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# Knowing how to look predicts the ability to draw realistically

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Some young children are able to create stunningly realistic drawings resembling those of adult artists. What perceptual abilities underlie this talent? This study examined two candidate skills on which adult artists excel: the ability to segment a complex form mentally (measured by the Block Design Task) and the ability to see hidden forms (measured by the Group Embedded Figures Test). Sixty-seven 6- to 13-year-olds with a wide range of drawing abilities completed these tasks as well as an IQ test and an observational drawing task. While children who scored high on drawing realism outperformed those who scored low in drawing realism on both perceptual tasks, only detection of embedded figures predicted drawing realism. This occurred independently of age, gender, years of training, and verbal and non-verbal IQ. There are certainly many contributors to this complex ability, but one component appears to be the tendency to see things more as they really are and thereby recognize the continuous contour of an object despite interference from other overlapping objects.

It is well documented that Western children's drawings become more realistic with age despite the fact that children do not typically receive much explicit instruction in drawing strategies (Bremner, Morse, Hughes, & Andreasen, 2000; Cox, 1992; Golomb, 1991; Jolley, 2010; Lange-Küttner, Kerzmann, & Heckhausen, 2002; Luquet, 1917; Milbrath, 1998; Willats, 1977; Winner, 1996). However, the ability to create a highly realistic drawing from observation is a rare skill that eludes most children as well as most adults. Children have difficulty translating information in the three-dimensional world onto a two-dimensional surface. While children as young as five can accurately trace a projection onto glass (Reith, Steffen, & Gillieron, 1997), it is not until at least the age of eight that children can mentally represent a three-dimensional object and translate it onto a two-dimensional surface (Reith & Dominin, 1997). When drawing realistically, young children also tend to rely on their schemas (intellectual realism) rather than on what they see (visual realism; Freeman & Cox, 1985; Jolley, 2010). Visual realism (drawing what one sees rather than what one knows) does not typically appear until the age of 11 or 12 (Lange-Küttner, 2011).

While the ability to represent depth on the pictorial surface is generally not seen until school age (Lange-Küttner, 1997, 2004; Willats, 1977), some children as young as four are able to create stunningly realistic drawings depicting the third dimension without having ever had instruction in drawing (Golomb, 1992; Milbrath, 1998; Winner, 1996). The drawing in Figure 1 was created by a child 4 years, 7 months of age and shows occlusion, perspective, motion, and a non-schematic rendering of the complex contours of twisting

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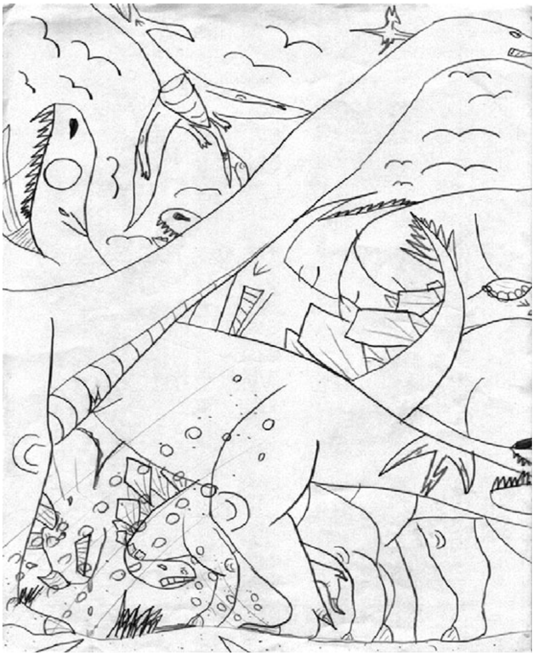

**Figure 1.** Dinosaurs, 4.7 years.

dinosaurs. Most adults cannot draw nearly as realistically as this child. I refer to such children as 'precocious realists'.

What skills make possible the ability to look at a complex three-dimensional scene and translate it so faithfully onto a two-dimensional surface? Clues to the perceptual skills underlying heightened drawing realism in children come from studies of adult artists. When compared to non-artists, adult artists excel in a wide variety of perceptual skills: visual memory (Winner & Casey, 1992); mental rotation, identification of out-of-focus pictures, completion of gestalt figures (Kozbelt, 2001); detection of embedded figures (Drake & Winner, 2011; Kozbelt, 2001); geometrical reasoning (Walker, Winner, Hetland, Simmons, & Goldsmith, 2011); and mental segmentation of complex forms, as measured by the Block Design Task (Drake & Winner, 2011). These skills could have been acquired from years spent drawing prior to admission to art school, or they could be the product of inborn talent. The earlier an association can be demonstrated between perceptual talents and drawing talent, the more likely it is that these perceptual skills are innate and are what attracts children to drawing in the first place.

There is mixed evidence that these above average skills acquired from extensive practice in analysing visual scenes translate into realistic drawing ability. Kozbelt (2001) found no differences between first- and fourth-year college art students on two of these skills (completion of gestalt figures and detecting embedded figures). While he found that fourth-year students outperformed the first-year students in identifying out-of-focus pictures (suggesting a training effect), the reverse was found for the mental rotation task.

There is evidence that perceptual skills are related to certain characteristics of gifted children's drawings. Level of drawing realism in children has been shown to be related to performance on both the Group Embedded Figures Test (GEFT) and the Block Design Task (Drake, Redash, Coleman, Haimson, & Winner, 2010). The GEFT assesses the ability to focus on object shape unaffected by surrounding details in the context; the Block Design Task assesses the ability to look at a complex form and analyse it mentally into its component parts. Both tasks would seem to assess perceptual skills that artists need if they are to translate a complex three-dimensional form onto a flat surface.

These findings are consistent with studies of typical drawing development in relation to spatial skills: Toomela (2002) found that Block Design performance was predictive of drawing realism in typical children. Lange-Küttner and Ebersbach (2013) found that performance on the embedded figures test was predictive of boys' ability to draw two cubes in the third dimension: higher performance on the embedded figures test was associated with the drawing of volume, but not occlusion (drawing the cubes as overlapping). In contrast, Morra (2002) had earlier reported that performance on the embedded figures test predicted children's drawing of occluded objects.

Drake *et al.*'s (2010) finding that skill on both the embedded figures and block design were predictive of realism was determined by regressing level of drawing realism onto each perceptual outcome separately. Because drawing realism was regressed onto each of these two skills separately, it could not be determined whether both of these perceptual skills make an equal contribution to drawing realism or whether these skills are confounded with age, gender, IQ, or years of training. Therefore, using an expanded sample that included the Drake *et al.* sample, the present study tested whether these two skills predict level of drawing realism independently of age, gender, IQ, and years of training, and whether these skills each make an independent contribution to level of drawing realism. The drawing measure included an assessment of four subskills: foreshortening, occlusion, detail, and use of line to stand for the edge of an object rather than the object itself. The goal was to test whether these drawing characteristics were related to skill in finding embedded figures and/or copying block designs.

The following was hypothesized: (1) children with talent in drawing realism should have superior mental segmentation skill as measured by the Block Design Task and superior visual observation skill as measured by the GEFT when compared to children not talented in drawing realism; (2) these two skills should each independently predict level of drawing realism overall as well as each of the four characteristics of drawing measured; and (3) neither age, gender, years of training, verbal IQ, nor non-verbal IQ should predict drawing realism.

Finally, gender was regressed onto each of the four drawing characteristics. It was hypothesized that boys might outperform girls in the depiction of occlusion (consistent with Morra, 2002), while girls might outperform boys in the prioritized use of detail rather than capturing the silhouette of the object (consistent with the work of Goodenough, 1926; Goodenough & Harris, 1950; Lange-Küttner, 2011; Lange-Küttner & Ebersbach, 2013; Lange-Küttner *et al.*, 2002; Lange-Küttner, Küttner, & Chromekova, 2013). No gender differences were predicted for the use of foreshortening (consistent with Lange-Küttner, 1997, 2004, 2009) or line as edge.

## Method

Participants were 67 children[1] (31 boys, 36 girls) between the ages of 6–13 ($M$ = 9.2 years, $SD$ = 1.10) recruited from local schools, a children's museum, and after-school art programs.

[1] *Children in this study included the 27 children who were participants in the Drake* et al. *(2010) study.*

### Materials and procedure

Children were seen individually by the experimenter either in their home, their after-school art programme, a children's museum, or the laboratory. Testing sessions lasted about 1 hr. For all tasks, child and experimenter were seated adjacently at a table. Tasks were administered in the following order: Block Design, Drawing, GEFT, and Kaufman Brief Intelligence Test-II. Children received a $20 gift card for participating.

### Measures

#### Block Design Task

The Block Design Task requires the ability to analyse a two-dimensional red and white geometric design and to reconstruct the pattern using a set of red and white blocks. This task requires mental segmentation of the design so as to determine which block matches which segment of the design. A comparison of performance on the traditional presentation of the task in which the design is presented in 'unsegmented' form with performance on a segmented version of the task with the units of the design separated from one another by one third of the width of each unit reveals the extent to which children benefit from external segmentation (Shah & Frith, 1993). A modified version of the Block Design Task developed by Caron, Mottron, Berthiaume, and Dawson (2006) was used in which the designs vary in perceptual cohesiveness (minimal, intermediate, and maximal) and number of blocks (4, 9, and 16). In the items with minimal perceptual cohesiveness, the boundary between red and white always co-occurs with the edge separating two blocks, making it easy to see each block as a unit. Minimally cohesive items are easily solvable by matching each square to a block and do not require the ability to analyse a whole into its parts because the parts clearly emerge from the figure to be reproduced. In the items with maximal perceptual cohesiveness, the boundary between red and white never co-occurs with the edge separating two blocks, making it difficult to see the contribution of each block as a unit. Maximally cohesive items require analysis of a whole into its parts by spontaneous mental segmentation since the edges do not provide segmentation information. Those intermediate in perceptual cohesiveness have approximately 50% same coloured adjacencies.

Children completed the unsegmented version followed by the segmented version, with nine items in each. The unsegmented version was always administered first to avoid a facilitation effect (Caron *et al.*, 2006; Shah & Frith, 1993). The time limit differed by the number of blocks used: 120, 180, and 240 s for 4, 9, and 16 blocks, respectively. For each matrix size and each presentation form (unsegmented, segmented), a motor-skill control item was administered in which children had to use red blocks to copy an all red design. All children performed at ceiling on the motor control items, allowing motor skill to be ruled out as a relevant factor in children's performance on the Block Design. Children received a point for each design correctly copied.

An unsegmented accuracy score was computed by totalling the number of correctly copied designs for the unsegmented items across size (4, 9, and 16 blocks) and perceptual cohesiveness (minimal, intermediate, and maximal). A similar score was computed for the segmented items. A segmentation accuracy difference score was then computed by subtracting the segmented accuracy score from the unsegmented accuracy score (following Drake *et al.*, 2010; Drake & Winner, 2011). As discussed by Zumbo (1999), the use of a difference score is an adequate measure to reflect change. A negative score indicates superior performance on the easier segmented version, while a positive score indicates superior performance on the more difficult unsegmented version. Scores could range from a negative to a positive number. The closer the score is to zero, the more equivalent performance is on both tasks, and thus, the less performance is shown to be facilitated by external segmentation.

### *Group Embedded Figures Test*

The GEFT (Witkin, Oltman, Raskin, & Karp, 1971) requires the ability to identify and outline a smaller geometric shape embedded within a larger figure. The test consists of seven control items in which one must trace a shape that is easily detected followed by 18 test items. Children were instructed to trace the shape completely and erase mistakes. A point was given for each correctly outlined shape, for a maximum score of 18. The test was given in untimed format.

### *Drawing task*

An ecologically valid observational drawing task from Drake *et al.* (2010) was administered. Children were given a 9″ × 11″ sheet of white paper and a sharp pencil with an eraser and asked to draw a still-life consisting of three complex shapes: a corkscrew, five connected transparent cylinders, and a branch of dried leaves inside one cylinder (Figure 2). Children were given 15 min to 'look at the still-life and draw what you see'.

Drawings were scored for features characteristic of precocious realists' drawings (Milbrath, 1998; Winner, 1996): use of line to indicate the edge of an object (a drawing convention) rather than using a line to stand for the object itself (outlining the screw part of the corkscrew or the stem of the leaves with two lines rather than drawing the screw or stem as one line slash see; Figure 3); detail (drawing at least one square-shaped rather than rounded corkscrew gear, drawing at least one organically shaped leaf rather than only schematic circles; see Figure 4); foreshortening (shortening the corkscrew, which was lying down and viewed frontally, drawing the tops of the cylinders as ellipses rather than circles; see Figure 5); and occlusion (showing depth by partially covering one part of the corkscrew or a cylinder by another cylinder; see Figure 6).

One point was awarded for each demonstrated feature, for a total possible score of eight (four features x two objects). Children who did not draw the corkscrew, vase, and leaves ($n = 10$) were excluded from the analyses. The children in the excluded sample ($n = 10$) did not differ from the final sample ($n = 57$) in terms of gender, age, or verbal and non-verbal IQ ($p > .3$). However, the excluded sample did complete more years of art training than the final sample (2.8 vs. 1.4 years, $p = .014$). The excluded sample did spend more time analysing the still-life and planning their drawings. Thus, it is possible that the excluded sample could consist of a set of skilled drawers who did not have enough time to finish the still-life.

A proportion score was created by dividing the number of correct features drawn by total number drawn, which yielded scores between 0.0 and 1.0. Two coders scored all drawings, with inter-rater reliability of $\Phi = 0.92$. Disagreements were resolved by consensus. Figure 2 shows a drawing with a perfect score of 1.0 (top) and another with a lower score of 0.22 (bottom).

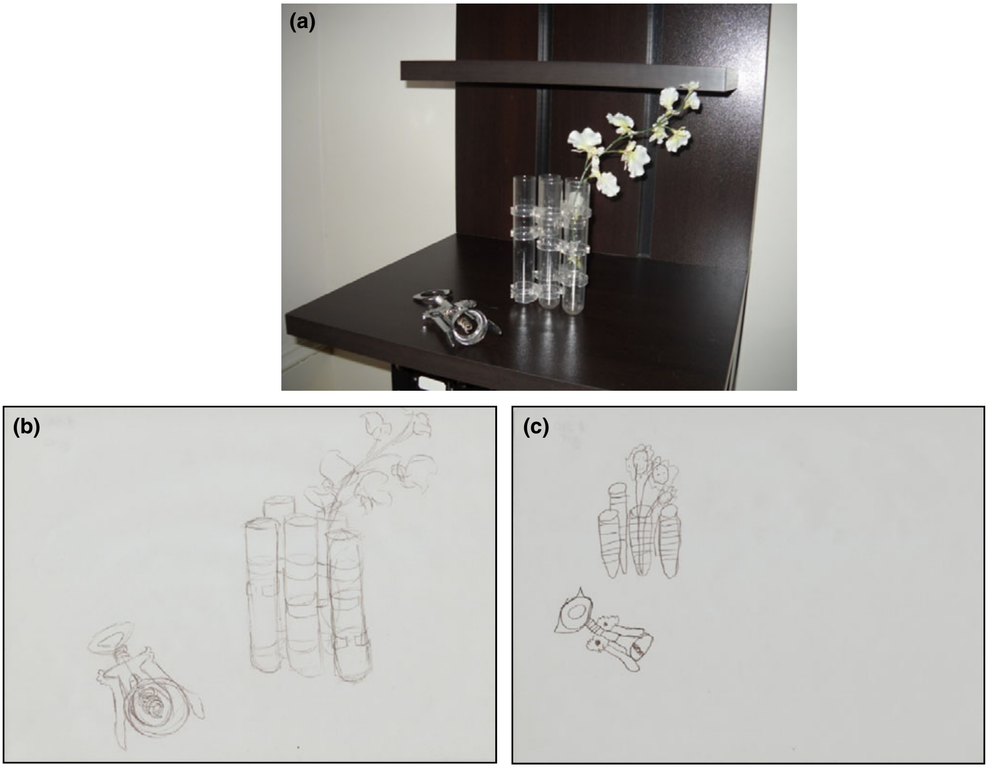


**Figure 2.** (a) A photograph of the still-life children was presented with (b) a child who drew all of the elements (line as edge, detail, foreshortening, and occlusion) and received a score of 1.0 out of 1.0 and (c) a child whose drawing received a score of 0.22 out of 1.0.

*Kaufman Brief Intelligence Test-II*

The verbal and non-verbal sections of the Kaufman Brief Intelligence Test-II (Kaufman & Kaufman, 2004) were administered. The verbal section consists of a vocabulary test with pictures of objects to be named and a definitions test in which a written word with missing letters must be inferred after hearing its definition. The non-verbal section requires completing matrices by perceiving relationships within the matrix. Age-scaled scores were computed.

*Years of art training*

Parents were asked to report years of art classes taken by their children.

## Results

Means and standard deviations for all outcome variables by gender are shown in Table 1. Children had an average of 1.4 years of art lessons ($SD$ = 1.6), a verbal IQ of 112.2 ($SD$ = 10.2), and a non-verbal IQ of 115.3 ($SD$ = 15.8). Children copied an average of 6.4 ($SD$ = 2.7) items on the unsegmented and 7.9 ($SD$ = 1.3) items on the segmented version of the Block Design Task and found an average of 7.3 ($SD$ = 5.7) figures on the GEFT. The average drawing realism score was 0.47 ($SD$ = .30).

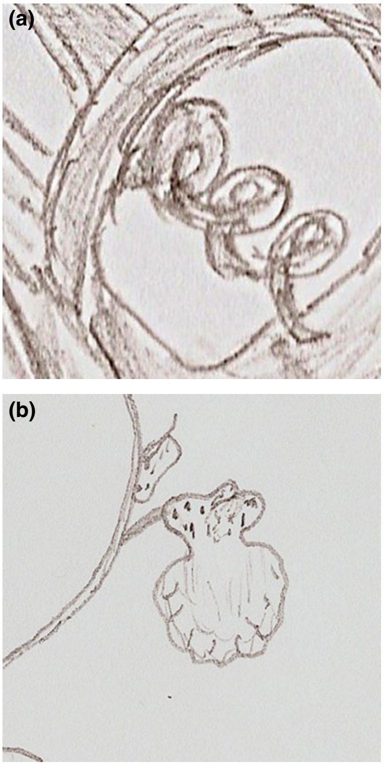

**Figure 3.** Line as edge: (a) curlicue of the corkscrew drawn with two lines; (b) the stem of the stalk of leaves drawn with two lines.

***Do children gifted in drawing realism show superior perceptual skills?***

The sample was first divided into two groups. Those in the highest third of drawing realism scores ($n = 19$) were compared to the rest of the sample ($n = 38$). While a median split would have allowed for the comparison of above average versus below average drawing abilities, dividing the sample into the highest third versus the rest of the sample allowed for the comparison of children with superior drawing abilities versus those that drew at an age typical level. The gifted group had nine girls and 10 boys ages 6.5–13.7; the non-gifted group had 21 girls and 17 boys ages 6.1–12.2. The mean drawing realism score for the gifted group was .81 ($SD = .14$) and for the non-gifted group was .30 ($SD = .19$).

Table 1 also presents the means and standard deviations for all variables for the gifted and non-gifted groups by gender. A univariate ANOVA by group (2) and gender (2) was run to determine whether there were any differences in age, years of training, verbal IQ, and non-verbal IQ. The gifted group was significantly older than the non-gifted group $F(1, 53) = 16.490, p < .001$; and this was found for both boys and girls. While age may be seen as the most plausible explanation for giftedness in visual realism, age would also be the most obvious explanation. The explanation was tested further by pitting age against other variables in subsequent analyses. The gifted group had a higher non-verbal IQ than the non-gifted group, $F(1, 53) = 15.143, p < .001$: boys in the gifted group had a significantly higher non-verbal IQ than boys in the non-gifted, $F(1, 25) = 14.442 p = .001$, while girls in the gifted group had a marginally higher non-verbal IQ than girls in the non-gifted group,

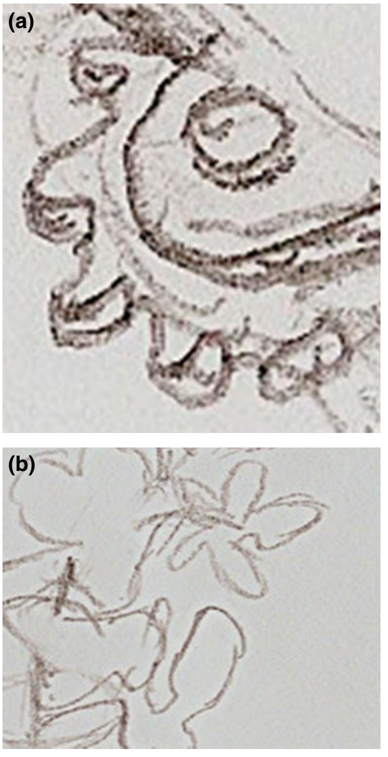


**Figure 4.** Detail: (a) at least one square-shaped gear; (b) at least one organic- and irregular-shaped leaf.

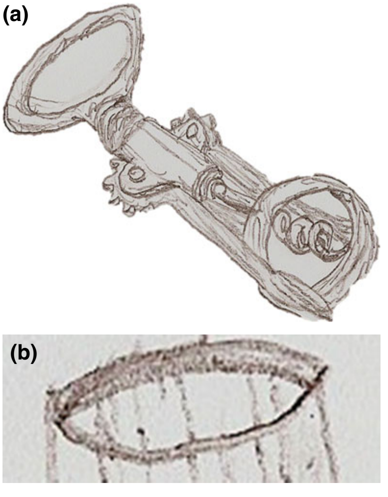


**Figure 5.** Foreshortening: (a) shortening the corkscrew; (b) drawing the tops of the vases as ellipses and not circles.

$F(1, 28) = 3.758$, $p = .063$. There were no effects of gender (all $p$-values > .05) and no interaction of group x gender (all $p$-values > .05).

A multivariate ANOVA by group and gender was then performed on the segmentation accuracy difference score and the Group Embedded Figures accuracy score. Segmenta-

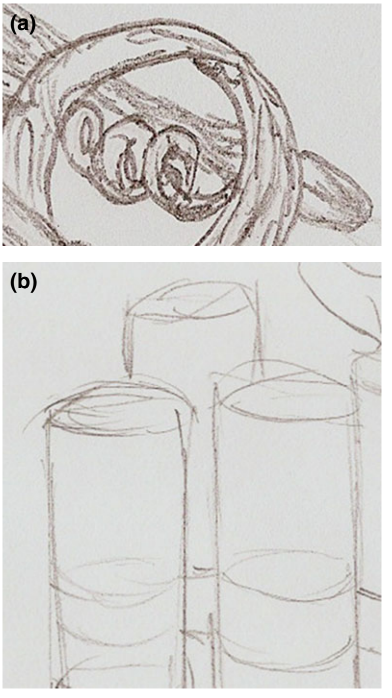


**Figure 6.** Occlusion: (a) showing depth by partially covering one part of the corkscrew; (b) drawing one of the cylinders behind another.

tion accuracy difference scores were higher for the gifted than the non-gifted group ($M = -.6$ vs. $-1.9$), $F(1, 53) = 5.341$, $MSE = 4.903$, $p = .025$, $n_p^2 = .092$. This occurred because the gifted group performed nearly equivalently on both versions of the task and was therefore helped less by segmentation relative to the non-gifted group. The gifted group also had higher scores than the non-gifted group ($M = 12.2$ vs. 4.8) on the GEFT, $F(1, 53) = 34.658$, $MSE = 19.824$, $p < .001$, $n_p^2 = .395$. There were no effects of gender (all $p$-values $> .05$) and no interaction between group $\times$ gender (all $p$-values $> .05$).

### *Predictors of drawing realism*

The next analysis examined whether these two perceptual factors, the Block Design segmentation accuracy difference scores and Group Embedded Figures accuracy scores, predicted drawing realism score independently of one another and independently of other non-perceptual factors.

First, correlations were performed between the perceptual and non-perceptual predictor variables (Table 2). Performance on the GEFT was significantly correlated with age, years of training, verbal and non-verbal IQ, and the segmentation accuracy difference score. In addition to the GEFT, the segmentation accuracy difference score was significantly correlated with age, verbal and non-verbal IQ, but not years of training. Non-verbal IQ was significantly correlated with age and verbal IQ, while years of training was significantly correlated with age.

Correlations were also performed between the perceptual and non-perceptual predictor variables separately for boys (Table 3) and girls (Table 4). For both boys and

**Table 1.** Means and standard deviations for the Block Design Task, Group Embedded Figures Test, and drawing realism score for all children and for the gifted and non-gifted groups

| | All children | Gifted group | Non-gifted group | $\chi^2$ | *p* | |
|---|---|---|---|---|---|---|
| *n* | 57 | 19 | 38 | | | |
| Gender | | | | | | |
| Boys | 27 | 10 | 17 | 0.317 | .574 | |
| Girls | 30 | 9 | 21 | | | |
| | M (*SD*) | M (*SD*) | M (*SD*) | Group (F) | Gender (F) | Group by gender (F) |
| Age | 9.2 (1.10) | 10.5 (1.9) | 8.6 (1.7) | 16.490*** | 0.001 | 0.05 |
| Boys | 9.2 (2.1) | 10.6 (2.1) | 8.5 (1.8) | 7.704* | | |
| Girls | 9.1 (1.9) | 10.4 (1.6) | 8.7 (1.7) | 8.878** | | |
| Years of Training | 1.4 (1.6) | 1.9 (1.9) | 1.1 (1.4) | $2.827^t$ | 0.158 | 0.1 |
| Boys | 1.5 (1.8) | 2.1 (2.1) | 1.1 (1.5) | 1.722 | | |
| Girls | 1.3 (1.5) | 1.7 (1.8) | 1.1 (1.4) | 1.086 | | |
| Verbal IQ | 112.2 (10.2) | 114.9 (11.1) | 110.8 (9.6) | 2.338 | 0.394 | 1.331 |
| Boys | 110.8 (10.2) | 115.6 (11.3) | 108.0 (8.6) | $3.905^t$ | | |
| Girls | 113.4 (10.2) | 114.1 (11.5) | 113.0 (9.9) | 0.066 | | |
| Non-verbal IQ | 115.3 (15.8) | 125.6 (15.6) | 110.1 (13.2) | 15.143*** | 0.031 | 0.838 |
| Boys | 115.6 (15.6) | 127.7 (13.2) | 108.5 (12.4) | 14.442** | | |
| Girls | 115.0 (16.1) | 123.3 (18.4) | 111.4 (14.0) | $3.758^t$ | | |
| Block Design Task Unsegmented | 6.4 (2.7) | 7.7 (2.0) | 5.8 (2.8) | 8.561** | 1.402 | $3.434^t$ |
| Boys | 5.85 (3.1) | 7.9 (2.3) | 4.7 (2.9) | 9.113** | | |
| Girls | 6.9 (2.1) | 7.4 (1.7) | 6.7 (2.3) | 0.743 | | |
| Block Design Task Segmented | 7.9 (1.3) | 8.3 (0.9) | 7.7 (1.4) | 2.308 | 0.171 | 1.469 |
| Boys | 7.8 (1.5) | 8.4 (1.1) | 7.4 (1.7) | 2.82 | | |
| Girls | 8.0 (1.1) | 8.1 (0.6) | 8.0 (1.2) | 0.066 | | |
| Group Embedded Figures Test | 7.3 (5.7) | 12.2 (5.0) | 4.8 (4.2) | 34.658*** | 0.879 | $3.017^t$ |
| Boys | 7.8 (6.3) | 13.8 (4.8) | 4.2 (3.9) | 31.260*** | | |
| Girls | 6.8 (5.1) | 10.4 (4.9) | 5.2 (4.5) | 8.104** | | |
| Drawing Realism Score | 0.47 (0.30) | 0.81 (0.14) | 0.30 (0.19) | 108.589*** | 1.436 | 0.476 |
| Boys | 0.51 (0.32) | 0.85 (0.15) | 0.31 (0.18) | 66.501*** | | |
| Girls | 0.43 (0.28) | 0.76 (0.13) | 0.29 (0.20) | 44.491*** | | |

*Note.* $^t p < .10$; $^* p < .05$; $^{**} p < .01$; $^{***} p < .001$; 1 *df* for group, 1 *df* for gender, and 1 *df* for group by gender.

**Table 2.** Pearson product-moment correlation matrix of the predictors for drawing realism score

| Variable | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| 1. Age | | | | | |
| 2. Years of Training | .376** | | | | |
| 3. Verbal IQ | .244 | .257 | | | |
| 4. Non-verbal IQ | .331* | .193 | .508*** | | |
| 5. Segmentation Difference Score | .486*** | .238 | .341** | .436** | |
| 6. Group Embedded Figures Test | .681*** | .378** | .474*** | .711*** | .620*** |

*Note.* *$p < .05$; **$p < .01$; ***$p < .001$.

**Table 3.** Pearson product-moment correlation matrix of the predictors for drawing realism score for boys

| Variable | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| 1. Age | | | | | |
| 2. Years of Training | .485* | | | | |
| 3. Verbal IQ | .478* | .159 | | | |
| 4. Non-verbal IQ | .505** | .026 | .450* | | |
| 5. Segmentation Difference Score | .676** | .278 | .358$^{t}$ | .497** | |
| 6. Group Embedded Figures Test | .751** | .428* | .545** | .644** | .668** |

*Note.* *$p < .05$; **$p < .01$.

**Table 4.** Pearson product-moment correlation matrix of the predictors for drawing realism score for girls

| Variable | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| 1. Age | | | | | |
| 2. Years of Training | .236 | | | | |
| 3. Verbal IQ | .010 | .383* | | | |
| 4. Non-verbal IQ | .154 | .365* | .571** | | |
| 5. Segmentation Difference Score | .205 | .218 | .306 | .413* | |
| 6. Group Embedded Figures Test | .434* | .306 | .438* | .796** | .632** |

*Note.* *$p < .05$; **$p < .01$.

girls, performance on the GEFT was significantly correlated with age, verbal and nonverbal IQ, and the segmentation accuracy difference score. For boys but not girls, performance on the GEFT was also correlated with years of art training. In addition to the GEFT, the segmentation accuracy difference score was significantly correlated with age and non-verbal IQ for boys but only non-verbal IQ for girls. For boys, non-verbal IQ was significantly correlated with age and verbal IQ, while years of training and verbal IQ was significantly correlated with age. For girls, non-verbal IQ was significantly correlated with verbal IQ and years of training, while verbal IQ was significantly correlated with years of training.

**Table 5.** Regression coefficients for drawing realism score

| Predictors | β | *t* | *p* | *VIF* |
|---|---|---|---|---|
| Age | .170 | 1.333 | .189 | 1.78 |
| Gender | −.067 | −0.651 | .518 | 1.14 |
| Years of Training | .027 | 0.252 | .802 | 1.25 |
| Verbal IQ | −.009 | −0.079 | .937 | 1.48 |
| Non-verbal IQ | .013 | 0.093 | .926 | 2.29 |
| Group Embedded Figures Test | .636** | 3.429 | .001 | 3.77 |
| Segmentation Difference Score | −.059 | −0.458 | .649 | 1.84 |
| $F$ ($df_1$, $df_2$) | 8.614 (7, 49) | | | |
| $R^2$ | .552*** | | | |

*Note.* VIF, Variance Inflation Factors. ** $p < .01$; *** $p < .001$.

**Table 6.** Pearson product-moment correlation matrix of the four drawing characteristics

| Variable | 1 | 2 | 3 |
|---|---|---|---|
| 1. Foreshortening | | | |
| 2. Occlusion | .616*** | | |
| 3. Detail | .439** | .368** | |
| 4. Line as Edge | .443** | .466*** | .410** |

*Note.* ** $p < .01$; *** $p < .001$.

As the perceptual and non-perceptual predictor variables were highly intercorrelated a regression was performed to determine which variable was the best predictor of overall drawing realism score. The segmentation accuracy difference score and Group Embedded Figures accuracy scores were regressed onto drawing realism scores, along with age, gender (boys = 0; girls = 1), years of training, verbal IQ, and non-verbal IQ (Table 5).[2] All variables were entered into the regression at the same time. Examination of the variance inflation factors (VIF) for the predictor variables indicated that there was no issue with multicollinearity: all VIFs were <4.0 (Cohen, Cohen, West, & Aiken, 2002).

Age ($p = .189$), gender ($p = .518$), years of training ($p = .802$), verbal IQ ($p = .937$), and non-verbal IQ ($p = .926$) proved unrelated to drawing realism. However, surprisingly and contrary to the hypotheses, the two kinds of perceptual skills were not both associated with drawing realism. While accuracy on the GEFT was strongly associated with drawing realism score ($\beta = .636, p = .001$), the Block Design segmentation accuracy difference score proved unrelated ($p = .649$).

The final analysis examined whether these two perceptual skills (GEFT and Block Design segmentation accuracy difference score) predicted the four drawing characteristics – foreshortening, occlusion, detail, and line as edge. Table 6 presents a correlation matrix of the four drawing characteristics. Because the four subscores were highly correlated, a regression was conducted separately for each drawing characteristic score as the dependent measure. The independent variables were segmentation accuracy difference score, Group Embedded Figures accuracy score, age, gender (boys = 0;

[2] *Because accuracy on the control items of the GEFT was not a significant predictor of drawing realism score, control scores were not included in the regression model.*

girls = 1), years of training, verbal IQ, and non-verbal IQ. All independent variables were entered into the regression at the same time.

### *Occlusion*

Accuracy on the GEFT was strongly associated with occlusion ($\beta = .738, p = .001$), while the Block Design segmentation accuracy difference score ($p = .291$) proved unrelated (as well as to the other drawing characteristics). Verbal IQ marginally predicted occlusion ($\beta = -.254$, $p = .066$), and none of the other entered variables, age ($p = .392$), gender ($p = .230$), years of training ($p = .489$), or non-verbal IQ ($p = .312$), were related to occlusion (Table 7).

### *Line as edge*

Accuracy on the GEFT ($\beta = .546$, $p = .022$) and gender ($\beta = .285$, $p = .030$) were strongly associated with line as edge. Being female predicted the line as edge subscore. Neither the Block Design segmentation accuracy difference score ($p = .945$) nor any of the other entered variables, age ($p = .467$), years of training ($p = .874$), verbal IQ ($p = .906$), or non-verbal IQ ($p = .957$), were related to line as edge.

### *Foreshortening*

None of the independent variables were related to foreshortening.

### *Detail*

None of the independent variables were related to detail.

## Discussion

The ability to draw in a highly realistic manner is rare in both children and adults. However, some children are able to draw with striking realism at a very young age with seeming ease. This study investigated what other characteristics are associated with this ability. Consistent with previous studies of adult artists (Kozbelt, 2001; Walker *et al.*, 2011; Winner & Casey, 1992), results showed that children gifted in drawing realism possess heightened perceptual skills. They are better able to segment a complex form mentally (as measured by the Block Design Task) and better able to ignore context and detect a hidden figure (as measured by the GEFT). However, the current study went on to show that only one of these skills actually contributes to drawing realism – knowing how to look carefully so that one can detect the contours of a figure when it is 'hidden' by other overlapping figures. Knowing how to look was associated with drawing realism independently of age, gender, verbal and non-verbal IQ, and years of training. This was found despite the fact that the gifted group had a higher non-verbal IQ than the non-gifted group.

Consistent with hypothesis, accuracy on the GEFT predicted skill at occlusion and line as edge. The finding for occlusion is consistent with the work of Morra (2002) who found that the embedded figures test predicted the use of occlusion. Lange-Küttner and Ebersbach (2013) found that it was not the embedded figures test that predicted the use of occlusion; instead, it was the mental rotation task. Mental rotation and drawing a partially

**Table 7.** Regression coefficients for the drawing characteristics

| Predictors | Foreshortening | | | Occlusion | | | Detail | | | Line as edge | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | β | *t* | *p* | *B* | *t* | *p* | *B* | *t* | *p* | β | *t* | *p* |
| Age | −.153 | −0.873 | .387 | −.128 | −0.864 | .392 | −.013 | −0.075 | .941 | −.116 | −0.733 | .467 |
| Gender | −.005 | −0.035 | .972 | .144 | 1.216 | .230 | .037 | 0.263 | .794 | .285* | 2.239 | .030 |
| Years of Training | .111 | 0.756 | .453 | .087 | 0.697 | .489 | .228 | 1.534 | .132 | .021 | 0.159 | .874 |
| Verbal IQ | −.202 | −1.266 | .211 | −.254$^t$ | −1.878 | .066 | −.124 | −0.764 | .448 | .017 | 0.119 | .906 |
| Non-verbal IQ | .080 | 0.401 | .690 | −.172 | −1.021 | .312 | .096 | 0.479 | .634 | .010 | 0.054 | .957 |
| Group Embedded Figures Test | .380 | 1.489 | .143 | .738** | 3.424 | .001 | −.010 | −0.038 | .970 | .546* | 2.367 | .022 |
| Segmentation Difference Score | .067 | 0.379 | .707 | .161 | 1.067 | .291 | .238 | 1.323 | .192 | −.011 | −0.070 | .945 |
| $F$ ($df_1$, $df_2$) | 1.268 (7, 49) | | | 4.585 (7, 49) | | | 1.081 (7, 49) | | | 3.087 (7, 49) | | |
| $R^2$ | .153 | | | .396** | | | .134 | | | .306** | | |

*Note.* $^t p < .10$; $*p < .05$; $**p < .01$.

occluded object may make similar demands: both require ascertaining features of an object that are not visible. Consistent with the work of Lange-Küttner (1997, 2004, 2009), and as hypothesized, gender did not predict the use of foreshortening. However, contrary to hypothesis, being a boy did not predict the use of occlusion and being a girl did not predict the use of detail. There was also not a single predictor for foreshortening or detail. Hence, the predictor variables proved unrelated to these two aspects of drawing.

Surprisingly, being a girl predicted the use of line as edge (drawing the stem of the leaf and curlicue of the corkscrew as two lines instead of one). No gender differences had been predicted for line as edge. Using line to represent the edge of an object requires an understanding of the conventions of drawing. When a line stands for an object (e.g., using a line to represent the stem of a plant), we have a one-dimensional representation of the object. When a line is used to stand for the edge of an object (e.g., using a line to represent each of the two edges of the stem), the object is depicted as a two-dimensional object. No previous work has found gender differences in this understanding. While Lange-Küttner and Ebersbach (2013) found that boys were more likely to draw object shape (the silhouette of the object) than girls, the current study focused on a different skill – the ability to create two-dimensional shapes rather than have shapes represented by one-dimensional lines. Because line as edge has not been previously assessed in relation to gender, no gender difference predictions were made.

Even though the Block Design Task and GEFT were highly correlated, only performance on the GEFT was related to the ability to draw realistically. Why should the ability to detect hidden figures be important for graphic realism? When drawing from observation, one must overcome one's generalized, formulaic schemas for objects (Arnheim, 1974; Gombrich, 1960) and strive to see things the way they actually are on the retinal image, as a camera would detect. When drawing from observation, artists often rely on aids that allow them to crop what they are looking at so they can focus in on details 'uncontaminated' by the surrounding context. Thus, artists have a long history of using viewfinders or the kinds of grids developed by Da Vinci and Durer (Hockney, 2001). These aids help the artist to break up a three-dimensional scene into smaller parts by weakening the influence of the whole. The advantage conferred by the use of such an aid would seem to be the same advantage conferred by having a strong ability to detect the contours of embedded figures, even though of course a grid breaks up a drawing in an arbitrary fashion while the embedded figures test does not.

The ability to detect embedded figures seems clearly related to the ability to capture object contours (the silhouette) when drawing (Lange-Küttner, 2008). The embedded figures test assesses the ability to 'see' the contour of an object despite interference from other overlapping objects. This same skill is needed for drawings of occluded (overlapping objects) – one must infer the occluded parts of the outline, avoiding interference from the other objects.

Skill at embedded figures also requires that one look carefully and focus on small relevant parts of a drawing. The current findings are therefore consistent with the report of the drawing savant E.C. (Mottron & Belleville, 1993) who demonstrated superior local processing – he excelled at tasks that required focusing on the details of a visual stimuli and avoiding the whole context. E.C. also drew hyperrealistically using a strategy referred to as 'construction by local progression' (Mottron & Belleville, 1993, p. 297). 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 onto an adjacent part before completing a part already begun. While several studies have demonstrated that autistic children and adults build their drawings part-by-part, these studies have consisted predominately of male subjects. Research should explore whether there are gender differences in autistics' use of part-by-part drawing strategies.

Studies of autistic children and adults have found that they excel at both the block design task (Shah & Frith, 1993) and the embedded figures test (Jolliffe & Baron Cohen, 1997). The current study found that gifted drawers like autistic individuals excel as both of these tasks but only performance on the embedded figures test predicted level of drawing realism. Future research should examine whether a similar result would be found for autistic individuals.

The results reported here differ from those reported by Toomela (2002), who found that both performance on Block Design and motor skills predicted realistic drawing. However, Toomela did not include the GEFT. The present study demonstrates that it was performance on the GEFT and not the Block Design Task that predicted the ability to draw realistically. Why might this be? While the two tasks used assessed children's ability to decompose an image mentally into its component parts, the tasks were not identical. In addition to mental segmentation, the Block Design requires the ability to rotate the blocks mentally to reconstruct the image. In contrast, the GEFT does not require mental rotation or reconstruction. Drawing realistically from a model does not require mental rotation or reconstruction either, but it does require the ability to look carefully and notice continuous object contours despite interference from overlapping lines and shapes. Still, precocious drawers are quite skilled at mental rotation (Golomb, 1995; Milbrath, 1995), and it is quite possible that the ability to rotate objects may be essential when drawing. Indeed, Lange-Küttner and Ebersbach (2013) found that performance on the mental rotation task was a predictor of the use of occlusion. Future research should investigate whether, in addition to the Group Embedded Figure Test, mental rotation (a skill necessary for the Block Design Task) is related to the ability to draw realistically.

The tasks were always administered in the same order (Block Design Task, Drawing Task, and GEFT). It is possible that the drawing task facilitated performance on the Group Embedded Figure Test. To draw highly realistically, children must focus on the details of the still-life. These same skills are used in the GEFT – focusing on the details instead of the overall design of the image. Future research on this question should counterbalance the order of task administration.

Taken together, these findings demonstrate the importance of investigating different predictors of drawing realism and of pitting these predictors against one another. Future research should continue to investigate the predictors of drawing realism including the ability to mentally rotate objects. It has been well documented that individuals differ in their ability to draw realistically and that these differences can be seen in as early as age two (Gardner, 1980; Golomb, 1992; Milbrath, 1998; Winner, 1996). These findings demonstrate that talent in drawing realistically is neither a function of IQ, age, gender, or training. There are certainly many contributors to this complex ability, but one component appears to be the tendency to see things more as they really are.

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