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Visuo-spatial abilities in autism: A review

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Abstract

Individuals with autism show various signs of heightened abilities in visuo-spatial functioning. First, it is long-established that they excel on embedded figures and block design tests relative to comparison participants. Second, some evidence suggests that processing global features is affected by inappropriate processing of the constituent elements of a stimulus. Third, they are more accurate than comparison participants in judging the shape of a slanted circle in a context where ambient visual cues are eliminated. This suggests that their perception of the shape was less influenced by prior knowledge. Fourth, they are fast at searching for feature and conjunctive targets in a visual array. Contrary to earlier reports, however, they are susceptible to visual illusions. Also, they do show evidence of utilising prior knowledge when pairing a colour with an atypically coloured target. Accordingly, we conclude that there is something distinctive about autistic visuo-spatial functioning, but not necessarily in ways that are predicted by the "weak central coherence" hypothesis.

Visuo-spatial abilities in autism: A review

Introduction

Autism is a pervasive developmental disorder that affects at least 4 per 10,000 in the population (International Molecular Genetics Study of Autism Consortium, 1998, with a ratio of 4 boys to every girl among those who are severely affected (Pickles, Starr, Kazak, Bolton, Papanikolaou, Bailey, Goodman & Rutter, 2000). There is a greater imbalance in the sex ratio in the higher functioning members of the autistic population. The occurrence of autism is not linked with a particular socio-economic group and neither does it result from a particular style of parenting (Frith, 1989). Its cause almost certainly has an organic basis, but as yet there is no consensus on exactly which brain structures are involved (Bauman & Kemper, 1994). It is present from birth or very early in life, though in some cases a diagnosis is not always made until later in development (Frith, 1989).

Evidence suggests genetic vulnerability, in the sense that relations of those with autism might also suffer the disorder, and the likelihood that they do so is based on how closely related the two individuals are in genetic terms (Pickles et al, 2000). However, it is also clear that the environment plays a part in developmental outcome, given that although there is a high probability that both members of identical twins will be sufferers (69% -- Bailey, Phillips & Rutter, 1996), the probability is well below 100 percent.

Individuals with autism display a triad of characteristically autistic impairments, identified by Wing and Gould (1979). This triad includes qualitative impairments in social behaviour, communication (both verbal and nonverbal) and imagination (including impairment in pretend play). Associated characteristics are resistance to change in routine and insistence on sameness.

Weak central coherence

Individuals with autism typically have good visuo-spatial ability, which often contrasts starkly with their severely impaired language, especially pragmatic skills. Therefore, a comprehensive theory of autism would account for the areas of spared or superior functioning as well as the impairments. According to Happe (1999), both the theory of mind hypothesis of autism (e.g. Baron-Cohen, 1995) and the executive dysfunction account (e.g. Russell, 1998) are imperfect because they concentrate on a deficit as the principal factor in explaining autistic performance. Happe argues that spared or superior functioning in certain areas cannot be explained by a general deficit, and instead we should consider that individuals with autism have a distinctive cognitive style that leads to peaks and troughs in performance.

Happe champions Frith’s (1989) highly influential theory of weak central coherence. She defines central coherence as the “tendency to process incoming information in its context – that is, pulling information together for higher-level meaning – often at the expense of memory for detail”. She goes on to say that, “this feature of … information-processing is disturbed in autism, and that people with autism show detail-focused processing in which features are perceived and retained at the expense of global configuration and contextualized meaning.” (Happe, 1999, p217). Supposedly, this kind of processing allows individuals with autism to detach from their prior knowledge and preconceptions when inspecting a stimulus, which ironically might allow them to visually analyze the stimulus more objectively and more efficiently. In other words, whereas those of us without autism are in danger of seeing what we think we will see, those with autism might be liberated to see what is really there. Consequently, we might say that although perception is less influenced by prior knowledge in autism, in some tasks this could actually be an advantage. In our view, this theory might have an element of truth, though some researchers have deduced predictions that cannot be supported, as we shall see shortly. Our aim is to review this research with a view to (1) reporting our current understanding of autistic visuo-spatial abilities and (2) assessing the status of Frith's theory of weak central coherence.

Shah and Frith (1983) reported some of the earliest evidence pointing towards weak central coherence in autism, based on the results of an embedded figures task. They found that participants with autism were faster at locating a target hidden within a more complex figure, compared with individuals who did not have autism. According to Brian and Bryson (1996), at least two explanations can be offered as to why comparison participants were relatively slow, which in turn promises to shed light on the speedy performance by individuals with autism. One possibility is that comparison participants were somewhat captivated by the meaning suggested by the global shape – for example, one shape resembled a pram. Classifying the picture in this way may effectively blind participants to the details, such as part of the pram consisting of a triangle – the embedded figure. Another possibility is that irrespective of how the stimulus is interpreted and classified, those without autism might naturally process the stimulus as a whole, such that it was hard to focus attention on elemental parts.

Brian and Bryson (1996) ingeniously tried to unconfound these two possibilities: They presented one kind of figure that resembled an object (e.g. a birthday cake), and another that was an abstract line drawing. If meaning were the important factor, then autistic superiority would only be apparent when stimuli were representational, whereas if being able to analyze parts were the important factor, then those with autism would perform relatively well with both kinds of embedded figure. Unfortunately, though, Brian and Bryson's data were uninformative because they failed to achieve a basic replication of autistic superiority in any kind of embedded figures task. Nonetheless, autistic superiority in this task is generally robust (e.g. Jolliffe & Baron-Cohen, 1997; Ropar & Mitchell, 2001a), and therefore it would be very valuable to repeat Brian and Bryson's procedure with a different autistic sample.

Shah and Frith (1993) offered a further demonstration of autistic visuo-spatial superiority in the block design task. In this, blocks with parts of a design on one face have to be assembled to recreate an entire pattern. Participants with autism completed the task more quickly and with fewer mistakes than individuals with typical development. While children with typical development benefited from seeing the target design pre-segmented, those with autism performed well whether the design was pre-segmented or unsegmented. According to Shah and Frith, pre-segmentation did not improve performance any further in participants with autism, because they could apprehend the elements of the stimulus even when presented unsegmented. Another possibility, though, is that the speed of responding of participants with autism was already as fast as the task constraints could allow, and therefore any benefit of seeing the stimulus pre-segmented would be masked by a ceiling effect (Plaisted, 2001). Nonetheless, the finding of superior autistic performance in the unsegmented condition is consistent with the possibility that individuals with autism had an aptitude for detail-focused processing, as suggested by the theory of weak central coherence.

Susceptibility to illusions

Happe (1996) made a striking prediction about weak central coherence at very low levels of perception, which is that individuals with autism should be less susceptible to visual illusions than comparison participants. Take, for example, the Titchener circles. The inducing context of the outer circles gives rise to the perceptual distortion of the size of the inner circle. If an individual were able to carry out the kind of detail-focussed processing of the stimulus that allowed them to ignore the inducing context, then presumably they would not be susceptible to the illusion. Such a participant would be able to judge the size of the inner circle as if the inducing context were absent. Accordingly, Happe suggested that the hypothesis of weak central coherence could be used in order to predict low susceptibility to visual illusions in autism. Putting aside that theory for a moment, Happe notes that it would be rather surprising if individuals with autism were not susceptible to visual illusions given that susceptibility is thought to arise as a fundamental characteristic of perception (Bruce, Green & Georgeson,1996). A person who was not susceptible to illusions probably would have conspicuously severe abnormalities in perception.

Happe (1996) duly tested her prediction and reported data in support. However, her method of testing might have been less than ideal. She asked participants if comparison elements in the illusions (e.g. the inner circles in the Titchener illusion) looked the same or different in size, and those with autism were more likely to respond “same” than comparison participants. Her procedure lacked a condition in which participants would have been scored correct for answering “different” and therefore we cannot tell whether the contrast in performance between those with and without autism was actually an artifact of the questioning. We sought a remedy not by asking participants to respond verbally but by asking them to adjust the size of one of the inner circles so that it matched the other, using a computer program (Ropar & Mitchell, 1999). Once participants were satisfied that they had adjusted the circles to be the same size, we were able to examine the physical discrepancy between the two, which serves as an index of illusion strength: A greater discrepancy implies higher susceptibility to the illusion.

In a further study, we collected additional data on tasks thought to directly measure weak central coherence, including block design and embedded figures (Ropar & Mitchell, 2001a). Reassuringly, those with autism gained higher scores than comparison participants on the tasks, and thus we successfully replicated earlier findings (Shah & Frith, 1983, 1993). However, we failed in both studies to demonstrate lower susceptibility to illusions in participants with autism. Secondly, there was either little or no evidence of correlations in performance between the illusions, suggesting that weak central coherence was not a common factor in accounting for susceptibility. Thirdly, there was no relation between superior performance on visuo-spatial tasks (e.g. embedded figures and block design) and non-susceptibility to illusions in participants with autism, despite the fact performance across the visuo-spatial tasks correlated very highly.

It remained a possibility that individuals with autism show attenuated susceptibility in a verbal mode of response, as in Happe’s (1996) study but show normal levels of susceptibility when making a manual adjustment to part of the illusion, as in our study. To find out, Ropar and Mitchell (1999) included a condition where participants had to respond verbally, except with additional controls in which they would be scored correct for responding with “different”. Contrary to Happe’s findings, individuals with autism were just as likely as comparison participants to judge that elements in the illusions looked different, suggesting that they were susceptible. Therefore, it seems susceptibility to illusions is not attenuated in autism and neither is low susceptibility related with good performance on measures of weak central coherence.

Attenuated influence by prior knowledge

Although susceptibility to illusions suggests low-level processes are not affected by autism, there might be other signs of distinctive perception. Apart from the finding that individuals with autism perform relatively well on embedded figures and block design tasks, they also seem unperturbed by “impossible” figures. Mottron and Belleville (1993) report the case of an individual with autism who did not notice the oddity of the devil’s fork and Penrose triangle. In a further study, Mottron, Bellville and Menard (1999) discovered that individuals with autism had less difficulty than comparison participants in reproducing these impossible figures, again suggesting they were not perplexed by the oddity.

While impossible figures contain cues on the paradoxical orientation of various planes, these could only be experienced as contradictions when comparing different parts of the figure. Perhaps individuals with autism attended successively to different regions of the stimulus in a detail-focussed fashion, with the consequence that they remained oblivious to the perspectival contradictions in the form as a whole (cf, Happe, 1996). Another possibility is that those with autism experienced “less capture by meaning” (Shah & Frith, 1983). Perhaps they did not compare the stimuli with prior knowledge of the prototypical form of triangles and forks. An absence of influence by prior knowledge would allow them to attend specifically to the stimulus as presented. Thus, two explanations compete to account for the failure to detect impossibility in the autistic group: One explanation says that individuals with autism experience less influence by prior knowledge and the other says they have difficulty integrating the parts of the stimulus.

In light of the intriguing results reported by Mottron and colleagues, and considering how the rival explanations for the phenomena relate to the theory for weak central coherence, we set about isolating the effect of prior knowledge on visual perception in autism (Ropar & Mitchell, 2002). Our investigation gained inspiration from classic studies conducted by Thouless (e.g. 1931) in the early part of the 20th Century. Thouless reported a striking phenomenon that he called "phenomenal regression to the real object". If a participant views a circle at a slant, they tend to exaggerate circularity when asked to draw the object exactly as they see it. In other words, they typically draw a more circular ellipse than that projected onto their retina. The phenomenon is apparent in typically developing children and can be demonstrated either by asking participants to reproduce the ellipse on a computer screen or by asking them to select an ellipse from a set of alternatives (Mitchell & Taylor, 1999).

Extant data already suggest that individuals with autism might show reduced exaggeration of circularity when reproducing a circle that gives an elliptical projection. Mottron and Belleville (1995) asked trained draughtsmen and a drawing savant (E.C.) to reproduce the drawing of a cylinder depicted from an oblique perspective. It seems that the draughtsmen were prone to the classic bias of exaggerating the elliptical projection generated by the circular top of the cylinder, while this effect was either far weaker or even absent in E.C.

In principle, this kind of exaggeration of circularity could arise from two possible sources. One is the ambient visual context surrounding the target stimulus, including cues that are sufficient to specify the object as a slanted circle. Another possible source is the knowledge that the stimulus is a slanted circle, which could exert an effect irrespective of the cues inherent in the visual context. We thus presented the task to participants with autism in two main versions (Ropar & Mitchell, 2002). In one, strong contextual cues were abundant, while in the other, all such cues were eliminated and participants could only see the slanted circle. In both conditions, though, they knew from prior exposure that the stimulus was a slanted circle. In a further condition, participants viewed a real ellipse presented not at a slant, and estimations of shape were accurate in all groups of participants, suggesting there was no general tendency to exaggerate circularity when the properties of the projection and the target were not in conflict.

In the main versions of the task, where there was a conflict between the properties of the projection and the target, participants with typical development (children and adults) showed the classic phenomenon by exaggerating circularity. This exaggeration occurred to the same extent whether contextual cues were present or absent. The effect generalized to participants with moderate learning disabilities who did not have autism. The participants with autism, in contrast, were unique in exaggerating circularity to a lesser degree specifically in the condition without contextual cues. When those cues were present, individuals with autism exaggerated to the same extent as comparison groups. Apparently, individuals with autism integrated the stimulus with its visual context, which presumably caused them to exaggerate circularity when contextual cues were present. However, the results suggest that they might have been less able to integrate the image of the stimulus with their prior knowledge that it was a slanted circle. Therefore, the finding is consistent with the possibility that autistic perception is peculiar in being less influenced by knowledge.

The results offer no support for Happe's (1999) predictions about weak central coherence disrupting perceptual integration of stimuli. Perhaps she would have expected individuals with autism to engage in a level of detail-focussed processing that enabled them to visually segregate the slanted circle from its visual context. She might have predicted, therefore, that individuals with autism would show less exaggeration of circularity than comparison participants in the condition where the visual context was present. It seems rather ironic, then, that participants with autism only showed less exaggeration when the visual context was absent. Hence, their exaggeration in the condition with visual context means that participants' processing must have involved perceptual integration between the slanted circle and the rest of the scene.

Happe (1999) refined her argument by suggesting that individuals with autism have impaired integration specifically at the level of discrete objects; she says that autism does not impair the ability to integrate the various features and facets that make up a single object. Happe offered the argument as a defence against the possibility that superior autistic performance in a conjunctive visual search task (Plaisted, O'Riordan & Baron-Cohen, 1998) depends on the ability to integrate features of the target stimulus. In the conjunctive task, participants searched for a red X among red T and green X distracters, such that success depended on taking into consideration (or integrating) both the colour and the form of the stimuli. However, even Happe's refined argument does not explain why participants with autism so readily integrated the circle with its visual context in Ropar and Mitchell's (2002) task: The integration that generated exaggeration of circularity was between a discrete object (the circle) and other things in the scene.

Apart from the theoretical implications of the finding, an aspect of methodology also deserves attention. In performing differently between conditions, depending on whether contextual cues were present or absent, individuals with autism were unique among the participant groups: Their pattern of data was unlike that in any other comparison group. This kind of result is important in autism research. Typically, it is seen as an achievement to demonstrate that individuals with autism differ from matched comparison participants in a specific test (e.g. embedded figures). Although such results have had great impact, there is sometimes a lingering doubt over whether the groups were ideally matched. Consider the embedded figures task as a case in point: Participants with autism usually outperform a group matched for verbal ability, and in some cases matched for nonverbal ability. But the performance of the autistic group still might not be uniquely autistic in the sense that high functioning adults without autism could perform to a similarly high level. Hence, the good performance of individuals with autism is not distinctive in an absolute sense, but is good relative to their weaker performance in other domains. For this reason, a pattern of results that is uniquely autistic is especially noteworthy, because the distinctive character of autistic performance would always be apparent irrespective of the composition of the comparison group. When individuals with autism are unique in performing differently between conditions, we are entitled to claim that their performance is categorically autistic, rather than that they are merely better or worse than certain comparison participants.

The findings relating to judging the shape of a slanted circle raise two questions about autistic functioning. First, does “less influence by prior knowledge” explain all the data? In other words, can all the reported peculiarities in autistic visual processing be explained by saying that autistic perception is less influenced by prior knowledge? Second, does any visuo-spatial tasks that draws on prior knowledge demonstrate a peculiarity in autistic processing? Turning the question on its head, is there any sign that autistic perception can be influenced by prior knowledge? We shall address these questions in turn.

Less influence by prior knowledge does not explain all the data: Hierarchical stimuli and visual search

In this section, we shall present material that clearly shows peculiarity in autistic perceptual processing that cannot be directly explained by saying there is less influence by prior knowledge. Additionally, these studies cast further light on the status of the theory of weak central coherence, and this is where we begin.

Mottron and Belleville (1993) argue that weak central coherence theory predicts a distinctive effect with regards to processing hierarchical stimuli. The stimuli in question were devised by Navon (1977) and have Stroop-like properties. Consider a pointilistic rendition of the letter H that is composed not of dots, but of small letter Ss. In this example, the elements are incongruous with the global form of the figure. Interestingly, Navon observed an asymmetrical Stroop effect. When participants where asked to state the smaller letters (Ss), they were slower if the global form was incongruent (H) than if it was congruent (S). However, when participants were asked to state the larger letter, response time was not affected by the incongruity of the smaller letter. That is, participants experienced interference from the global to the local, but not the reverse. In consequence, it seems that processing the global form takes precedence over processing the local elements. Mottron and Belleville recognized the value of the hierarchical stimuli for testing predictions from the theory of weak central coherence, which says that autism gives rise to detail-focused processing. Specifically, individuals with autism ought to show a reversal of the direction of interference: From the local to the global.

Mottron and Belleville (1993) set about testing the hypothesis by presenting hierarchical stimuli to an autistic savant artist (E.C.). Unfortunately for the theory of weak central coherence, E.C. showed global interference similar to that in participants without autism. However, E.C. was not like comparison participants in every respect. Interestingly, he showed signs of interference from the local to the global as well as the opposite. The results led Mottron and Belleville to conclude that while individuals with autism process at the global level in a normal way, nonetheless the global does not have any special precedence over the local level. They suggest that individuals with autism may fail to show the typical global precedence effect due to problems with “hierarchical organisation” in processing information. This suggestion is distinct from the theory of weak central coherence. It says that while individuals with autism process visual information at both the global and local levels like individuals without autism, there is an autistic impairment in handling the relationship between these two levels.

Subsequent studies have found mixed support for this suggestion. For example, Ozonoff, Strayer, McMahon, and Filloux (1994) failed to find interference from the local to the global. However, Plaisted, Swettenham, and Rees (1999) identified a crucial difference between the task used by Ozonoff et al and that used by Mottron and Belleville. The latter was a divided attention task that asked participants to report a letter at the local or global level on each trial. For instance, participants were asked to press one button if the letter 'A' was present (at either the local or global level) and a different button if 'A' was absent. Hence, this would require divided attention between the global and local level within each trial. Conversely, Ozonoff et al. (1994) presented a selective attention task, in which participants were instructed before each block of trials to attend to a particular level. For example, on being told selectively to attend to the local level, they were instructed to press one button if it was an 'H' and the other if it was an 'S'.

To clarify matters, Plaisted et al. (1999) presented both kinds of task within a single study, and found interference from local to global in the divided attention task but not in the selective attention task. However, Rinehart, Bradshaw, Moss, Brereton, and Tonge (2002) subsequently demonstrated interference from local to global specifically in individuals with autism even on a selective attention task. This differed from the previous studies by employing numbers rather than letters as stimuli, which the authors claimed to be more sensitive to interference from local to global. In summary, then, the bulk of evidence points towards a uniquely autistic interference from local to global, that compares with the more common interference from global to local. Rinehart et al. conclude that individuals with autism, "may be characterised by a deficiency in inhibiting further processing," (p776) even when the global figure has been identified. They proceed to suggest that autistic peculiarities in processing hierarchical stimuli can be explained as forming part of a broader problem of inhibition, that is associated with executive dysfunction (e.g. Hughes & Russell, 1993).

The evidence presented so far suggests an autistic peculiarity in processing stimuli that can be apprehended on hierarchically different levels. Does this peculiarity arise specifically from the fact that the stimuli are hierarchical or would the peculiarity occur with any stimuli that can be interpreted in two different ways ? A study reported by Ropar, Mitchell & Ackroyd (2003) helps to address this question. Participants were presented with ambiguous figures, similar to the well-known duck-rabbit, and tested on their ability to switch between the two interpretations. Normally developing children aged around 3 years seemed unable to take on board the two possible interpretations. Although they claimed they could see both interpretations, when asked to point to features of one or other, it became apparent that they had actually made only one interpretation. In sharp contrast, the great majority of participants with autism easily and genuinely made both interpretations, as revealed by their correct location of features in the figure.

The purpose of Ropar et al.'s (2003) research was to investigate the hypothesis that impairments in handling representations would prevent individuals with autism making both interpretations of ambiguous figures, as seems to be the case with normally developing children below the age of about 4 years. Clearly, that hypothesis gained no support. Incidentally, though, the results might help to clarify the basis of peculiar processing of hierarchical stimuli in autism. With respect to ambiguous figures, individuals with autism showed no sign of difficulty in switching from one interpretation to the other. Additionally, there was no sign of a failure to inhibit features of one interpretation interfering with their attempt to identify features associated with the other interpretation.

Still, it remains a possibility that individuals with autism would have been slower than comparison participants to identify features when an alternative interpretation can be made. That is, there might be more subtle interference from one interpretation to the other that can be picked up by measures of response time. Nonetheless, it is possible that an autistic peculiarity in processing is confined to hierarchical stimuli, indicating that we need to explain specifically why there is interference from local to global. In that case, it would not be sufficient to say that individuals with autism have difficulty with inhibition or switching from one level to the other, which could have been explained with reference to a broader executive impairment (pace Rinehart et al., 2002).

Interference from local to global cannot be explained by saying that individuals with autism are influenced less by prior knowledge. The kind of prior knowledge that participants could draw upon (e.g. knowledge of the letter H) was constant across conditions, while the form of potential interference varied: The form of the H existed either at the global or the local level. Hence, interference from local to global needs to be explained as a peculiarity relating to precedence in processing the different levels of hierarchical stimuli.

Tasks employing hierarchical stimuli are not the only kind to reveal differences in autistic perception that cannot be directly explained as less influence by prior knowledge. A highly rigorous study by O'Riordan, Plaisted, Driver and Baron-Cohen (2001) suggests that autistic visual processing is distinctive in other ways. They tested participants on visual search and found superior performance in individuals with autism in tasks with a conjunctive target and hard tasks with a feature target. In the hard feature task, participants searched for a vertical target among tilted distracters. Participants without autism take longer to identify targets in both these kinds of task as a function of the number of distracters, suggesting they conduct a serial search (Treisman & Gelade, 1980). Those with autism identified targets faster than comparison participants, and the increase in response time was less marked as a function of the number of distracters in the array.

As with hierarchical stimuli, it is difficult to explain the results reported by O'Riordan et al (2001) on the basis of less influence by prior knowledge. It would be implausible to argue that prior knowledge interferes more with larger than smaller sets, given that the content of information differs quantitatively rather than qualitatively across the different set sizes. That is, the prior knowledge concerns vertical and slanted lines, and this knowledge would have been uniformly relevant to all conditions in the study. In consequence, this factor could not explain variations in performance across the different set sizes.

<u>Autistic perception can be influenced by prior knowledge</u>

Whilst demonstrating attenuated influence by prior knowledge, the study by Ropar and Mitchell (2002) nonetheless shows unequivocally that individuals with autism are influenced to some degree by prior knowledge. If they had not been so influenced, then they would not have shown systematic exaggeration of circularity in the condition where contextual cues were absent.

In principle, whether or not perception is influenced by prior knowledge might depend upon the kind of knowledge in question. In Ropar and Mitchell's (2002) study, the prior knowledge had two aspects. One is the semantic prior knowledge relating to the class of circular things. When Shah and Frith (1983) suggested that individuals with autism experience “less capture by meaning”, they were probably referring to this kind of semantic prior knowledge. The other aspect is the episodic prior knowledge relating to different trials in Ropar and Mitchell’s experiment, for example whether the target was a circle presented at a slant or an ellipse not at a slant. Perhaps the attenuated influence by prior knowledge in Ropar and Mitchell’s study is explained by the possibility that the category of ‘circle’ is undeveloped in autistic cognition. In that case, the explanation lies at the semantic level. Alternatively, perhaps the impact of episodic prior knowledge is weakened in autistic processing (cf, Bowler, Gardiner, Grice & Saavalainen, 2000). In other words, the category knowledge of circles might be normal in autism, but briefly seeing that a stimulus is a circle might be insufficient to strongly activate the appropriate category prototype. In consequence, there would be less scope for the prior knowledge to influence judgements of the shape of the presented stimulus, and hence there would be less exaggeration of circularity.

While we do not yet know which aspect of prior knowledge was relevant to Ropar and Mitchell’s (2002) results, another study suggests that children with autism can be as heavily influenced as comparison participants by prior knowledge in another kind of task (Ropar and Mitchell, 2001b; also, Pring & Hermelin, 1993). In this study, we investigated children’s preference to pair colours with objects. Participants were shown a coloured picture of an object with two colours placed alongside and asked which goes best with the object. Some of the objects had an associated colour, such as a banana, but these were presented atypically coloured. Some of the objects did not have an associated colour, such as a balloon. These two stimuli were both presented (in separate trials) coloured blue, and both had blue and yellow colours for children to choose from. If children were not influenced by their prior knowledge of the colours of objects, then presumably, they would choose blue in both cases because of the visual match. If they were influenced by prior knowledge, then perhaps they would choose blue for the balloon but yellow for the banana because their knowledge tells them that bananas are characteristically coloured yellow. All groups or participants in the study tended to make their choice according to the second strategy, including those with typical development, with moderate learning difficulties and with autism. Specifically, children with autism were more likely to choose an associated colour for objects like bananas and tomatoes, apparently drawing on prior knowledge, but were more likely to choose a colour that matched the surface colour of the presented stimulus for things like balloons and cars. The tendency to behave in this way in autism was just as strong as in comparison participants with moderate learning difficulties. Hence, individuals with autism were clearly being influenced by their knowledge of the object’s characteristics in this task. It could still be the case, of course, that participants with autism would have been demonstrably less influenced by prior knowledge if the task had been more subtle, with a more sensitive measurement of performance. Nonetheless, it would be incorrect to say that individuals with autism have an extensive problem in utilising prior knowledge when processing visual input.

Summary and Conclusions

The aim of this article was to review a selection of studies about visuo-spatial abilities with a view to summing up our current understanding of autistic functioning in this sphere of activity. A further aim was to assess the implications of these various findings for the theory of weak central coherence. The bulk of evidence shows that individuals perform well on embedded figures and block design – much better than we might have expected from their general level of ability. Also, their prior knowledge seems not to strongly contaminate their perception of the shape of a slanted circle – at least their prior knowledge has less impact compared with individuals who do not have autism. In this respect, individuals with autism might be equipped to inspect a scene more objectively. However, they are not completely immune to prior knowledge when processing visual input, and they are as susceptible to visual illusions as individuals without autism. Moreover, they uniquely show interference from local to global when processing hierarchical stimuli and they tend to be faster at a difficult visual search task relative to closely matched comparison participants.

Do these findings add up to compelling support for the theory of weak central coherence? The findings show that there is something special about autistic visual processing but it is not necessarily enlightening to explain this by saying they have weak central coherence – on the contrary, this probably would give an incorrect impression of autistic abilities. The theory posits that individuals with autism are characterised by detail-focused processing such that they have an aptitude for visually segregating an array into its component parts. From this account, Happe (1996) hypothesised that individuals with autism would show low susceptibility to visual illusions, but this has proved not to be the case (Ropar & Mitchell, 1999, 2001a). Also, the theory is at a loss to explain why participants with autism are so good at visual search (e.g. O'Riordan et al, 2001), why they show interference from local to global when processing hierarchical stimuli, and why they are prone to exaggerate the circularity of a slanted circle presented in a visually rich context. The latter finding implies that individuals with autism do perceptually integrate a target object with the rest of the array.

Another idea to arise from the theory of weak central coherence is that individuals with autism might experience "less capture by meaning". If this phrase can be interpreted to mean that visual processing in individuals with autism is less influenced by prior knowledge, then there is some supporting evidence. Namely, it seems that individuals with autism are less influenced by prior knowledge relative to comparison participants when judging the shape of a slanted circle in the absence of contextual cues. However, superior performance in visual search by individuals with autism cannot be explained with reference to weakened influence by prior knowledge. Conversely, there are instances where individuals with autism clearly have been influenced by prior knowledge, as in selecting a colour to partner an atypically coloured object.

Is weak central coherence a bad theory? Unequivocally, we can say that this has been a very useful theory. First, the theory has stimulated a great deal of activity that has led to a burgeoning in our understanding of the assets as well as the deficits in autistic functioning. Even if the data do not always support the theory, at least our understanding is richer following the quest to find out. In any case, the evidence reported in this article is confined to visuo-spatial functioning, and the theory also offers explanations for phenomena in totally different domains, such as processing text. That aspect of the theory might continue to be useful.

Is there a better explanation for distinctive perceptual processing in autism? A rival to the theory of weak central coherence is Plaisted's suggestion of enhanced discrimination in autism (e.g. Plaisted, 2001; Plaisted et al, 1998). However, it might be stretched too far to try to explain phenomena such as less exaggeration of circularity when reproducing the shape of a slanted circle. Hence, we need an account that explains both the heightened performance on low-level tasks, like visual search and processing hierarchical stimuli, and evidence of attenuated influence by prior knowledge, as in the ellipse task. A recent suggestion by Mottorn and Burack (2001) offers a neat solution. In developing their account, Mottron and Burack draw attention to a phenomenon called “paradoxical functional facilitation”, which is that a deficit in one of two neurological systems can lead to development of the other. So, for example, an individual who suffers visual impairment is likely to develop a finer sense of hearing.

Mottron and Burack (2001) use this idea to shed light on autism. They effectively suggest that individuals with autism have difficulty processing input on a deeper level, which gives rise to increased dependence on processing at a low level. In other words, the finer processing on a low level is presented as the consequence of diminished processing on a deeper level. Essentially, we suggest that Mottron and Burack’s account is the most effective in explaining the diverse range of data: There are signs that individuals with autism show weaker processing on a deep level but heightened processing on a low level.

So, for example, individuals with autism would have an aptitude for processing the form of hierarchical stimuli both as Ss and an H, which would give rise to interference from the local to the global as well as the reverse. People without autism might process the stimulus primarily as an H, giving rise to interference from the global to the local but not the reverse. That is, the more extensive processing on a low level might equip participants with autism to easily consider the two aspects of the form of the stimulus, while the lesser processing by individuals without autism might constrain them to concentrate only the level that takes precedence—namely, the global. On the other side of the coin, the attenuated processing on a deeper level in autism might effectively mean that prior knowledge is less likely to influence processing, such that they are inclined to process the projection of a slanted circle merely as an ellipse. Apart from accounting for the findings reported in this article, Mottron and Burack's theory explains a diverse range of phenomena in the auditory modality and it also explains savant abilities by saying that low-level processes have developed to a very great extent in such individuals.

A distinctive quality of Mottron and Burack's (2001) theory is the implication of a developmental aspect of heightened processing on a low level in autism. Apparently, they do not regard individuals with autism as having a constitutional aptitude for low-level processing, contrary to the implication that seems to be made in Plaisted's (2001) account. Rather, they seem to present heightened low-level processing as a kind of 'expertise' that might develop in lieu of processing on a deeper level. Therefore, Mottron and Burack might uniquely predict that heightened low-level processing would emerge with increasing age and maturity, but would not be discernible at an early point in development. Moreover, their account could imply that the form of autistic 'expertise' in visuo-spatial processing might be characteristic of expertise in general. In other words, the 'chunking' in visuo-spatial processing in autism might be similar to that in an individual without autism who developed visuo-spatial expertise as part of their job – such as a draughtsman. If the chunking structure in autism were unlike that of a regular expert, of course, this would cast some doubt on Mottron and Burack's account; it would once again raise the possibility that heightened visuo-spatial processing in autism is constitutional.

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