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Children with Autism Show Local Precedence in a Divided Attention Task and Global Precedence in a Selective Attention Task

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Children with a diagnosis of autism and typically developing children were given two variations of the Navon task (Navon, 1977), which required responding to a target that could appear at the global level, the local level, or both levels. In one variation, the divided attention task, no information was given to children regarding the level at which a target would appear on any one trial. In the other, the selective attention task, children were instructed to attend to either the local or the global level. Typically developing children made most errors when the target appeared at the local level whereas children with autism made more errors when the target appeared at the global level in the divided attention task. Both groups of children were quicker to respond to the global target than the local target in the selective attention task. The presence of normal global processing in the children with autism in one task but not in the other is discussed in terms of a deficit in mechanisms that inhibit local information in the absence of overt priming or voluntary selective attention to local information.

Keywords: Attention, autistic disorder, perception.

Abbreviations: CA: chronological age; ITI: intertrial interval; RSPM: Raven's Standard Progressive Matrices; RT: reaction time; STG: superior temporal gyrus.

Introduction

An increasing awareness of the special abilities of persons with autism in certain psychological tasks has led to theorising about possible perceptual anomalies (Frith, 1989; Happé, 1994, 1996; Mottron & Belleville, 1993). For example, individuals with autism show superior performance on the Block Design subtest of the Wechsler intelligence scales relative both to their performance on other subtests and to other individuals without autism matched for mental age; compared to controls, they make fewer errors and are faster at detecting a target figure embedded within a picture (Jolliffe & Baron-Cohen, 1997; Shah & Frith, 1983).

One account of this superior performance is that individuals with autism exhibit weak central coherence—a deficit in central control processes responsible for drawing together component features into a coherent whole (Frith, 1989; Happé, 1991). The argument is that this deficit serves to enhance performance substantially in tasks such as the Block Design and Embedded Figures tasks because it is assumed that, in developmentally normal individuals, success on these tasks results from overcoming the gestalt perception of the whole pattern in order to detect its component parts (Shah & Frith, 1993). The weak central coherence hypothesis thus predicts that since processes of global perception are disrupted in autism, these individuals would not suffer the interference by the gestalt in perception of the parts normally produced by global processing.

This prediction can be tested by using tasks in which stimuli can be analysed at both the global (i.e. the overall shape of the stimulus) and local level (i.e. the individual features which comprise the overall shape). An example is the "Navon task", in which participants are briefly presented with a large letter shape made up of smaller letters of either the same kind (compatible condition) or a different kind (incompatible condition), and are required to identify the letters at the global and/or local level (Navon, 1977). A classic finding is that participants make more errors and are slower to identify the letters at the local than at the global level—the so-called "global

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advantage'' effect. Furthermore, in incompatible conditions, participants are slower to detect the target letter when it is at the local level compared to when it is at the global level—the ''global interference'' effect. The co-occurrence of both effects is often referred to as the global precedence effect, a term which is in keeping with the hypothesis that global information is processed faster and is therefore available earlier than local information (Badcock, Whitworth, Badcock, & Lovegrove, 1990; Navon, 1981; see also Kimchi, 1992, for a review of the alternative hypotheses concerning the global interference and global advantage effects).

Several neuropsychological studies have shown that responding to local and global levels is subserved by separate processing channels and neuroanatomical regions (Robertson & Lamb, 1991). For example, patients with right superior temporal gyrus (STG) and adjacent parietal damage preferentially process local information in versions of the Navon task and the converse is true of patients with left STG and adjacent parietal lesions (Lamb, Robertson, & Knight, 1989, 1990; Robertson, Lamb, & Knight, 1988). Furthermore, patients with STG damage on either the left or right sides show no global interference effect, suggesting that in normal individuals one system influences the other (Lamb et al., 1989).

This raises two possibilities concerning the performance of individuals with autism on the Navon task. Given the fact that these individuals show superior performance on the Block Design and Embedded Figures tasks, which may involve local and global processing, one possibility is that they, like patients with right STG and adjacent parietal damage, may show a precedence of local over global processing compared to normal individuals. The weak central coherence hypothesis, which suggests that there is an abnormality in global or gestalt processing in autism (Frith, 1989; Happé, 1996), predicts both local advantage and local interference in autism.

The second possibility is that individuals with autism, like patients with selective left or right STG damage, will show the presence of a global advantage effect but an absence of the global interference effect. This prediction has been proposed by Mottron and Belleville (1993). Their hierachisation deficit theory of autism, in contrast to weak central coherence, states that both local and global processing are intact in autism but that there is an abnormality in the interaction between the two levels. Thus, the theory makes the same prediction as weak central coherence concerning performance on the Block Design and Embedded Figures task, that the global analysis of the pattern or picture will not interfere with local analysis and that performance on these tasks will be superior compared to individuals without autism. However, regarding performance on the Navon task, the hierarchisation deficit theory predicts that individuals with autism will show a global advantage effect comparable to that of developmentally normal individuals, but a reduction or absence of global interference.

In support of their theory, Mottron and Belleville (1993) cite the case of an individual with autism, EC, who exhibited a global advantage effect but no global interference effect on a Navon task. Indeed, there was a reversal of the global interference effect to a local interference effect—EC made far fewer local than global errors when stimuli were incompatible. However, a subsequent study by Ozonoff, Strayer, McMahon, and Filloux (1994) stands in contradiction to both weak central coherence and hierarchisation deficit theory. They compared participants with autism with two groups, one with Tourette syndrome and the other typically developing, on the Navon task and found that all three groups showed the global advantage effect and the global interference effect.

What is the reason for this discrepancy? One possibility may be differences in the parameters of the task used in each study. Jolliffe and Baron-Cohen (1997) have argued that one critical difference is the duration for which stimuli were presented in each study (between 5 and 13 msec in Mottron and Belleville's study and 1000 msec in Ozonoff et al.'s study). If the abnormality in autism is a reduction in the speed at which central control processes operate, then, they suggest, the longer stimulus duration employed in Ozonoff et al.'s (1994) study could allow sufficient time for processes involved in central coherence to operate. One might therefore expect a reduction in the number of errors made at the global level compared to when short stimulus durations are employed. However, this explanation predicts no difference in speed of processing local and global targets and no interference between levels in a group with autism, yet both effects were observed in Ozonoff et al.'s study.

An alternative reason may be the difference in the nature of the tasks employed in each study. Mottron and Belleville employed a divided attention procedure in which participants were asked to describe the letter both at the global and local level on each trial. In the study by Ozonoff et al., participants were required to respond to either the global or the local target within a given block of trials. This selective attention procedure may therefore have reduced task difficulty and eliminated the possibility of observing preferential local processing in autism.

It is also of potential importance that there were two problematic aspects of Mottron and Belleville's (1993) study, one which precludes generalisation of the result to the population of individuals with autism and the other which precludes interpretation of that result in terms of underlying processes in autism. First, the performance of the single individual with autism, EC, was compared to a group of six control individuals, whose scores were pooled and presented as group averages. Hence, it is possible that there may have been one or two individuals whose performance was similar or identical to the individual with autism. Second, while the procedure used replicated the global advantage effect in both EC's and control participants' performance, no interference effect was obtained in the performance of control participants. Hence, even if all control participants did perform differently to EC, the local interference observed in EC's performance is difficult to interpret because it cannot be known whether this resulted from superior local processing or inferior global processing, compared to control participants.

There were two objectives of the current experiment. One was to compare the performance of the *same* children with autism and typically developing children on two versions of the Navon task. The children, whose chronological ages were similar to those children who took part in Ozonoff et al.'s (1994) study, were matched for nonverbal IQ using Raven's Standard Progressive Matrices (RSPM; Raven, 1958). One task employed a divided attention procedure and was analogous to the task used by Mottron and Belleville (1993) in that participants were required to attend to both local and global levels in order to detect the target. The other employed a selective attention procedure of the same kind used by Ozonoff et al. in which participants were instructed to attend to either the global or local level. If there is a deficit in global processing in autism, this may be apparent only in the divided attention procedure, as suggested by Mottron and Belleville's study, where participants are not instructed to attend to the global or local level. Hence, the first objective was an attempt to replicate the apparent discrepancy between the results of Ozonoff et al. and Mottron and Belleville.

The other aim was to evaluate the differential claims of the weak central coherence and hierarchisation deficit theories. Whereas weak central coherence would predict an absence or reversal of the global advantage and global interference effect in autism, hierarchisation deficit theory predicts only an absence of global interference. (The predictions from these theories hold, regardless of the type of procedure used to conduct the Navon task.) It was important, therefore, to replicate the global precedence effect in typically developing children in both the divided and selective attention procedures in order to provide a basis from which to interpret any differential responding between the two groups.

In the divided attention task, the target letter could appear at the local level only (incompatible/local conditions), the global level only (incompatible/global condition), or at both levels (compatible conditions). A global advantage effect would be manifest in this procedure if responding on incompatible/global trials was as fast and/or accurate as responding on compatible trials, while responding on incompatible/local trials was slower or less accurate. A global interference effect would be manifest if responding on incompatible/local trials was slower and/or less accurate than responding on incompatible/global trials.

In the selective attention procedure, there was a large letter condition in which participants were instructed to identify the letter at the global level and a small letter condition in which participants were instructed to identify the letter at the local level. In both conditions, the letter at one level could either be compatible or incompatible with that at the other level. The global advantage effect would be manifest in this procedure if large letters were responded to more quickly and/or more accurately than small letters. The global interference effect would be manifest if responding when stimuli were incompatible was slower and/or less accurate than responding when compatible in the small letter condition.

Method

Participants

There were two groups of participants: a group of 17 high-functioning children with autism (none had received a diagnosis of mental handicap) and a comparison group of 17 typically developing children. All children but one in the group with autism met established criteria for autism, such as those specified in DSM-IV (American Psychiatric Association, 1994) and had previously received a diagnosis for autism by trained clinicians using instruments such as the Autism Diagnostic Interview (Le Couteur et al., 1989), and the remaining child had a diagnosis of Asperger's syndrome. The chronological ages (CAs) of the children with autism ranged from 6 years 7 months to 16 years 7 months. The CAs of the developmentally normal participants ranged from 6 years 1 months to 14 years 4 months. The typically developing children were matched with children in the group with autism for nonverbal IQ using the RSPM (Raven, 1958). Average CAs and Raven's Matrices scores for each group are presented in Table 1.

Table 1
Participant Characteristics

Group	Age (yrs:mths)	Ravens Matrices scores
Autism ($N = 17$)		
Mean	10:4	33.2
SD	2:4	11.03
Range	6:7–16:7	9–47
Normal ($N = 17$)		
Mean	10:2	33.3
SD	2:0	9.6
Range	6:1–14:4	14–45

Apparatus

The stimuli were generated by a 486 IBM-compatible PC and displayed on a 14-inch monitor. Participants responded on each trial by pressing one of two buttons that were mounted on a response pad measuring 27 × 18 cm. The response buttons were 2 cm in diameter and mounted 13 cm apart.

Stimuli

Letter stimuli were employed in both the divided attention and selective attention tasks. Each stimulus comprised a large letter made up from 56 small letters. There were 152 pixels per small letter. In both tasks, participants sat 140 cm away from the computer monitor and at this distance the visual angle of the large letters was $4.6° \times 3.0°$ and the visual angle of the small letters was $0.3° \times 0.2°$.

Design and Procedure

Each participant was given two testing sessions, separated by an interval of 1 week. During the first session, the RSPM (Raven, 1958) was administered, followed by either the divided attention or the selective attention task. Half the participants in each group received the divided attention task first and the selective attention task second and the remaining participants were given the tasks in the reverse order. This counterbalancing was intended to control for practice effects.

The Divided Attention Task

Throughout the session, the children's task was to press one button if the stimulus contained the letter A and the other button if the letter A was not present. Participants were informed at the start of the session and reminded during practice trials which button to press given a particular stimulus.

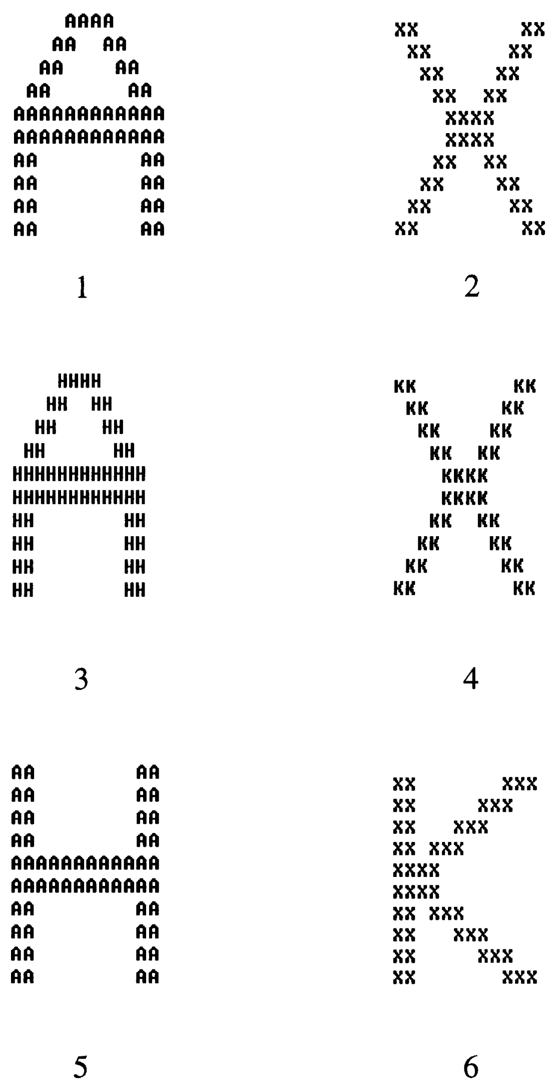

Figure 1. The six stimuli used in the divided attention procedure. Those on the left appeared on target present trials; those on the right appeared on target absent trials.

Six different stimuli were used—three contained the letter A and three contained the letter X—and are shown in Fig. 1. Stimulus 1 was a large A made up of small As and Stimulus 2 was a large X made up of small Xs. These two stimuli appeared on compatible trials. Stimulus 3 was a large A made up of small Hs and Stimulus 4 was a large X made up of small Ks—these stimuli appeared on incompatible/global trials. Stimulus 5 was a large H made up of small As and Stimulus 6 was a large K made up of small Xs, and these appeared on incompatible/local trials.

The session was divided into 14 blocks of trials. In each block, half the trials contained the letter A and trial types were randomly intermixed. The first two blocks contained practice trials. In each practice block, each of the six stimuli appeared four times. In the first practice block, the stimulus remained on the screen until a response had been made. Following an intertrial interval (ITI) of 500 msec, the next stimulus was presented. In the second practice block and the remaining test blocks, each stimulus was presented for 1000 msec and trials were separated by a 500-msec ITI. There were 24 trials in each of the 12 test blocks and each stimulus type appeared 4 times per block. Hence, there was a total of 288 test trials. Reaction times and error data were recorded on each trial.

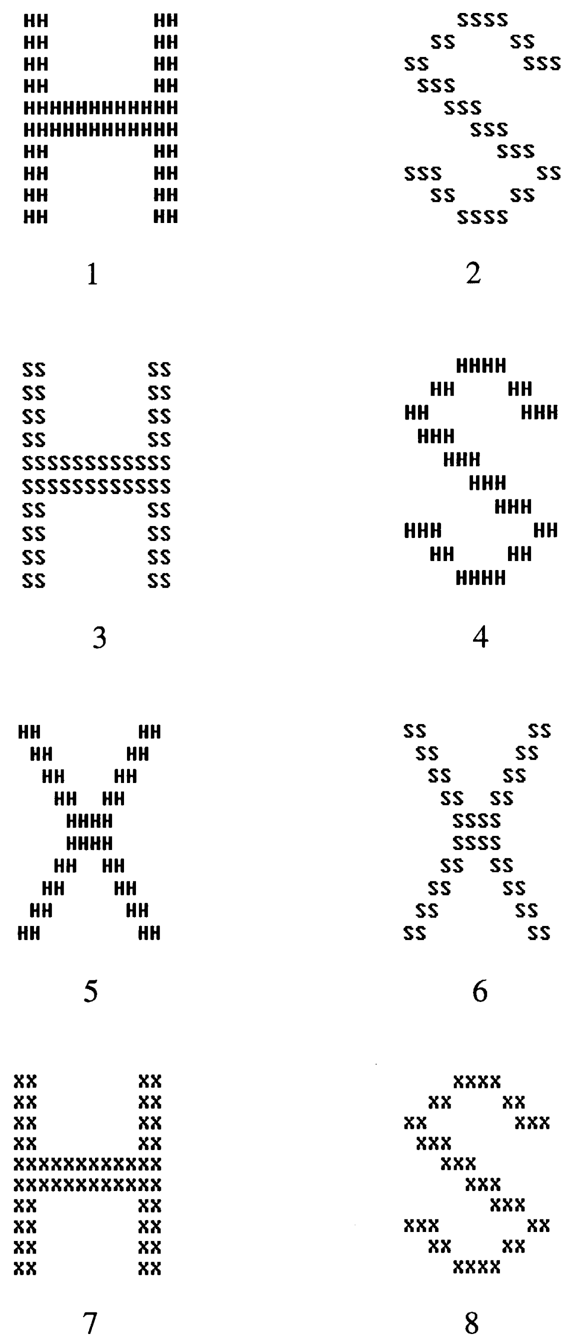

Figure 2. The eight stimuli used in the selective attention procedure.

The Selective Attention Task

The children's task was to identify either the small letter or the large letter in the presented stimulus. Participants pressed one button if the letter to be identified was an H and the other button if it was an S. Eight different stimuli were used in this task and are illustrated in Fig. 2. These were of the same type as those employed by Ozonoff et al. (1994). There were two types of compatible test stimuli—(1) a large H made up of small Hs and (2) a large S made up of small Ss—and two types of incompatible test stimuli—(3) a large H made of small Ss and (4) a large S made up of small Hs. In addition, there were four neutral stimuli—(5) a large X made up of small Hs, (6) a large X made up of small Ss, (7) a large H made up of small Xs, and (8) a large S made up of small Xs.

The session began with two blocks of practice trials. Each practice block was divided into four sub-blocks. Participants were told to name the small letter prior to two sub-blocks and the large letter prior to the remaining two sub-blocks. Of the eight stimulus types, six appeared in each sub-block—four compatible and incompatible stimuli (stimuli 1 to 4) and two neutral stimuli, either those where the H and S appeared at the local level if the subject's task was to name the small letter (stimuli 5 and 6) or those where they appeared at the global level if the subject's task was to name the large letter (stimuli 7 and 8). Order of type of sub-block and trial types within sub-blocks were randomly intermixed. In the first practice block, each stimulus appeared on the screen until a response had been made and in the second practice block and test blocks, stimuli were presented for 1000 msec. The ITI was 500 msec throughout.

There were 24 test blocks of trials. Participants were instructed to name the large letter immediately prior to half of these blocks and to name the small letter prior to the remaining blocks and type of block was randomly intermixed. There were 12 trials per block. In large letter blocks, stimuli 1 to 6 appeared, and in small letter blocks, stimuli 1 to 4 and 7 and 8 appeared. Each stimulus type appeared twice within a block and trial types were randomly intermixed. Hence there were a total of 288 test trials. Reaction times and error data were recorded on each trial.

Results

Divided Attention Task

The graph in Fig. 3 shows average reaction time (RT) on correct trials to positive (A present) and negative (A absent) trials for each group of participants when those targets appeared at either the local, global, or both levels. The groups differed very little in their RTs on negative trials in all three conditions. On positive trials, however, the pattern of performance in each condition differed between groups. The typically developing children responded least quickly when target A appeared at the local level (incompatible/local condition) and most quickly when it appeared at both levels (compatible condition). In contrast, the children with autism responded least quickly when the target appeared at the global level (incompatible/global condition) compared to the other two conditions.

Analysis of RT Data

A mixed ANOVA was conducted on these data, with one between-subjects factor of Group (developmentally normal and autistic) and two within-subjects factors of Trial (positive and negative) and Condition (incompatible/local, incompatible/global, and compatible). There were no main effects of either Group or Trial but an interaction between Group and Trial [$F(1,32) = 5.8$, $p < .02$]. Although simple effects analysis indicated no significant effects for any factors involved in this interaction, the graph in Fig. 3 suggests that it arose because the children with autism responded more slowly on target present trials than the typically developing children, and because there was a greater difference in speed of responding between positive and negative trials in the group of typically developing children but not in the group of children with autism.

There was a significant main effect of Condition [$F(2,64) = 7.75$, $p < .002$] and a significant interaction between Trial and Condition [$F(2,64) = 14.58$, $p < .001$]. Simple effects analysis revealed that this was because responding in the compatible condition was quicker on target present than target absent trials [$F(1,32) = 5.66$, $p < .03$], and response times differed across the three conditions on positive trials [$F(2,64) = 18.14$, $p < .001$], but not on negative trials.

Finally, there was a three-way interaction between Group, Trial, and Condition [$F(2,64) = 6.48$, $p < .003$]. In order to establish the source of this interaction, two further analyses were conducted on the data from each group. In each ANOVA, there were two within-subjects factors of Trial (positive and negative) and Condition (incompatible/local, incompatible/global, and compatible). The analysis of the data from children with autism

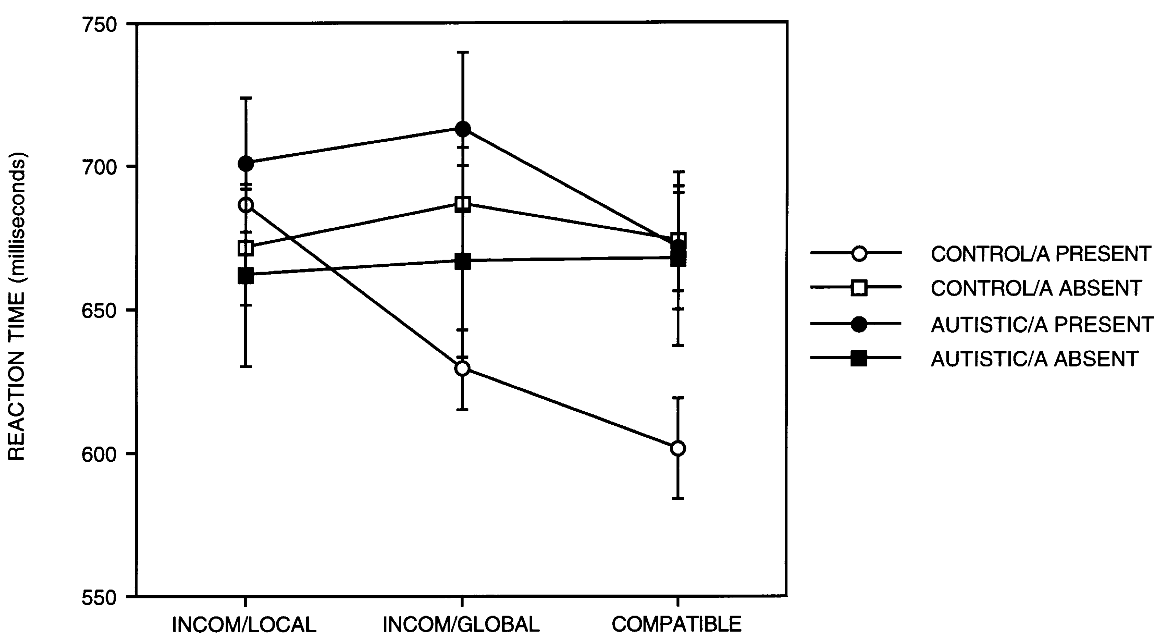

Figure 3. Average RT on positive and negative trials in the divided attention procedure for each group of participants. Error bars represent standard error of the mean—SEM.

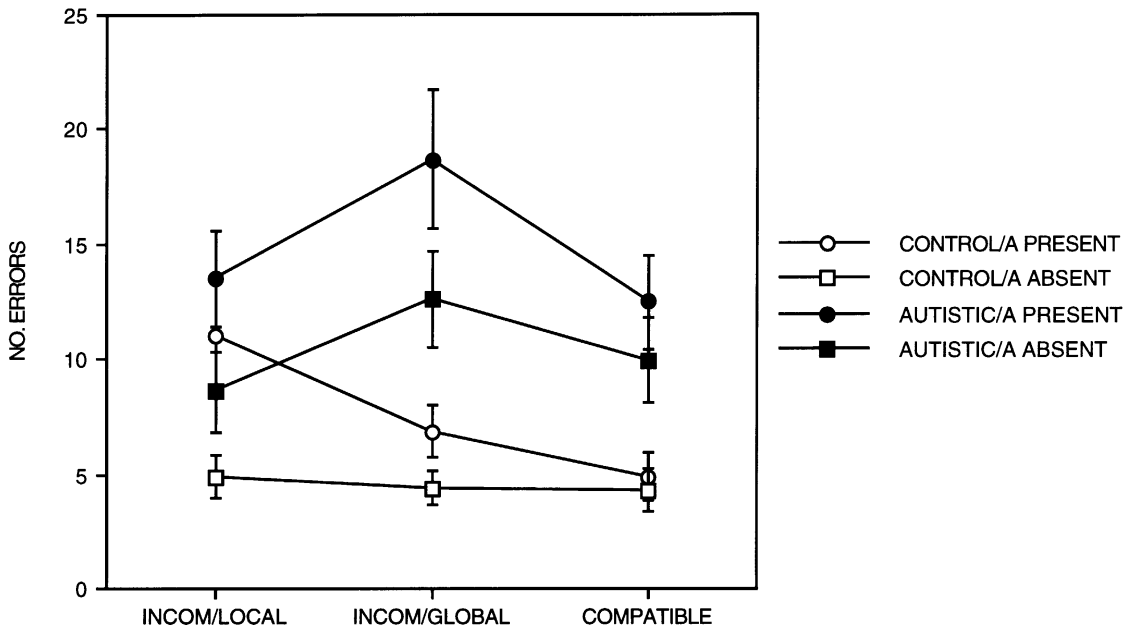

Figure 4. Average number of errors on positive and negative trials in the divided attention procedure for each group of participants. Error bars represent SEM.

revealed no significant main effects or interaction between factors. The analysis of the data from the group of typically developing children revealed significant effects of Trial [$F(1,16) = 4.69$, $p < .05$] and of Condition [$F(2,32) = 17.67$, $p < .001$]. There was also an interaction between Trial and Condition [$F(2,32) = 30.42$, $p < .0001$], and simple effects analysis confirmed that significant differences between conditions occurred on positive trials only [$F(2,32) = 47.29$, $p < .001$]. Newman-Keuls pairwise comparisons showed that responding was faster in the incompatible/global condition compared to the incompatible/local condition, and faster in the compatible condition compared to the incompatible conditions ($p = .05$).

Hence, the final analysis confirmed that this procedure replicated the global interference effect in RT in typically developing children. In the two incompatible conditions, responding was faster when the stimulus consisted of the target letter A at the global but not the local level. Although there was also some evidence of global advantage in the RT data of the typically developing children in that responding on positive trials was faster in the compatible condition compared to the incompatible conditions, it should be noted that our criterion for a true global advantage effect was not fulfilled—responding in that group was faster in the compatible condition compared to the incompatible/global condition. No such effects were observed in the group of children with autism—response times did not differ significantly between incompatible conditions, and responding was no faster statistically in the compatible condition compared to the incompatible conditions.

Analysis of Error Data

The average error scores for each group in each condition are presented in the graph in Fig. 4. The mixed ANOVA conducted on these data, which included the same factors as before, revealed a significant main effect of Group [$F(1,32) = 10.99$, $p < .002$], reflecting the fact that, overall, the children with autism made more errors than the typically developing children. There was a main effect of Trial Type [$F(1,32) = 14.93$, $p < .0005$], because more errors were made on positive than on negative trials. There was also a main effect of Condition [$F(2,64) = 6.84$, $p < .002$], reflecting the fact that the greatest number of errors were made in the incompatible/local condition and the least number made in the compatible condition. There was also a significant interaction between Trial and Condition [$F(2,64) = 3.35$, $p < .04$] and simple effects analysis confirmed that more errors were made on positive than on negative trials in the incompatible/local and incompatible/global conditions [$Fs(1,32) = 14.96$ and 7.87, respectively, $p < .002$], but not in the compatible condition.

More importantly, there was a significant interaction between Group and Condition [$F(2,64) = 10.71$, $p < .0001$]. Simple effects analysis revealed differences between groups in the incompatible/global and compatible conditions [$Fs(1,44) = 21.42$ and 9.38 respectively, $p < .005$]. Furthermore, simple effects revealed a significant difference between the three conditions in the performance of the typically developing children [$F(2,64) = 5.26$, $p < .009$] and the children with autism [$F(2,64) = 12.28$, $p < .001$]. It seems quite clear from the graph in Fig. 4 that the reason for the difference in the group of typically developing children was because most errors were made when the target appeared at the local level and fewest when stimuli were compatible. Newman-Keuls pairwise comparisons of the typically developing children's data from positive trials confirmed that there was a significant difference between the incompatible/local and compatible conditions but not between the incompatible/global and compatible conditions ($p = .05$). There was also a difference between the incompatible/local and incompatible/global conditions ($p = .05$). Thus, both global

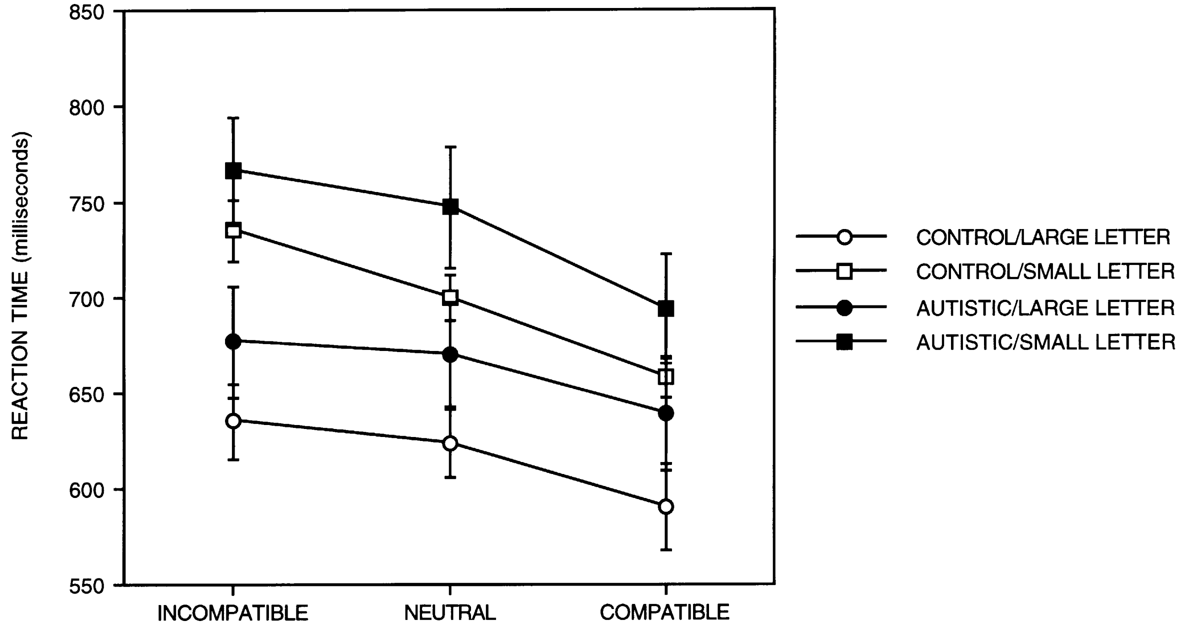

Figure 5. Average RT on positive and negative trials in the selective attention procedure for each group of participants. Error bars represent SEM.

advantage and global interference effects were observed in the typically developing children's error data.

In contrast, Newman-Keuls pairwise comparisons of error data on positive trials from the children with autism revealed a difference between the compatible and the incompatible/global condition but not between the compatible and incompatible/local conditions. There was also a difference between the two incompatible conditions. Thus, both local advantage and local interference effects were observed in the error data from the children with autism.

Finally, we examined the data from the single individual with Asperger's syndrome. Although one study has found no difference in the performance of individuals with autism and individuals with Asperger's syndrome on tests of weak central coherence (Joliffe & Baron-Cohen, 1997), there is still some debate concerning the degree of similarity in performance on psychological tests between the two disorders. The child with Asperger's syndrome tested here showed a similar pattern of performance to the remaining children with autism. The mean RT scores for this individual on positive trials were 602.4, 704, and 587.1 msec for the incompatible/local, incompatible/ global, and compatible conditions respectively, and 598, 722.4, and 652.3 for the same three conditions on negative trials. The mean error scores on positive trials were 10, 17, and 7 for the incompatible/local, incompatible/global, and compatible conditions respectively, and 9, 15, and 10 for the same three conditions on negative trials.

The Selective Attention Task

The graph in Fig. 5 shows average RTs on correct trials to large and small letters in the three conditions—incompatible, neutral, and compatible for each group of children. The graph suggests that both groups responded more quickly to large than to small letters and more slowly to both large and small letters in incompatible conditions than in compatible conditions.

Analysis of RT Data

The data were analysed by mixed ANOVA with Group as a between-subjects factor and within-subjects factors of Letter Size (large vs. small) and Condition (incompatible, neutral, and compatible). There were significant main effects of Letter Size [$F(1,32) = 78.85$, $p < .0001$] and of Condition [$F(2,64) = 39.34$, $p < .0001$]. The effect of letter size reflected the fact that large letters were responded to more quickly than small letters, thus replicating the global advantage effect. Furthermore, Newman-Keuls pairwise comparisons of the data from the three conditions revealed a significant difference between responding in the compatible condition compared to the other two conditions, replicating the global interference effect. There was also an interaction between Letter Size and Condition [$F(2,64) = 3.76$, $p < .03$]. The source of this interaction was that there was a greater effect of Condition when the target appeared at the local level as a small letter than when it appeared at the global level as a large letter [$Fs(2,64) = 50.16$ and 8.85 respectively, $p < .001$].

Most importantly, there was no effect of Group or any interaction of Group with any factor. Thus, the global advantage and global interference effect was replicated in both groups of children in RT data. The RT data from the individual with Asperger's syndrome also displayed global precedence—the mean RT scores for large letters were 663, 647.2, and 641.8 for the incompatible, neutral, and compatible conditions respectively, and 791.2, 723.5, and 734.7 for small letters in the same conditions.

Analysis of Error Data

The average number of errors made by each group in each condition is presented in the graph in Fig. 6. The

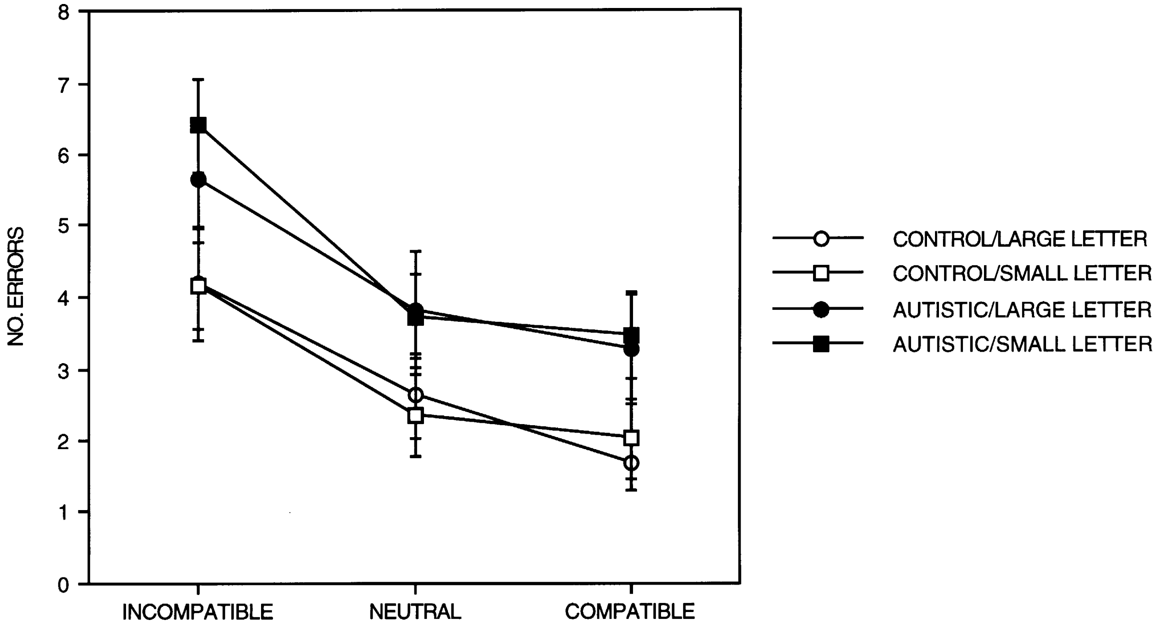

Figure 6. Average number of errors on positive and negative trials in the selective attention procedure for each group of participants. Error bars represent SEM.

graph suggests that the group of children with autism made more errors overall than the typically developing children and both groups made more errors in the incompatible condition than in the compatible condition. Error data were analysed in the same way as RT data. The mixed ANOVA revealed a difference between Groups falling just short of significance [$F(1,32) = 3.89$, $p = .057$] and a significant difference between Conditions [$F(2,64) = 57.92$, $p < .001$]. Newman-Keuls pairwise comparisons confirmed that significantly more errors were made in the incompatible condition compared to the other two conditions ($p < .05$). There were no other significant main effects or interactions. The error data of the individual with Asperger's syndrome showed the same pattern as that of the individuals with autism—the mean error scores for large letters were 10.5, 6, and 7.5 for the incompatible, neutral, and compatible conditions respectively, and 8, 6, and 5.5 for small letters in the same conditions. Hence, the global interference effect was replicated in both groups in error data, and the global advantage effect was replicated in neither.

Discussion

This study set out to compare the performance of a group of children with autism and a group of typically developing children on two versions of the Navon task in order to assess the claims of the weak central coherence and hierarchisation deficit hypotheses. Whereas the weak central coherence hypothesis predicts children with autism would show neither a global advantage nor a global interference effect in such tasks, the hierarchisation deficit hypothesis predicts the abolition only of the interference effect but not the global advantage effect. The predictions of these hypotheses stand regardless of the procedure by which the Navon task is conducted. We employed two procedures—one in which the target letter could appear at either the global or local level or at both levels on any trial (the divided attention procedure) and the other in which the target always appeared at the global level or the local level or at both levels within a block of trials (the selective attention procedure).

Our first concern was to establish that both procedures replicated the global precedence effect in the group of typically developing children, from which we would be able to interpret any differences in responding by the children with autism. In the divided attention task, typically developing children showed a global advantage effect (global targets were detected more quickly and more accurately than local targets in incompatible conditions) and a global interference effect (significantly more errors were made in the incompatible/local condition than in the compatible condition, while there was no statistical difference in number of errors between the incompatible/global and compatible conditions). In the selective attention task, both effects were observed in the typically developing children's RT data—responding was faster when the target appeared at the global (the global advantage effect) and when it appeared in compatible conditions (the global interference effect).

In contrast, in the divided attention task, the error data from the group of children with autism showed a local advantage effect (more errors were made in the incompatible/global condition than in the incompatible/local and compatible conditions) and a local interference effect (more errors were made in the incompatible/global condition compared to the incompatible/local condition and there was no significant difference in the numbers of errors made between the incompatible/local and compatible conditions). However, in the selective attention task, children with autism performed in the same manner as typically developing children—their RT data showed a global advantage and global interference effect.

The presence of both local advantage and local interference effects in the divided attention procedure in the group of children with autism is consistent with the weak central coherence hypothesis, which predicts that the lack of central control processing, which diminishes global perception, would affect both global advantage and global interference. The alternative hypothesis, that there is a deficit in hierarchisation processes in autism, is not supported by these data, because the hierarchisation deficit theory predicts the presence of global advantage in autism but an absence of global interference. However, both hypotheses are challenged by the results obtained in the selective attention procedure. Both the typically developing children and the children with autism showed global advantage and global interference in RT data, thus replicating the results of Ozonoff et al.'s (1994) study.

The presence of global precedence in one but not another procedure in the same group of children with autism is important in confirming the impression in the literature that global processing in autism is deficient under some conditions (Mottron & Belleville, 1993) and normal under others (Ozonoff et al., 1994). Furthermore, because the divided and selective attention procedures employed stimuli of the same density, visual angle, and time of presentation, it is unlikely that the difference in performance of the children with autism between the two procedures resulted from some difference in task parameters. The difference is therefore likely to be due to differences in the nature of the tasks and raises the question of how these differences affect the performance of the children with autism.

One clear difference between the two procedures was that participants were overtly primed by instruction in the selective attention procedure about the level at which targets would appear prior to each block of trials. The results therefore suggest that global processing is intact in autism and shows the normal properties of quicker operation than local processing (Badcock et al., 1990) but operates only under conditions of overt priming. This is consistent with the idea that central coherence processes in autism are "weak" (Frith, 1989) rather than absent.

This raises the question of what mechanism gave rise to local precedence in autism in the absence of overt priming in the divided attention procedure. One possibility is that visual attention in the group of children with autism was focused on a small area of the screen that failed to encompass the entire stimulus, facilitating local target detection but retarding global target detection. This notion is consistent with recent claims that the distribution of visual attention is restricted among those individuals with autism with known damage to the parietal cortex (Townsend & Courchesne, 1994), implicating the involvement of parietal systems in manipulating the boundaries of a visual "spotlight" of attention in response to task demands.

However, not all individuals with autism show an abnormally narrow spotlight of attention (Townsend & Courchesne, 1994), and Burack (1994) has presented some evidence which suggests that the distribution of visual attention in autism can be abnormally broad—RT for the identification of a target was significantly improved in children with autism when a visual "window" defining the area in which the target would appear was presented on the screen. Furthermore, he found that children with autism were less efficient than typically developing children at filtering irrelevant distracters. One further contender for a mechanism underlying the weak central coherence effect in the divided attention procedure, therefore, is that in the absence of priming, children with autism were unable to inhibit the irrelevant distracters that appeared at the local level in the global/incompatible condition.

Hence, these results indicate that weak central coherence can be conceived of as an inability to filter out information at the local level rather than a deficit in the ability to draw together component features of an object into a global whole (Frith, 1989; Happé, 1996). The locus of the weak central coherence effect observed here could therefore be abnormally high levels of activity in channels responsible for local information processing. Following from Burack's (1994) results, we speculate that this elevated activity could result from a reduction in the inhibition of the output of local information processing channels in the absence of priming by instruction.

Alternatively, children with autism may *voluntarily* attend to the local level, unless instructed to do otherwise. There is substantial evidence that normal individuals can voluntarily attend to the global or local level as a result of instruction by the experimenter, or increased probability of a target appearing at one level rather than the other within a block of trials (Kinchla, Solis-Macias, & Hoffman, 1983; Shulman & Wilson, 1987). Kinchla et al. have also argued that an increase in attention to one level not only produces more efficient processing of the information in that level but also an accompanying decrease in the efficiency of processing at the other level. According to this attentional-tradeoff principle, children with autism would make more errors at the global level in tasks such as the divided attention task, where they had voluntarily directed their attention to the local level. This is not inconsistent with the weak central coherence hypothesis but, again, shifts the argument concerning the locus of the effect from an inability of central mechanisms to draw parts into wholes to highly activated processing of the local level.

One final possibility is that the difference in the pattern of results from the two tasks in the group of children with autism resulted from an attention shifting deficit. Unlike the selective attention task, the divided attention procedure demanded vigilance at both global and local levels on each trial. Hence, the task presumably required attention to be disengaged from one level and re-engaged at another in order to find the target. There is now substantial evidence that individuals with autism perform poorly on divided attention tasks that require attentional switching between one stream of information and another (Courchesne, Townsend, Ashoomoff, Yeung-Courchesne, et al., 1994; Courchesne, Townsend, Ashoomoff, Saitoh, et al., 1994). However, if the performance of the children with autism on this task (i.e. from global to local or from local to global) was solely determined by an attention switching deficit, there would have been no indication of any advantage or interference effects. Although this prediction was supported by RT data from the group of children with autism, it was not supported by the presence of the local precedence observed in their error data.

Nevertheless, it is plausible that a deficit in attention switching contributed to the greater number of errors in detecting the target at the global level. That is, if a local processing bias led children with autism to begin each trial by processing the local level first (for the reasons outlined above), there would be a need to switch attention to the global level on incompatible/global trials, and it would therefore be on these trials that an impairment in attention switching would be revealed. The pattern of data from the divided attention procedure might therefore be explained by a combination of two factors—enhanced local processing in the absence of priming and a deficit in switching attention to the global level (we thank an anonymous reviewer for this suggestion).

In summary, both the weak central coherence and hierarchisation deficit hypotheses are challenged by the differential responding to global and local stimuli by children with autism in the two versions of the Navon task. The observation of global precedence in the performance of these children, replicating Ozonoff et al. (1994), confirms that global processing is intact in autism. The results suggest instead either that inhibitory mechanisms which operate upon the output of local information processing channels do not operate automatically in autism but must be primed, or that children with autism voluntarily attend selectively to local information in the absence of overt instruction.

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