

Local and global processing in savant artists with autism

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Abstract: We explored the hypothesis that an enhanced local processing style is characteristic of both art and autism spectrum disorder (ASD) by examining local and global processing in savant artists with ASD. Specifically, savant artists were compared against non-talented individuals with ASD or mild/moderate learning difficulties (MLD), as well as talented or non-talented students, on the block design task and meaningful and abstract versions of the Embedded Figures Test (EFT). Results demonstrated that there were no significant differences between the meaningful and abstract versions of the EFT, in any of the groups. This suggests that the primary process governing performance on this task was perceptual (local), rather than conceptual (global). More interestingly, the savant artists performed above the level of the ASD and MLD groups on the block design test, but not the EFT. Despite both the block design task and the EFT measuring local processing abilities, we suggest that this is due to the block design task being an *active construction* task (requiring the conversion of a visual input into a motor output), whereas the EFT is a *passive recognition* task. Therefore, although an enhanced local processing style is an important aspect of savant artistic talent, motor control also appears to be a necessary skill.

## Local and global processing in savant artists with autism

The term ‘autism spectrum disorder’ (ASD) is used to refer to a group of neurodevelopmental disorders characterised by impairments in social interaction and communication, as well as the presence of restricted and repetitive behaviours, interests and activities (American Psychiatric Association 2000). Although not included in the diagnostic criteria for ASD, a common characteristic of this group is an unusual perceptual processing style. Specifically, individuals with ASD have been found to favour the processing of local elements (weak central coherence), often at the expense of the tendency to process information globally (strong central coherence) (Happé and Frith 1994). Consistent with this hypothesis, individuals with ASD tend to display superior performance on tasks such as the Embedded Figures Test (EFT) (Jolliffe and Baron-Cohen 1997) and on the block design subtest of the Wechsler intelligence scales (Happé and Frith 1994), which necessitate the processing of local features, rather than focusing on the Gestalt whole. In addition, individuals with ASD experience difficulties on tests of visual illusions (Happé 1996) and in processing context-dependent information (Happé 1997); both of which require holistic information processing.

Recently, two key modifications have been made to central coherence accounts (see Happé and Frith 2006). First, although evidence of a local processing bias in ASD has proved to be consistent, reports of poor global coherence have been mixed (Mottron et al 2006). Consequently, the emphasis has shifted from the notion of poor global

processing as being a core deficit in ASD, to the idea that enhanced local processing ability is most pertinent. Second, rather than central coherence being viewed as a central cognitive *deficit* in ASD, it is now more accurately defined as a cognitive *style* that can be overridden in tasks explicitly requiring global processing (Happé 1999). Similar principles are proposed in more recent models of perceptual processing in ASD, including the Enhanced Perceptual Functioning model of Mottron and colleagues (Mottron and Burack 2001; Mottron et al 2006) and Plaisted's (2001) Enhanced Discrimination theory, both of which emphasise the enhanced discrimination and perception of individual elements as a consistent and unique feature of ASD.

The tendency to focus on local, opposed to global, features is thought to be evident in all individuals to a greater or lesser degree (Happé 1999). In particular, this processing style is thought to be particularly strong in those gifted in visual arts. One reason for this is that the ability to attend to details and segment a gestalt into its constituent parts aids in the production of realistic drawings (Happé and Vital 2009). In line with this suggestion, several studies have demonstrated that artistically talented individuals are faster than non-gifted controls on the tasks such as the EFT (Getzels and Csikszentmihalyi 1976; Ryder et al 2002). It therefore follows that if this processing style is associated with both ASD and artistic ability, enhanced local processing should be particularly strong in savant artists with ASD.

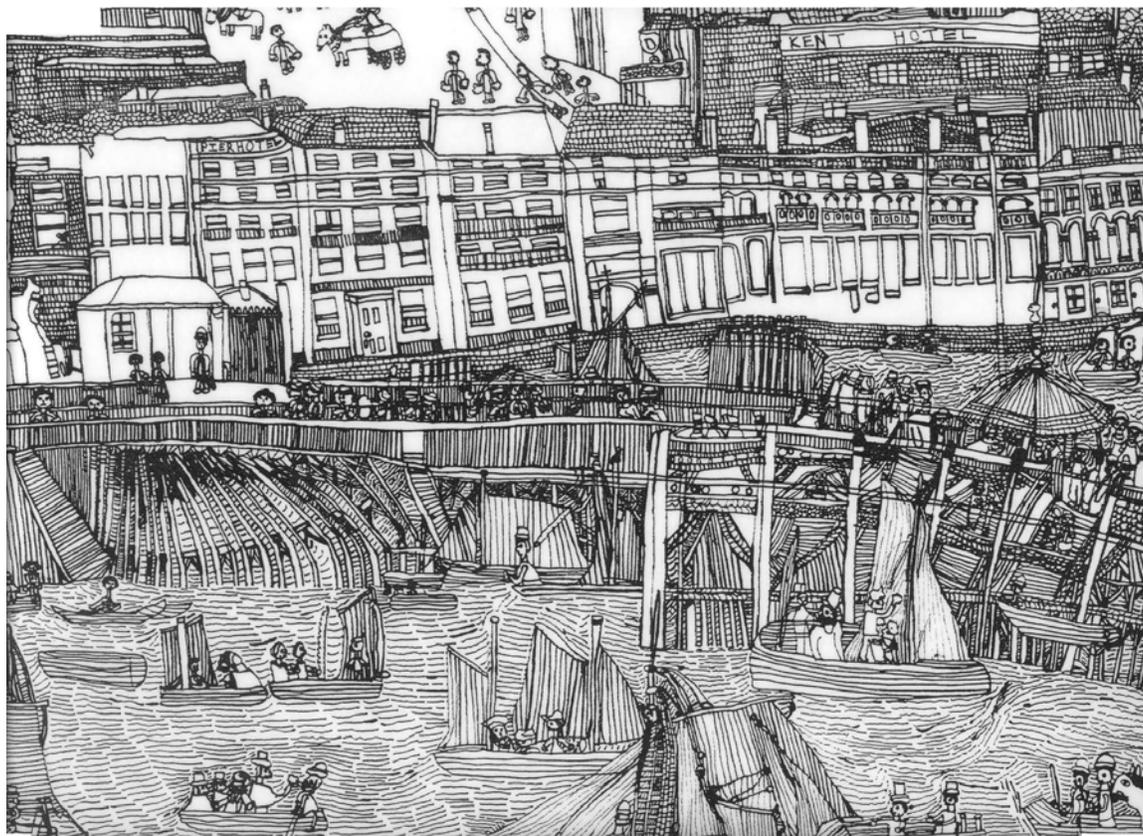
The term 'savants' was initially coined to refer to individuals with an outstanding talent who also possessed low levels of intelligence (Down 1887); a definition that was later extended to include individuals with average or above average intelligence (Miller 1999). Savant abilities are observed in around ten percent of individuals with ASD

(Rimland 1978), although more recent estimates suggest that up to 30% of individuals with ASD display an outstanding skill in at least one domain (Howlin et al 2009).

Domains of talent in individuals with savant abilities include memory (Hill 1974), music (Hermelin et al 1987), poetry (Dowker et al 1996), arithmetic (Heavey 2004) and, the focus of the current investigation, art (Pring et al 1997; Pring et al 1995).

A growing body of evidence indicates that the segmentation skills of savant artists are above those found in non-talented individuals with ASD or with mild/moderate learning difficulties (MLD) (O'Connor and Hermelin 1987). In some cases, these abilities are even found to be higher than those of the population as a whole (Hermelin et al 1994). In a key study on this topic, Pring, Hermelin and Heavey (1995) reported that on an 'abstract' block design task (in which participants were required to construct meaningless patterns and designs), artistically talented individuals (both with and without ASD) performed similarly to a group of non-talented adults with ASD, but above that of non-talented mental aged controls without ASD. However, Pring and colleagues found that this pattern was reversed on a 'meaningful' block design task (which required the construction of pattern that represented real objects). This finding was attributed to the strategies used by each of the groups to aid completion; whereas the two groups without ASD could use semantic information processing to aid performance on the 'meaningful' task, the two groups with ASD did not appear to use the semantic information presented to them. This suggests that semantic independence may play an important role on performance on tasks such as the block design and EFT in savant artists with ASD. The illustration in Figure 1 is a drawing provided by one of the savant artists involved in this study.

Figure 1: Drawing provided by one of the savant artists involved in this study.



The current study sought to explore the nature of local and global processing in savant artists with ASD. The first aim of this study was to replicate previous reports of enhanced local processing in savant artists on the standard version of the block design test (Pring et al 1995). The savant artists were compared to non-talented individuals with ASD, talented art students without ASD and non-talented individuals with moderate learning difficulties (MLD). This was to determine whether the performance of the savant artists was due to their diagnosis of ASD, their artistic talent, or their general level of intellectual functioning. A further aim of this study was to investigate the hypothesis that

a perceptual style favouring segmentation is associated with both ASD and artistic ability. If this were the case, it would be expected that the performance of the savant artists would reflect earlier studies and be up to the level of a group of gifted, non-ASD art students. It was further hypothesised that both groups with ASD would produce superior scores relative to the MLD group. The third aim of this study was to highlight the nature of this perceptual style; specifically, whether superior performance in savant artists would arise as a result of a visual segmentation (strong local processing) or semantic context-independence (poor global processing). To examine these hypotheses, modified forms of both the ‘meaningful’ and ‘abstract’ versions of the EFT, were presented to participants; tasks that had not previously been used to assess savant artists. If, as suggested, the ASD and art student groups experienced a contextual independence, a significant interaction effect would be predicted. This would arise as a result of these participants experiencing less distraction from the overall semantic context in the meaningful condition compared to the non-ASD or non-talented groups. If, on the other hand, this processing style were primarily perceptual, then the ASD and artistically gifted groups would be predicted to produce significantly greater levels of performance on both conditions, with no interaction effects. In order to investigate this effect fully, the inclusion of a fifth group of non-gifted artists was necessary, to assess the influence of artistic ability.

## Method

### Participants

Five groups of participants were included in this study: savant artists with ASD, non-talented adults with ASD, non-talented adults with MLD, artistically talented students and non-artistically talented students. See Table 1 for participant demographics.

The savant artists comprised nine adults that had previously received a formal diagnosis of ASD; five were diagnosed with autism, three with Asperger syndrome and one with atypical autism. This group were recruited from an existing database of graphically gifted savants, specialist services affiliated to the National Autistic Society (UK), and by contacting savant artists following local art exhibitions. Examples of artwork from each savant were assessed by an independent art examiner (who was unaware of the aims and hypotheses of the study) who rated their work as being of a standard that would gain them entry into art school. Their verbal IQ (VIQ) was assessed using the Peabody Picture Vocabulary Test (Dunn and Dunn 1997) and their performance IQ (PIQ), as assessed using Raven's Standard Progressive Matrices (Raven 1960) or Raven's Coloured Progressive Matrices (Raven 1956).

The ASD group comprised nine adults with a formal diagnosis of ASD: five were diagnosed with autism, three with Asperger syndrome and one with atypical autism (as in the savant artist group). They were recruited from a day centre for adults with ASD run by the National Autistic Society (UK). None of this group displayed any artistic talent, although several did take part in art sessions at their day centre. These participants were individually matched to the savant artists on the basis of age (within three years), gender, and IQ (within three IQ points).

The MLD group consisted of eight adults with general learning difficulties who did not have a diagnosis of ASD or any related pervasive developmental disorder. This

was confirmed using a brief screening measure adapted from the Autism Diagnostic Observation Schedule (Lord et al 1989). The MLD group was recruited from a local adult education centre. One further participant was included in this group, who was recruited from the University of London. This was to provide a participant match for one of the savant artists with a relatively high IQ (VIQ =111, PIQ = 114). These adults were individually matched to the savant artists on the basis of age (within three years), gender and PIQ (within three IQ points). None of the participants in this group displayed any artistic ability.

The artistically talented students comprised nine 'A' Level art students who were in the top 10% of their year for artistic ability and were consistently receiving A and B grades for their 'A' Level coursework. Each had previously received an A or B grade for their GCSE Level art course. As can be seen in Table 1, this group were significantly younger than the savant, ASD and MLD groups. This decision was made as, although several of the savant group received some formal training in art, this would not compare to the training of an adult professional artist (many of whom would have received intensive training at a professional art college). This decision was made following discussions and consultations with art experts at professional art colleges and the art teachers who trained the savant artists. In addition, the art students and savant artists spent a comparable amount of time on their artwork per week (approximately ten hours), and their work was judged to be of a similar standard by an independent art examiner who was unaware of the aims and hypotheses of the study.

The non-artistically talented students comprised nine psychology students that were matched to the art students for IQ (within three IQ points) and age (within three

years). Participants in this group had no formal art qualifications and did not participate in art as a pastime.

Table 1: Participant demographics

Group		Age	Gender	VIQ	PIQ
Savant artists	<i>Mean (SD)</i>	34.55 (5.13)	7:2 (m:f)	83.66 (17.49)	84.00 (18.50)
	<i>Range</i>	23-43		56-111	55-114
ASD	<i>Mean (SD)</i>	32.22 (6.59)	7:2 (m:f)	78.78 (14.79)	82.33 (16.59)
	<i>Range</i>	22-43		53-109	54-112
MLD	<i>Mean (SD)</i>	33.56 (5.49)	7:2 (m:f)	95.11 (17.86)	83.55 (19.19)
	<i>Range</i>	22-42		63-117	53-115
Art students	<i>Mean (SD)</i>	17.44 (.72)	7:2 (m:f)	114.67 (12.99)	114.00 (9.00)
	<i>Range</i>	16-18		95-125	94-120
Psychology students	<i>Mean (SD)</i>	18.72 (.55)	7:2 (m:f)	115.22 (9.08)	116.44 (12.12)
	<i>Range</i>	17-20		93-123	92-118

## Materials

### *Block Design Test*

The block design subtest of the Wechsler Adult Intelligence Scale (Wechsler 1999) involves nine identical blocks, each with two red sides, two white sides and two red and white diagonally split sides. Participants are required to assemble the blocks so that they resemble a pattern illustrated on a card, as quickly as possible. A score is

assigned depending on the amount of time taken to produce the design. This raw score is converted into a standardised score, with scores of ten representing mean performance. The block design test was administered to participants in accordance with the instructions presented in the WAIS (Wechsler 1999).

### *Embedded Figures Test*

The EFT involves the participant detecting a 'hidden figure' within a larger design. Meaningful, fragmented and abstract conditions were presented to participants. In the meaningful condition, stimuli were adapted from the children's EFT (Witkin et al 1971). The children's EFT involves two hidden figures (a 'tent' and a 'house') that are embedded within a series of coloured pictures. In the current study, the tent was hidden within a television, pram, ship and jug, and the house was hidden within a rowing boat, digger, present and robot (i.e., within meaningful designs). Several modifications were made to the original children's EFT stimuli, so that they were suitable for the adults taking part in the current study. Specifically, the size of the images was reduced by 75% and the colours were removed.

Stimuli in the abstract condition were taken from the standard adult EFT (Witkin et al 1971), in which two hidden figures (labelled A and G) are embedded within eight larger abstract pictures (i.e., not resembling meaningful designs or objects). In order for performance in the meaningful and abstract conditions to be comparable, it was necessary to modify the original stimuli in terms of size and overall difficulty. Specifically, the colours were removed and the size of each figure increased by 75%. To further equate the complexity of the abstract and meaningful conditions, the number of lines included within the abstract stimuli was reduced.

In the fragmented condition, stimuli were modified from the standard adult EFT (Witkin et al 1971). Here, the hidden figures labelled C and E were used. To allow the overall image to be fragmented effectively, the hidden figure E was simplified into a square, from its original cube form. In addition, the original figures were simplified by removing the colours and by increasing the size of the image by 75%. As this was a simple shape discrimination task, the overall image was fragmented into several distinct parts (see Figure 2 for an example).

Figure 2: Example of the fragmented EFT.



### Procedure

Participants were tested individually in a quiet room at their day centre or college. For the block design task, participants were given a specific time period in which they needed to assemble between two and nine blocks (either two, four or nine) so that the pattern on the top of the blocks matched that illustrated on a card. Up to 12 patterns were presented to participants, which they were required to copy. Testing ceased after the participant assembled all 12 patterns or participants could not complete three consecutive

items in the allotted time. Practice trials were also administered, in line with WASI guidelines (Wechsler 1999). For the EFT, participants were first presented with each of the meaningful condition items and were asked to name what each picture was. This was to ensure that all items in this condition were genuinely meaningful and could be identified by the participants. This naming condition was presented before participants knew the full requirements of the task; hence it is unlikely that it had any confounding effects on the results. However, a limitation of this methodology is that mild priming effects may have occurred. It is therefore important to consider this when interpreting the results of the current study. All participants were able to name the figures. A training condition was then presented, to ascertain that all participants fully understood the instructions. This training session consisted of three extra items (one from each of the conditions) presented in a fixed order, beginning with the fragmented condition, followed by the meaningful condition and then the abstract condition. A pen was given to the participants to draw their response on the laminated cards, which could easily be wiped off following any mistakes or after the correct response had been identified. On this task, participants were told that they would be shown drawings of patterns or real things, as well as a small shape. Their task was to find the small shape within the bigger picture. On the training items, no time restriction was included and all participants were able to identify the hidden figures. For the test items, the order of presentation was randomised amongst participants, with all three conditions interspersed within the same testing session. Participants were then told that they would be given some more pictures and that they had to find the small shape within the larger picture as quickly as they could. The hidden figure was then placed in front of participants and timing began on presentation of

the complex figure. The total response time was taken when the participant informed the examiner that they had correctly identified the shape. If the response was incorrect, the participant was informed and their response was removed from the laminated card. An upper time limit of 180 seconds was imposed for each figure and this time was assigned on trials in which participants failed to find the hidden figure. Studies were carried out in accordance with the guidelines of the Declaration of Helsinki.

## Results

### *Block Design Test*

Mean scores of the five groups on the block design task are illustrated in Table 2. A one-way ANOVA revealed there to be a significant main effect of group,  $F(4, 40) = 14.83, p < .01$ . Post hoc analysis indicated that this was due to the savant artists assembling the designs significantly faster (according to age-related norms) than both the MLD and ASD groups ( $ps < .001$ ). However, there were no significant differences between the savant artists and two student groups ( $ps > .05$ ), nor did a difference emerge between the MLD and ASD group ( $p > .05$ ).

Table 2: Mean (standardised) block design scores in the five participant groups.

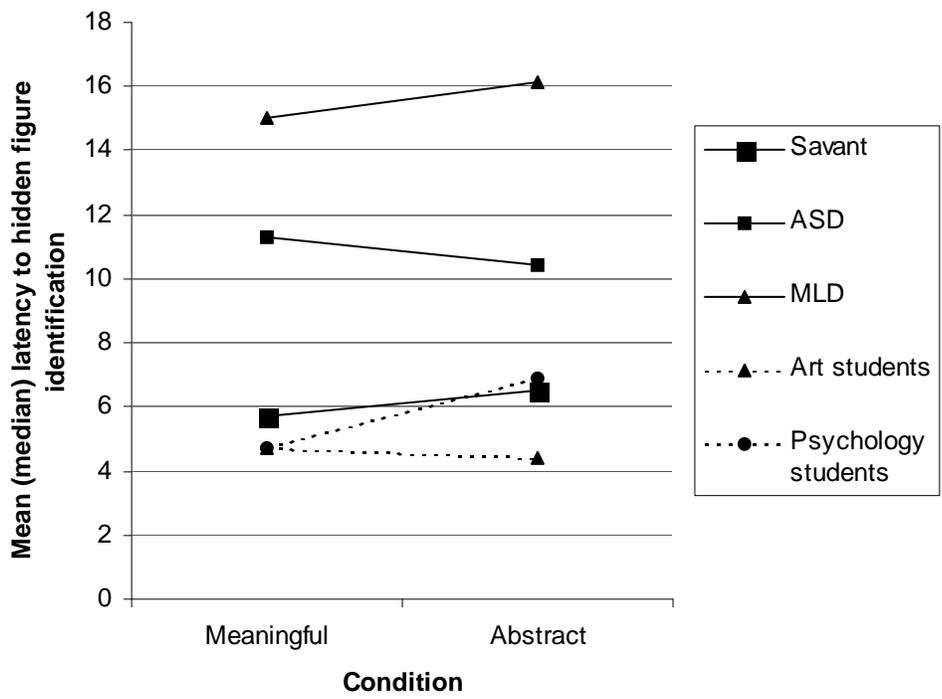
Group	Mean (SD) Block Design score
Savant artists	12.22 (1.92)
ASD	8.22 (2.17)
MLD	6.89 (3.69)

Art students	14.22 (1.92)
Psychology students	12.00 (1.50)

### *Embedded Figures Test*

On the EFT, although the three conditions were presented together, the main aim was to investigate the relationship between the abstract and the meaningful conditions. Therefore, the results of these two conditions are presented first. Due to several participants experiencing difficulties with one or more items on the EFT, median scores were calculated, to reduce the effects of outlying scores (see Figure 3). A 2 (condition: meaningful or abstract) x 5 (group: savant, ASD, MLD, art students or psychology students) revealed there to be a significant main effect of group,  $F(4, 40) = 6.91, p < .01$ . This was due to the MLD and ASD groups taking significantly longer than the savant artists and the two student groups on the EFT. No significant differences were found between the MLD and ASD groups, or the savant artists and the two student groups ( $ps < .05$ ). There was a non-significant effect of condition,  $F(1, 40) = .70, p > .05$ , as well as a non-significant interaction,  $F(4, 40) = .65, p > .05$ .

Figure 3: Mean scores of the five participant groups on the meaningful and abstract versions of the EFT.



On the fragmented version of the EFT (see Table 3), there was a significant main effect of participant group,  $F(4, 40) = 3.56, p < .01$ . Post hoc analyses indicated that the only significant within-group difference was due to the superior performance of the art students relative to the MLD group ( $p < .05$ ).

Table 3: Mean median scores in the fragmented version of the EFT in the five participant groups.

Group	Mean median (SD) fragmented identification score
Savant artists	2.06 (1.22)

ASD	4.56 (4.20)
MLD	4.97 (3.68)
Art students	1.37 (.51)
Psychology students	2.03 (.95)

### *Correlational analysis*

Correlations between the Block Design and Embedded Figures tasks: Interestingly, although there was a strong correlation between the EFT and Block Design performance in the ASD ( $r = -.77, p < .01$ ) and MLD ( $r = -.84, p < .01$ ) groups, there were no significant correlations between performance on these tasks in the remaining three groups ( $ps > .05$ ).

Correlations between the Block Design and Embedded Figures tasks and IQ: No significant correlations between task performance and IQ in the savant artists. In contrast, in the ASD group there was a significant correlation between performance on the EFT and VIQ ( $r = .71, p < .05$ ) and between performance on the Block Design task and PIQ ( $r = .59, p = .09$ ). In addition, in the MLD group, there were significant correlations between EFT performance and VIQ ( $r = .69, p < .05$ ) and PIQ ( $r = -.80, p < .01$ ), and between performance on the block design task and PIQ ( $r = .71, p < .05$ ).

### Discussion

The current study explored the hypothesis that an enhanced local processing style is characteristic of both art and ASD by investigating local and global processing in

savant artists with ASD. In this study, a group of savant artists were compared against non-artistically talented individuals with ASD or moderate learning difficulties (MLD), as well as artistically talented or non-talented students, on the block design test and the EFT. Results demonstrated that the savant artists performed significantly better than the ASD comparison group on the block design task, but not the EFT. In addition, although the savant artists performed to the level of the student groups on the block design task and EFT, there was no significant difference between the performance of the talented and non-talented students on these measures. Further, no significant group differences were observed between the ASD comparison group and the MLD on either task.

The first key finding from the EFT regards the nature of the perceptual style found in savant artists. In the introduction, the question was raised as to whether this processing style was perceptual or semantic. The results of this investigation found no advantage, in any of the groups, for the meaningful condition over the abstract condition. The lack of an advantage arising from contextual independence in the groups with ASD (or indeed the two artistically gifted groups) indicates that the primary process governing performance was a perceptual one. This concurs with recent reformulations of the central coherence model (Happé and Frith 2006), suggesting that enhanced local processing (but not weak central coherence) is a consistent feature of ASD (also see Mottron et al 2006; Plaisted 2001). This conclusion is also supported by the results of the fragmented condition, on which the performance of the MLD group was equivalent to that of the ASD groups, and also mirrors the findings of Shah and Frith (1993), on their pre-segmented block design task.

Perhaps the most interesting result of the current study regards how the performance of the savant artists on the EFT contrasts with that of the block design task. This result is intriguing, especially considering the number of previous studies reporting a high correlation between these two measures (Jarrold et al 2000; Ropar and Mitchell 2001); a result mirrored in the ASD and MLD comparison groups in the current study. If, then, the two tasks are thought to measure essentially the same ability (i.e., a focus on perceptual detail), the question arises of why the EFT failed to discriminate between the two groups with ASD, whereas the block design task did.

In order to address the above question, it is necessary to examine the differential demands of the two tasks. We propose that the EFT can be classed as a *passive recognition* task, whereas the block design task is an *active construction* task. It therefore appears that the superiority of the savant group (compared to the ASD and MLD groups) on the block design task is due to the strong visual-motor component inherent in this task. Although one may argue that the EFT also has a visual-motor component, in that participants are required to trace a hidden figure in the larger shape, this is only required after the hidden figure has been visually located. As such, the visual-motor demands of this task are much lower.

This hypothesis is consistent with Hermelin and O'Connor's (1990) suggestion that the superior drawing ability of savant artists is dependent on the conversion of a visual input into a motor output. This also concords with the results of several studies that have found savant artists to perform better than control groups when recalibrating visual feedback into motor ability (Crane et al submitted; Pring et al under review). In essence, this is what is required on the block design task (but not the EFT), and it may be this

motor element that distinguishes between the savant artists and the non-talented controls. Therefore, local processing alone is not sufficient to produce superior performance in savant artists; the task must also incorporate a motor element.

A further noteworthy finding from this study regards how performance on the EFT and the block design task appeared not to be facilitated by artistic ability, as demonstrated by the failure to find a significant difference between the art and psychology students. With regards to the EFT, this may reflect the comparative ease of the task for the student groups, as the demands of the task was considerably reduced so that it was suitable for individuals of below average intelligence. As such, it may be that the task demands were not high enough to discriminate between individuals of normal intelligence (or even those with a specific developmental disorder such as ASD). Unfortunately, this was a necessary measure to ensure that the lower functioning groups could complete the tasks. Regarding the block design task, this non-significant finding might be because the standardisation of scores on this measure (in line with age-related norms) reduced the intricacies of performance. Taken together, these methodological issues could account for the failure to find an art-related superiority on this measure, despite previous positive findings.

It is also important to note the failure of both tests to discriminate between the ASD and MLD groups, suggesting that enhanced local processing is not autism-specific. This is particularly surprising considering the strong evidence for superior performance in individuals with ASD on such tasks. One explanation regards the large IQ range of participants in this study, which (when combined with the small sample size) may have masked any significant group differences. However, whilst there was a strong correlation

between task performance and IQ in the MLD group, this was not the case in the ASD group. Here, PIQ was also found to correlate with block design performance, but on the EFT the only significant correlation was the positive relationship with VIQ. This indicates that those with higher VIQ produced slower responses on the EFT. Although the sample size was small, meaning any conclusions are tentative, it does appear that the individuals in the ASD group who displayed low verbal abilities have poorer central coherence and employ more detail focused processing strategies in the visual domain. This finding requires further, more systematic investigation.

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