.086
EFT	.043	.151
Out-of-Focus Pictures	-.185	.050
Coherent Form	-.205	-.205
Autistic-related Traits	-.172	-.126

Note. Art students $n = 31$ and non-art students $n = 36$. MRT = Mental Rotation Task; EFT = Embedded Figure Test. $*p < .05$ $**p < .01$. Partial correlations were performed with the transformed Mental Rotation variable and controlling for non-verbal IQ.

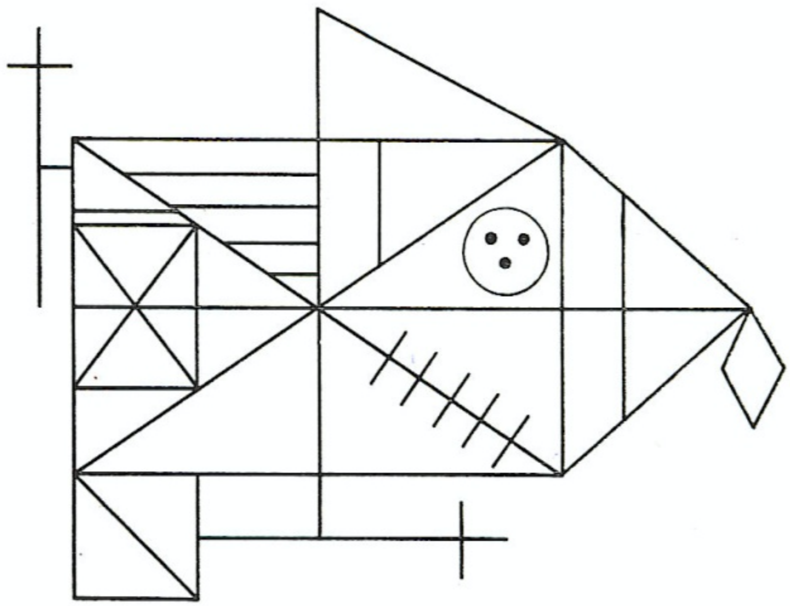

Figure 1. The Rey-Osterrieth Complex Figure.

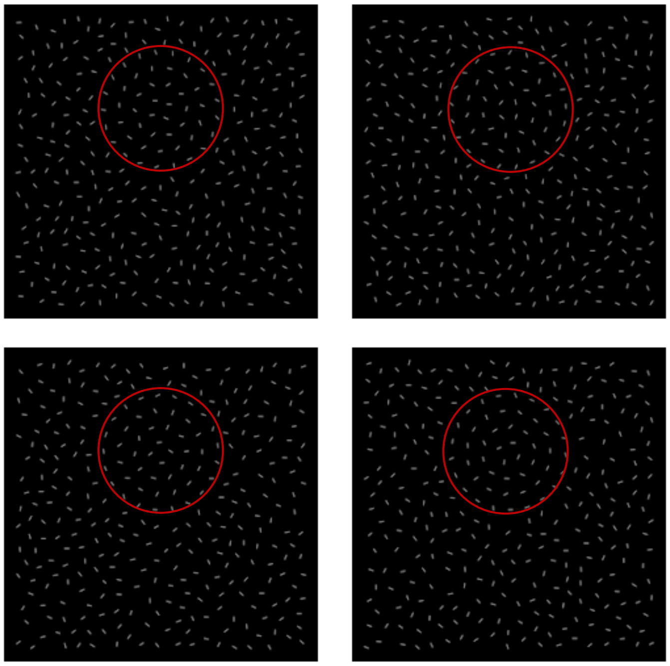

Figure 2. Example stimuli from the Coherent Form Task where the orientation of line segments vary in jitter from 56% (top, left), 40% (top, right), 24% (bottom, left) to 0% (bottom, right). In each image, the concentric circle is located at the top of the image, circled in red.

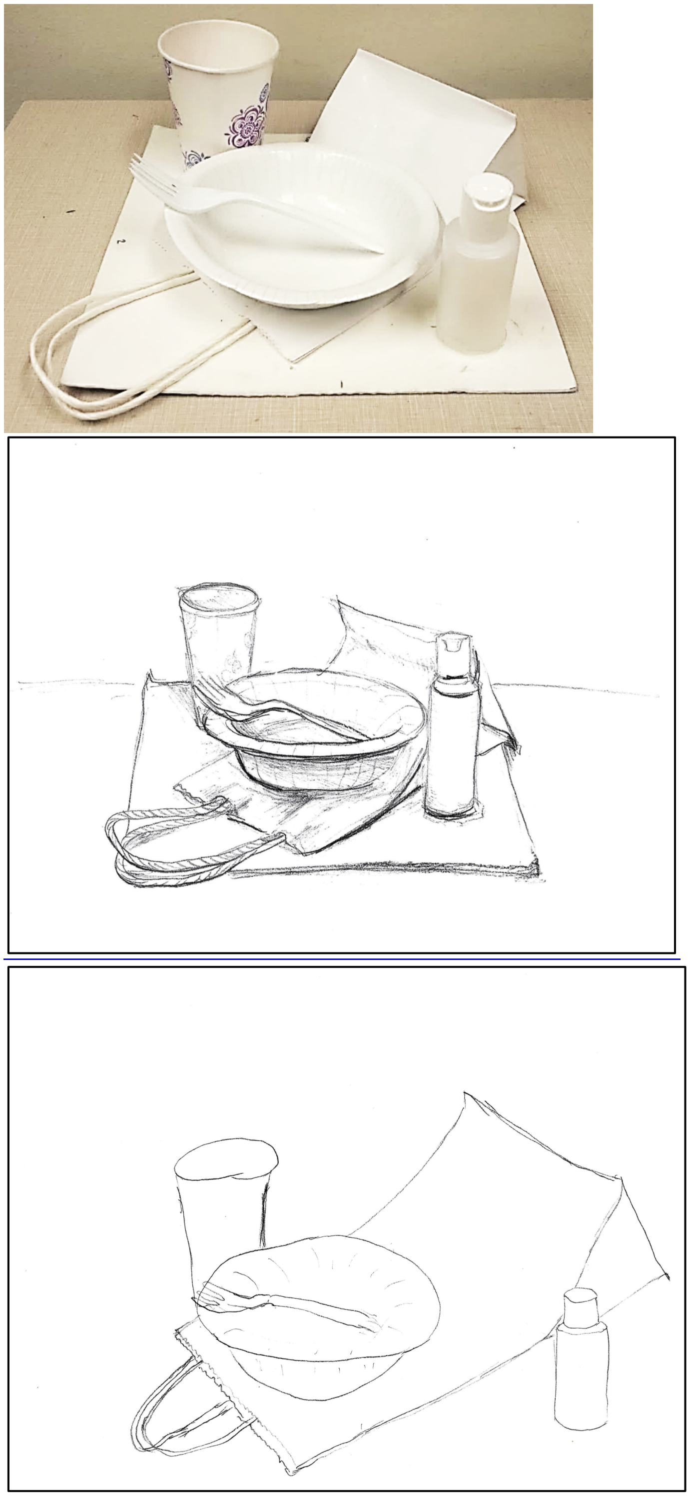

Figure 3. A photograph of the still-life (top); drawing by an art student (middle); and drawing by a non-art student (bottom).

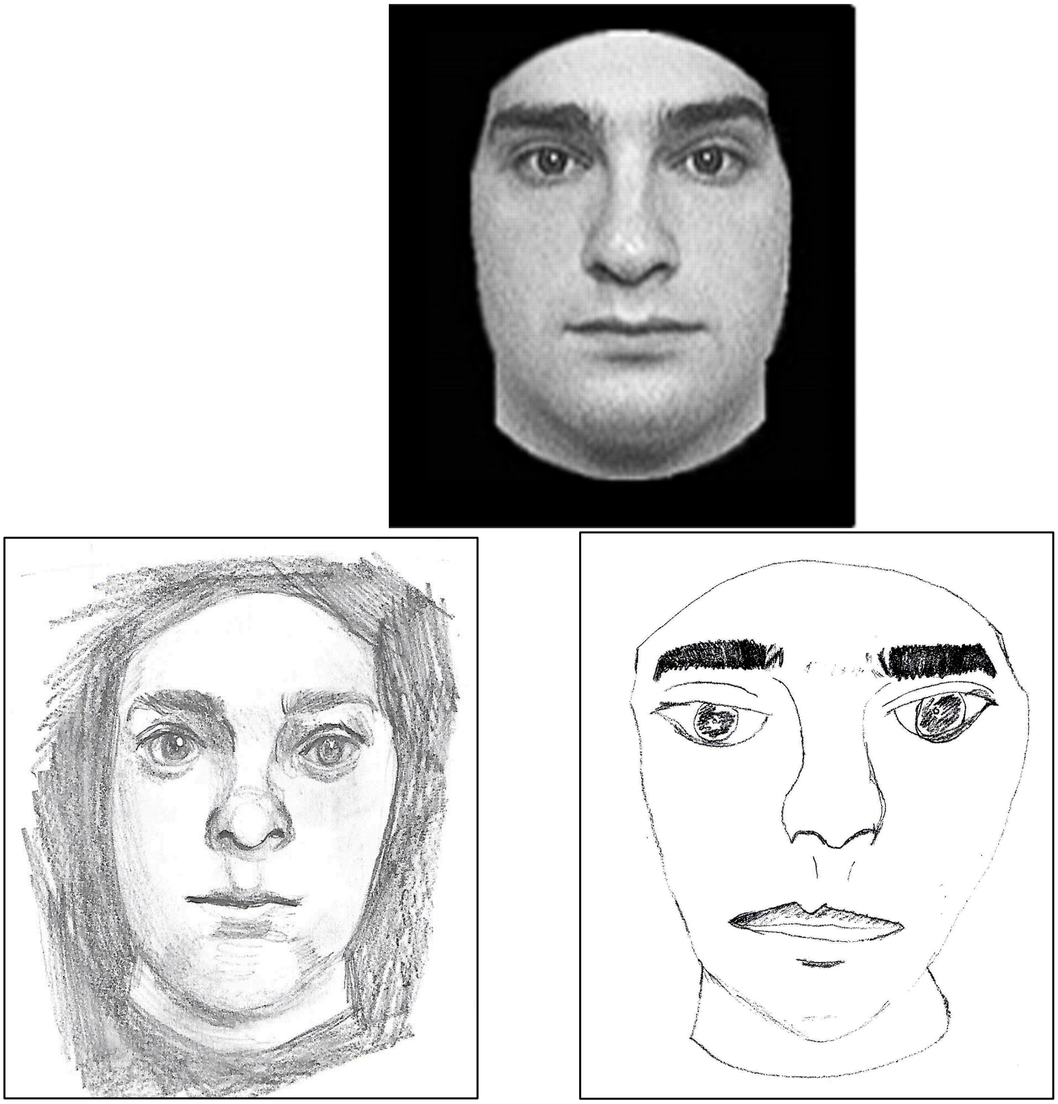

Figure 4. The face photograph (top); drawing by an art student (bottom, left); and drawing by a non-art student (bottom, right).

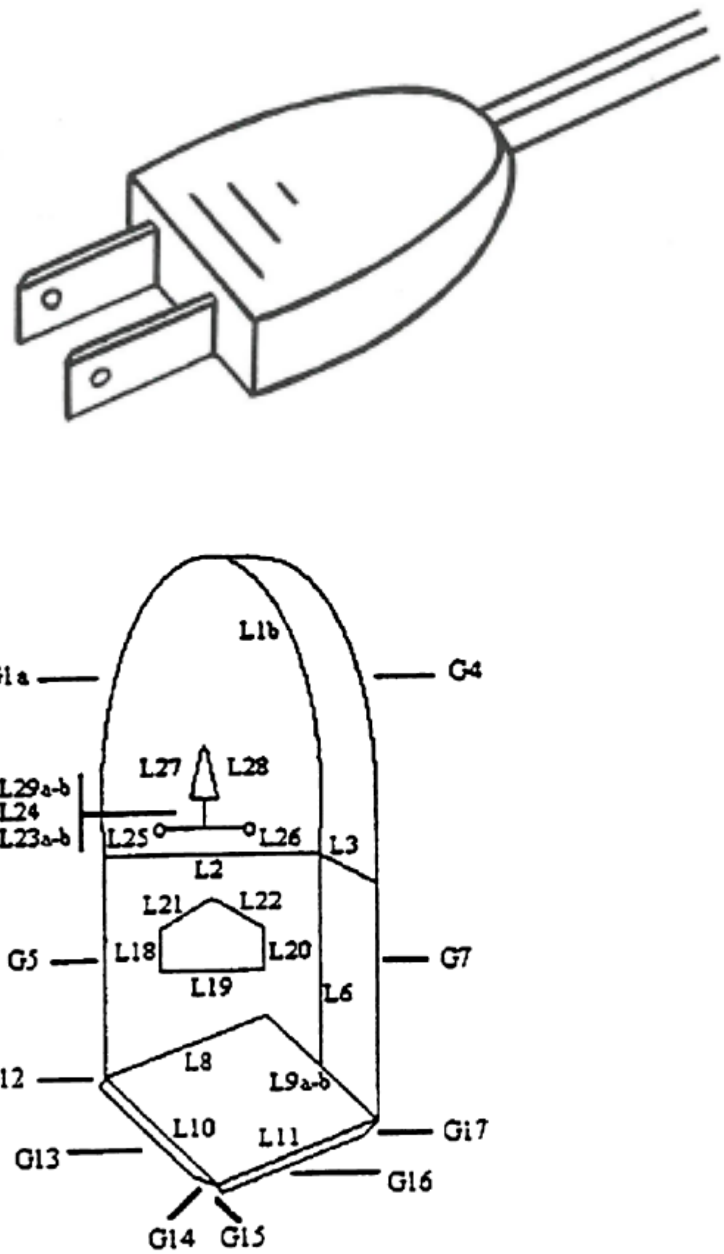

Figure 5. Examples of an object (top) and non-object (bottom). The non-object also contains the scoring procedure with each line segment labeled L for local item or G for global item.