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Flexible Visual Processing in Young Adults with Autism: The Effects of Implicit Learning on a Global–Local Task

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Abstract We utilized a hierarchical figures task to determine the default level of perceptual processing and the flexibility of visual processing in a group of high-functioning young adults with autism (n = 12) and a typically developing young adults, matched by chronological age and IQ (n = 12). In one task, participants attended to one level of the figure and ignored the other in order to determine the default level of processing. In the other task, participants attended to both levels and the proportion of trials in which a target would occur at either level was manipulated. Both groups exhibited a global processing bias and showed similar flexibility in performance, suggesting that persons with autism may not be impaired in flexible shifting between task levels.

Keywords High-functioning autism · Visual attention · Hierarchical figures · Implicit learning

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Introduction

Visual scenes tend to be structured hierarchically, with the global whole being made up of smaller local elements. In the laboratory setting, Navon (1977) first designed a hierarchical figure to mimic complex visual scenes. This stimulus is a "global" letter made up of smaller "local" letters. The letters at the global and local levels of processing can either be congruent, the same at the two levels, or incongruent, different at the two levels. By manipulating the presentation of congruent and incongruent stimuli, the precedence, interference, and flexibility aspects of attention can be studied. Precedence refers to the level of processing (global or local) to which attention is first directed, and is operationalized in terms of faster response times (RTs) to that level. Interference refers to the delay in responding to one level of the stimulus when the other level is different, and is operationalized as the overall slowing of RTs on incongruent trials as compared to congruent trials. Flexibility refers to the ease or difficulty of switching one's attention from one level of processing to the other from one trial to the next, and is operationalized in terms of the slowing of RTs when switching attention between levels.

The performance of typically developing (TD) adults is characterized both by global precedence, with faster responses to global as compared to local stimuli, and by global interference, with responses to local stimuli slowed by information at the global level (Love et al. 1999; Navon

1977; Priyanka et al. 2010). The global precedence effect is contingent on manipulations of the stimulus properties (e.g., Enns and Kingstone 1995; Kimchi 1992; Kimchi et al. 2005) and global interference on the meaningfulness of the stimuli (e.g., Poirel et al. 2008), whereas flexibility seems to be more impervious to task characteristics (e.g., Hübner 2000; Monsell 2003). Contrary to these typical patterns, people diagnosed with an autism spectrum disorder (ASD) display a different pattern of behaviour (e.g., Wang et al. 2007) with an apparent emphasis on parts across a wide variety of visual processing tasks. For example, Happé and Frith (2006) characterized persons with autism as having a detail-focused cognitive style or bias. If this is the case, we should be able to identify and address which task parameters lead to the "non-default" global processing. One way to investigate the task parameters that can lead to a shift in cognitive style could be to manipulate expectations, either explicitly or implicitly, of when and where a target will occur. Specifically, explicit instructions, such as "attend to the global level and ignore the local level" could prompt one way of performing the hierarchical figures task, whereas implicit information regarding the frequency at which the targets will appear at each level of processing could lead to a different pattern of performance.

Plaisted et al. (1999) demonstrated that level precedence can vary in relation to task demands. They found that both children with ASD and nonverbal mental age-matched TD peers (mean chronological age of 10 years) showed global precedence on a selective attention task, in which one level of processing was consistently the focus of attention while the other was ignored. In contrast, the children with ASD showed a local precedence rather than the global precedence displayed by the TD children on a divided attention task, in which attention needed to be oriented simultaneously to both levels of the hierarchical figure on each trial. Plaisted et al. (1999) concluded that persons with ASD are able to effectively process both the global and local levels when instructed to do so, but when forced to divide attention between the two levels, their processing is biased toward the local, rather than the global, form.

An alternative explanation to the one provided by Plaisted et al. (1999) regarding the divergent findings with the two paradigms is that the two tasks may have different attentional demands. The selective attention task, with its explicit instructions regarding level of processing, requires attention to a single level of the hierarchical figure and the ignoring or inhibiting of the processing of the other level. Conversely, the divided attention task, with no instructions regarding level of processing, requires attention to both levels and the ability to flexibly shift between them while ignoring the stimulus at the other level. Thus, the findings regarding group differences could have been due to this added demand (i.e., Hill 2004; Hughes et al. 1994; Ozonoff and McEvoy 1994; but also see Dichter et al. 2010), as the ability to flexibly shift between rules is thought to be impaired among persons with ASD.

This notion of impaired flexibility is central to the diagnosis of autism, which includes restricted, repetitive, and stereotyped patterns of behaviour (American Psychological Association (APA) 2000), all of which appear to reflect inflexible behaviour. In one study with children with ASD and two groups of TD children, one matched for verbal mental age (7.5 years of age) and the other matched for nonverbal mental age (8.3 years of age), Iarocci et al. (2006) implicitly manipulated the percentage of trials that the target in a visual search task with hierarchical figures would appear at either the global or the local level. This manipulation of hierarchical figures may be more ecologically valid than the typical random presentation as the number of trials in which the target could be found at the global versus the local level varied across the blocks of trials, thereby reflecting the more real world considerations of the non-random likelihood of an event and the changing nature of the likelihood over time. In the "global bias" condition, the target shape appeared at the global level 70% of the time, in the "local bias" condition, the target shape appeared at the local level 70% of the time, and in the "neutral" condition, the targets were equally likely to be presented at either the global or local level. The nonverbal mental age-matched TD children were faster to respond when the targets were biased toward the global level as compared to when the targets were not biased toward one level or were biased toward the local level, and the verbal mental age-matched TD children showed the same pattern of RTs regardless of the condition. In contrast, the RTs of the children with ASD were faster when the targets were biased toward either the global or the local levels as compared to when the targets were not biased toward either level. This suggests both that a global precedence may only emerge among TD children around the age of 8 years and that, contrary to the notion of inflexibility in autism, children with ASD are able to flexibly use the implicit bias in both the global and local directions to improve RT performance.

The Present Study

A selective attention task with explicit instructions regarding level of processing and a divided attention task with an implicit biasing manipulation regarding the level of processing were administered to young adults with high-functioning autism (HFA) and TD young adults matched on age and full-scale IQ (as measured by the WISC-III, the WAIS-III or the WAIS-R). The selective attention task entailed attending to one level while ignoring the other, whereas the divided attention task entailed attending to both levels of the stimulus while the proportion of trials that a target appeared at the global level or the local level was implicitly manipulated across the blocks of trials. The paradigm of our study differs from the one used by Iarocci et al. (2006) in two ways. One, our design included a single hierarchical stimulus presented at a central fixation point, whereas Iarocci et al.'s (2006) involved a visual search task with multiple hierarchical stimuli. Two, our design included additional biasing proportions, such that the target could appear at either the global or the local level 0, 20, 40, 50, 60, 80 or 100% of the trials in each block.

Predictions

On the selective attention task, we expected to replicate previous findings of a typical global precedence and asymmetric interference effects for both the young adults with HFA and the TD young adults (Ozonoff et al. 1994; Plaisted et al. 1999; Rinehart et al. 2000). This would be manifested with faster RTs and fewer errors overall in the "attend-to-global" as compared to the "attend-to-local" condition, by slower RTs when the stimulus is incongruent, and by the slowest RTs when the global form interferes with attending to the local level. For the divided attention task, we expected to replicate Iarocci et al.'s (2006) findings of intact implicit learning in both groups. This would be manifested by faster RTs and fewer errors as the contingency increases toward 100%. Additionally, as this condition requires flexible shifting between the two levels, we attempted to determine if flexibility in young adults with HFA was impaired as compared to TD young adults. As evidence of both inflexibility (Rinehart et al. 2000) and flexibility (Iarocci et al. 2006) among persons with ASD has been found, we did not propose a prediction. The measurements of flexibility were attained by examining the average RTs for trials in which the target switched from one level to the other and comparing it to the average RTs for trials with no switch in target level.

Method

Participants

The participants included 12 young adults diagnosed with HFA (i.e., IQ > 80) (one female) and 12 TD young adults (two females). The young adults with HFA were recruited from the database of the Specialized Clinic for Diagnosis and Evaluation of Pervasive Developmental Disorders at Rivière-des-Prairies Hospital (Montréal). All of the participants had IQs above 80. One participant was taking Risperidone at the time of testing. The TD young adults were recruited from the community, and were screened for a past or current history of psychiatric, neurological, or other medical disorders. All of the TD young adults had a typical educational background and reported normal or corrected-to-normal vision. Autism was diagnosed using the algorithm of the Autism Diagnostic Interview-Revised (ADI-R) (Lord et al. 1994) combined with the Autism Diagnostic Observation Schedule-Generic (ADOS-G; Lord et al. 2000), both of which were conducted by a trained researcher (LM) who obtained reliability on these instruments. In terms of diagnostic cut-offs, all 12 participants with autism scored above both the ADOS and the ADI cut-off in the three relevant areas for diagnosis (social, communication, restricted interests and repetitive behaviours). The groups did not differ significantly on age or full scale IQ, both $ps > 0.61$. Demographic information of the participant groups is presented in Table 1.

Table 1 A summary table of average age (SD and age range) and average IQ (SD and IQ range) of both the comparison group and the persons diagnosed with HFA

Group	Average age (years) ± SD	Age range (years)	Average IQ ± SD	IQ range
TD	20.17 ± 3.64	17–29	103.42 ± 14.26	81–120
HFA	20.42 ± 2.97	17–27	100.58 ± 12.60	82–120

TD typically developing young adults, *HFA* high-functioning young adults with autism, *SD* standard deviation, *IQ* intelligence quotient

Apparatus and Stimuli

The tasks were run on a Power Macintosh computer running VScope software (Rensick and Enns 1992) with a 14 inch Apple Colour Plus screen set to black and white. The stimuli were presented on a computer monitor placed in a dark room and viewed from a distance of approximately 57 cm. The participants responded using a two button response box.

The stimuli, the same as used by Iarocci et al. (2006; experiment 2), were black and white drawings shown on a white background. They included a global shape (diamond or square, measuring 3.12° of visual angle [VA] high by 3.12° VA wide) that was made up of eight local elements (diamond or square, measuring 0.62° VA high by 0.62° VA wide). The combination of global and local elements resulted in three types of stimuli combinations that were manipulated in this study. The stimuli are illustrated in Fig. 1. They were considered congruent (Fig. 1a) when the shapes were the same at both the global and local levels (e.g., a global diamond made up of local diamonds) and were considered incongruent (Fig. 1b) when the shapes were different between the levels (e.g., a global square

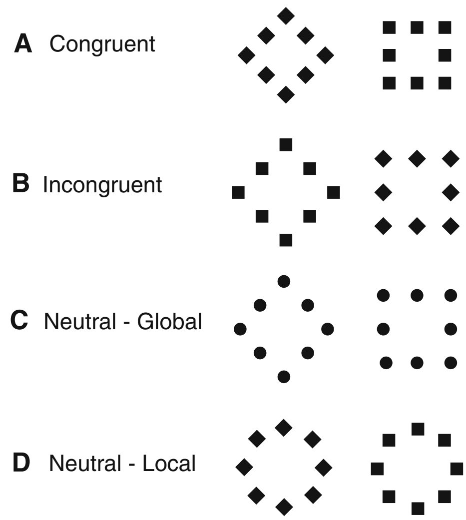

Fig. 1 Schematic drawing of stimuli (not drawn to scale). **a** Congruent stimuli are made up of the same target shape at both levels of the stimulus. **b** Incongruent stimuli have one target shape at one level of the stimulus and the other target shape at the other level of the stimulus. **c**, **d** Neutral stimuli are made up of a target shape at one level of processing (either at the **c** global level or the **d** local level) and a neutral shape at the other level of processing (either at the **c** local level or the **d** global level). All stimuli were used for the selective attention task, and the neutral stimuli were used for the divided attention task

made up of local diamonds). The stimuli were considered neutral, when a neutral shape (a circle) was presented at one level and a target shape (a diamond or square) were presented at either the global (Fig. 1c) or local (Fig. 1d) level.

Design and Procedure

Both a selective attention task and a divided attention task were administered. For both tasks, each trial began with the presentation of visual feedback from the previous trial for a duration of 1,000 ms, followed by a blank screen for a duration of 500 ms. Then a stimulus was displayed at the centre of the screen until a response was made or until 3,000 ms had elapsed, whichever came first. Feedback was provided in the form of a "+" for a correct response, "−" for an incorrect response, and "0" for no response. The task order was counterbalanced across the participants (see Fig. 2).

The Selective Attention Task

The selective attention task was comprised of two parts. In one part, the participants were presented with a single block of 120 "attend-to-global" trials, at which time they were explicitly instructed to attend to the global shape and to ignore the local shape. In the other part, the participants

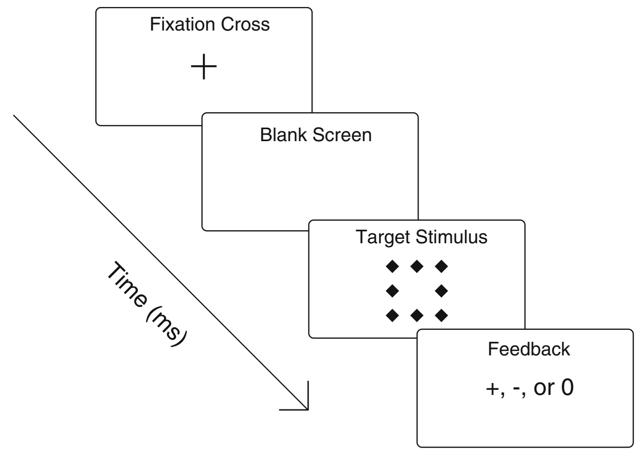

Fig. 2 Example trial sequence (not drawn to scale). The first trial began with a fixation cross; subsequent trials began with the presentation of a feedback sign from the previous trial (duration of 1,000 ms). Next, a blank screen was displayed for 500 ms. Then a hierarchical figure was displayed at the centre of the screen until either a response was made or until 3,000 ms had elapsed. Feedback was then presented; "+" for a correct response, "−" for an incorrect response, and "0" for no response

were presented with a single block of 120 "attend-to-local" trials, at which time they were explicitly instructed to attend to the local shape and to ignore the global shape. A response box with two buttons was used to collect RTs. For half of the participants, the left button corresponded to the diamond target shape and the right button corresponded to the square target shape, and for the other participants the button-shape correspondence was reversed. The participants were told to press the correct target button as quickly as possible when they saw the target shape at the 'attended-to' target location (e.g., global), and to ignore the shape at the other level (e.g., local). The task order was counterbalanced across the participants, and all the permutations of congruent, incongruent, and neutral stimuli were presented equally often in random order.

The Divided Attention Task

The participants were instructed to attend to both the global and the local elements simultaneously. For this task, only the neutral stimuli were used (i.e., a target shape at one level and a neutral shape at the other level). If we had used congruent stimuli, we would not have been able to determine the level to which the participants were attending as their response could be due to seeing the target shape at either the global or the local level. Conversely, if we utilized incongruent stimuli, with one target shape at the global level and the other target shape at the local level, we would not have been able to manipulate the percentage of trials that a target appeared at a particular level, as a target would always have been presented at each of the levels.

The percentage of the trials in which the target stimulus appeared at the global or the local level was manipulated within a block of trials, such that it could appear at either level 0, 20, 40, 50, 60, 80, or 100% of the 100 trials. Therefore, if the target appeared at the global level 80 out of 100 trials in one block, then the other 20 out of 100 trials would have the target at the local level—RTs to the former would be used to calculate the mean RTs of the global performance and RTs to the latter would be used to calculate the mean RTs of the local performance. The order of these six blocks was randomly assigned and counterbalanced, and each was comprised of 100 trials. The participants were instructed to respond as quickly and as accurately as possible, but were not informed about the contingency manipulation. Practice trials were run at the beginning of each condition. The RTs and error rates were recorded for all of the experimental trials.

Results

The incorrect button presses and response time outs (RT > 3 s) were classified as errors and removed from the RT data. Next, the average RTs and standard deviations (SD) for each participant (for each condition) were calculated, and those trials with RTs greater or lower than 2SD from the mean were removed. This led to a total removal of 10.4% of trials from the selective attention task (HFA = 10.6% removal, TD = 10.2% removal), and 9.65% of trials from the divided attention task (HFA = 10.1% removal, TD = 9.2% removal). All of the data were used in the error computations.

Mean RTs, SD, and error scores for the selective attention and divided attention tasks as a function of Group (TD, HFA), Processing Level (Global, Local) and either Congruency (Congruent, Neutral, Incongruent) for the selective attention task, or Contingency (20, 40, 50, 60, 80, 100%) for the divided attention task are presented in Table 2.

Response Time Analyses

Selective Attention Task

A repeated measures ANOVA was performed on the mean RT data, with Group (TD, HFA) as the between-subjects factor, and Congruency (congruent, incongruent, neutral) and Processing Level (global, local) as the within-subjects factors. Neither main effects nor interactions were found with the Groups, indicating that the overall performances by the young adults with HFA and the TD young adults were comparable. Main effects of both Congruency $F(2,44) = 21.222$, $p < .001$, $\eta^2 = 0.0706$, and Processing Level $F(1,22) = 31.547$, $p < .001$, $\eta^2 = 0.477$, were found, indicating slower RTs to the incongruent trials and faster RTs to targets that appeared at the global level. In addition, a two way interaction between Processing Level and Congruency $F(2,44) = 3.781$, $p < .05$, $\eta^2 = 0.0061$, was found, indicating faster RTs to all of the stimuli at the global as compared to the local level, although this difference was less pronounced for the neutral stimuli. No other effects were found (all Fs < 1). The mean RTs as a function of Congruency and Processing Level, by Group are presented in Fig. 3a.

Table 2 Mean inter-participant response timesdeviations (ms) and error rates (%) for the selective attention and divided attention tasks as a function of group and processing level

Condition	Global						Local					
	TD			HFA			TD			HFA		
	RT	SD	ERR	RT	SD	ERR	RT	SD	ERR	RT	SD	ERR
Selective attention												
Congruent	498	73	4.08	502	77	4.58	563	81	4.17	558	72	5.67
Neutral	488	58	5.08	497	82	5.58	543	75	5.5	539	70	6.17
Incongruent	509	73	6.58	515	84	7.83	578	87	8.0	573	71	7.42
Divided attention (%)												
20	641	121	7.08	637	110	9.17	626	101	12.1	672	107	9.17
40	582	86	4.38	612	93	6.25	604	83	7.92	631	67	7.5
50	564	69	4.5	602	101	7.33	593	58	6.33	617	86	7.67
60	557	78	4.17	570	102	5.14	592	81	5.28	610	61	7.36
80	517	59	4.38	553	85	5.94	586	101	8.65	589	59	4.58
100	482	63	3.58	498	72	4.17	517	73	3.75	538	66	4.25

TD typically developing young adults, *HFA* high-functioning young adults with autism, *RT* response time (ms), *SD* standard deviation (ms), *ERR* error rates (%)

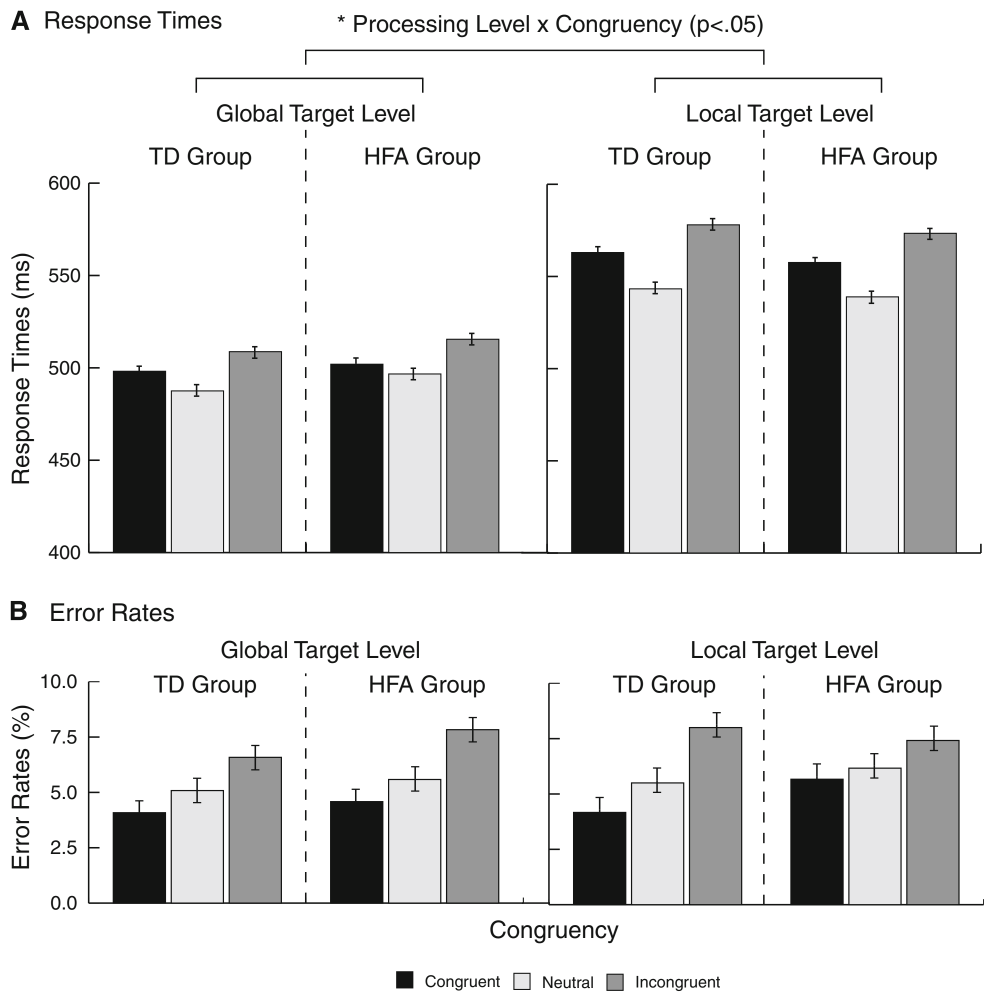

Fig. 3 Selective attention task RT results. The *top* portion of the figure **a** depicts mean response times (RT) for the global target level and the local target level, for both the young adults with HFA and the TD young adults as a function of congruency. The *bottom* portion of the figure **b** depicts the percentage of errors for the global target level and the local target level, for both the young adults with HFA and the TD young adults as a function of congruency. *Error bars* depict the standard error of the difference between the means

Divided Attention Task

A repeated measures ANOVA was performed on the mean RT data, with Group (TD, HFA) as the between-subjects factor, and Contingency (0, 20, 40, 50, 60, 80, 100%) and Processing Level (global, local) as the within-subjects factors. Neither main effects nor interactions were found with the Groups, indicating that the overall performances by the young adults with HFA and the TD young adults were comparable. Main effects of both Contingency $F(5,110) = 44.449$, $p < .001$, $\eta^2 = 0.2$, and Processing Level $F(1,22) = 27.427$, $p < .001$, $\eta^2 = 0.026$, were found, indicating that the overall RTs decreased with increasing contingency percentage, and for targets appearing at the global level. No other effects were found (all $Fs < 2$, $ps > .15$). The mean RTs as a function of Contingency and Processing Level by Group are presented in Fig. 4a.

Errors

Selective Attention Task

A repeated measures ANOVA was performed on the mean error data, with Group (TD, HFA) as the between-subjects factor, and Congruency (congruent, incongruent, neutral) and Processing Level (global, local) as within-subjects factors. Neither main effects nor interactions were found with the Groups, indicating that the overall performances by the young adults with HFA and the TD young adults were comparable. A main effect of Congruency $F(2,44) = 10.505$, $p < .01$, $\eta^2 = 0.039$, was found, indicating that both the young adults with HFA and the TD young adults committed the most errors on those trials with incongruent stimuli. No other effects were found (all $Fs < 1$). The mean errors as a function of Congruency and Processing Level by Group, are presented in Fig. 3b.

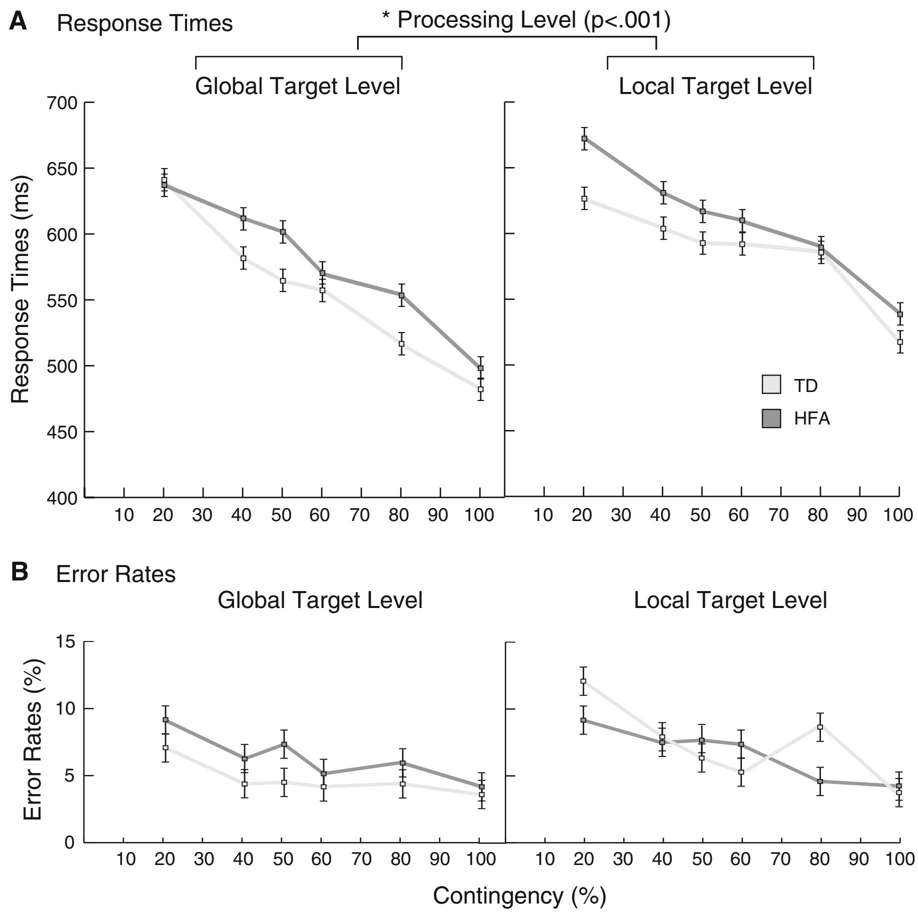

Fig. 4 Divided attention task RT results. The *top* portion of the figure **a** depicts mean response times (RT) for the global target level and the local target level, for both the young adults with HFA and the TD young adults as a function of contingency. The *bottom* portion of the figure **b** depicts the percentage of errors for the global target level and the local target level, for both the young adults with HFA and the TD young adults as a function of contingency. *Error bars* depict the standard error of the difference between the means

Divided Attention Task

A repeated measures ANOVA was performed on the mean error data, with Group (TD, HFA) as the between-subjects factor, and Contingency (0, 20, 40, 50, 60, 80, 100%) and Processing Level (global, local) as the within-subjects factors. Neither main effects nor interactions were found with the Groups, indicating that the overall performances by the young adults with HFA and the TD young adults were comparable. Main effects of Contingency $F(5,110) = 6.397$, $p < .001$, $\eta^2 = 0.045$, and Processing Level $F(1,22) = 7.740$, $p < .05$, $\eta^2 = 0.0098$, were found, indicating that overall errors decreased as contingency level increased, and that fewer errors were committed on the trials in which the target shape was presented at the global level than at the local level. In addition, there was a trend toward a Processing Level by Group interaction $F(1,22) = 4.105$, $p = .0550$, $\eta^2 = 0.005$, indicating that the young adults with HFA made the same number of errors when identifying targets at both the global and local levels, whereas the TD young adults committed fewer errors when identifying targets at the global level and more errors when identifying targets at the local level. No other effects were reliable (all $Fs < 1$). The mean errors as a function of Contingency and Processing Level, by Group, are presented in Fig. 4b.

Target Level Switching

This analysis was performed to further explore the finding that the young adults with HFA and the TD young adults showed the same RT pattern of a global precedence for both tasks. Only the divided attention task was designed to have the participants switch between the local and global levels from trial to trial, and therefore this analysis was conducted on the RT data for the divided attention task only.

The mean RTs were calculated for those trials in which no switch in processing level occurred between each trial and the one prior (e.g., all trials that had targets at either two global or two local locations in a row), and another set of mean RTs were calculated for those trials in which a switch in processing level occurred between two consecutive trials and analyzed as outlined above. This calculation was performed on each of the five blocks of the divided attention task in which switching could occur (Condition, i.e., Global 20%/Local 80% G20L80, G40L60, G50L50, G60L40, and G80L20). These RTs were subjected to a repeated-measures ANOVA, with Group (TD, HFA) as the between-subjects factor, and Level Switch (yes, no) and Condition as the within-subjects factors. Neither main effects nor interactions involving Group were found, indicating that the overall performances by the young adults with HFA and the TD young adults was comparable. Main effects of Level Switch $F(1,22) = 85.036$, $p < .001$, $\eta^2 = 0.067$, and Condition $F(4,88) = 2.913$, $p < .05$, $\eta^2 = 0.019$ were found, indicating that the participants were faster to respond to a target when the target was at the same level in the previous trial, and that the participants were faster to respond when the percentage of trials at the global level increased. In addition, a two-way interaction between Level Switch and Condition $F(4,88) = 23.713$, $p < .001$, $\eta^2 = 0.0039$, was found, indicating that both the young adults with HFA and the TD young adults had faster RTs when there was no switch in attending to one target level from one trial to the next in all of the conditions except for the condition that had an equal number of targets appearing at the global and the local levels (i.e., the G50L50 condition). No other effects were found (all Fs < 2). Finally, the directionality of target switching was further investigated, with both groups demonstrating slower overall RTs when the target level switched from the global level to the local level, as compared to RTs when the target level switched from the local level to the global level $F(1,22) = 11.309$, $p < .05$, $\eta^2 = 0.06$, especially in the G60L40 condition $F(2,44) = 9.538$, $p < .01$, $\eta^2 = 0.061$. The mean RTs as a function of Level Switch and Condition, by Group, are presented in Fig. 5.

Cross-Task Comparison

The only difference between the selective attention task with neutral stimuli and the divided attention task with a target appearing 100% of the time at one level was the instructions to the participants. For the selective attention task, the participants were explicitly instructed to attend to one level and ignore the other, whereas for the divided attention task, no explicit instructions were provided regarding level of processing. Therefore, any changes in RT performance would illustrate differences in explicit versus implicit orienting of attention. The mean RTs were subjected to a repeated measures ANOVA, with Group (TD, HFA) as the between-subjects factor, and Task (selective attention, divided attention) and Processing Level (global, local) as the within-subjects factors. Neither main effects nor interactions were found between the Groups, indicating that the overall performances by the young adults with HFA and the TD young adults were comparable. A main effect of Target Level $F(1,22) = 46.882$, $p < .001$, $\eta^2 = 0.093$, was found, as RTs were faster to the global targets than to the local targets,

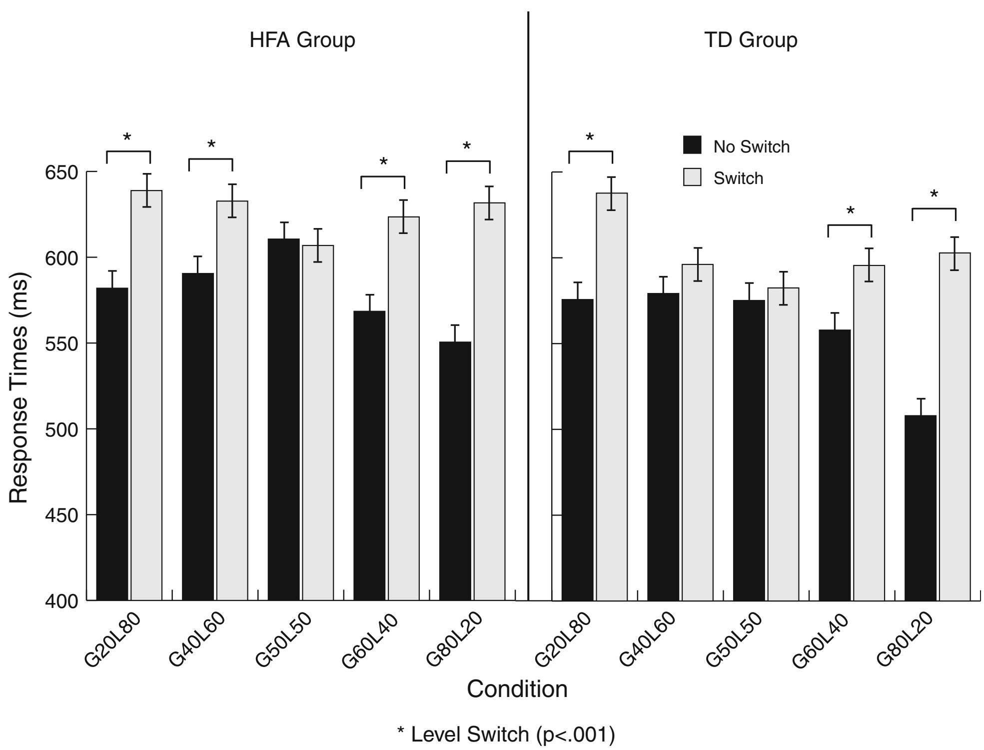

Fig. 5 Task switching RT results. The figure depicts mean response times (RT) for switch trials (i.e., when the target was presented at one level for one trial, and then presented at the other level for the next trial) and no switch trials (i.e., when the target was presented at the same level for two subsequent trials), as a function of condition. RTs for the HFA young adults is on the *left*, and RTs for the TD young adults is on the *right*. *Error bars* depict the standard error of the difference between the means

regardless of the task. No other effects were found (all Fs < 1).

Discussion

The two main goals of the study were to extend Plaisted et al.'s (1999) findings to consider whether young adults with HFA demonstrate global precedence and global interference, and to assess whether young adults with HFA and TD adults can make use of implicit information to locate a target shape within a hierarchical figure. With a selective attention task, we expected to find a typical global precedence effect and overall interference effects, which are larger when the target shape is at the local level (indicating a greater interference from the global shape during "attend-to-local" trials). Consistent with previous findings (Ozonoff et al. 1994; Plaisted et al. 1999; Rinehart et al. 2000), we found that both groups were faster to respond in the "attend-to-global" condition as compared to the "attend-to-local" condition and committed the most errors on the incongruent trials, demonstrating a global precedence effect. However, in contrast to Plaisted et al.'s findings, we found overall interference effects that were not asymmetrically in nature.

Our findings on the divided attention task are consistent with those of Iarocci et al. (2006), as both groups responded faster to global targets and committed fewer errors as the contingency increased toward 100%. However, the divided attention task findings were inconsistent with Plaisted et al., who found a local precedence among children with HFA. The discrepancy between our findings and those of Plaisted et al. could be attributed to the differences in the ages of the participants, as those in our study were adolescents and young adults, whereas those in Plaisted et al.'s study were children, but this seems unlikely because Iarocci et al.'s (2006) participants were also children. A more experimentally relevant reason might be due to differences in task design. In accordance with Iarocci et al., we implicitly manipulated the proportion of trials in which a target appeared at the global or the local level, whereas Plaisted et al. used an equal number of targets appearing at either level. Thus, the uncertainty about the location of target presentation in both Iarocci et al.'s and our own study may more effectively capture the unpredictability of everyday visual experiences.

We also expected to find asymmetric interference effects, indicated by slower RTs when the stimulus was incongruent, and by the slowest RTs when the global form interfered with attending to the local. Consistent with our hypothesis, we found asymmetrical interference costs for both groups in the selective attention task. Both the young adults with HFA and the TD young adults displayed slower RTs to the targets (e.g., a diamond) at the attended-to level when the shape at 'to-be-ignored' level was another target (e.g., a square), and this slowing of RTs was most pronounced when the participants were asked to attend to the local level, indicating a global interference effect.

We also investigated the effects of explicit and implicit task instructions. In the divided attention task, we expected that implicit information about the likelihood of the appearance of a target at a specific level of processing would enhance the performance of both groups. Consistent with Iarocci et al.'s findings, we found that both groups displayed faster RTs and fewer errors as the contingency increased toward 100%. We also found that both the young adults with HFA and the TD young adults responded faster to targets that appeared at the global level. This finding was consistent across tasks, as the only significant effect in the cross task analysis was a finding of faster responses to targets appearing at the global level. Together, these data suggest that individuals with ASD as well as TD individuals can modify their visual processing strategy as a function of the demands on tasks with implicit as well as explicit manipulations. Thus, these findings provide support that at least some aspects of flexibility appear to be intact for young adults with ASD.

These conclusions indicating flexibility of attentional processing are also corroborated by our analysis of the costs associated with switching the processing level on a trial-by-trial basis. We observed similar switch costs across all conditions and for both groups of participants, with both groups displaying faster RTs to targets that appeared at the same level as the previous trial for all blocks in which there were more targets that appeared at one level as compared to the other (e.g., in the 20G80L, 40G60L, 60G40L, and 80G20L conditions). In addition, for the condition in which the number of target level switches were the same as the number of trials in which no switches occurred (i.e., in the 50G50L condition), the RTs were the same for trials with switches and trials with no switches, thereby indicating a level of sensitivity to the implicit task manipulations by both groups.

In summary, the findings from this study suggest a similar pattern of global precedence and intact implicit learning can be seen between the young adults with HFA and TD matched peers. Both groups displayed a global precedence effect regardless of task instructions and typical switch costs, while demonstrating the ability to flexibly shift between the target levels, as evidenced by faster RTs and fewer errors as the contingency moved towards 100%. The finding of intact flexibility by persons with ASD is consistent with evidence that children and adolescents with ASD did not differ from TD-matched comparison groups on speed of response to a rule change, regardless of whether the sorting rules were blocked or mixed (Dichter et al.

2010; Poljac et al. 2010). Our findings of global precedence and intact flexibility among young adults with autism further suggest that persons with HFA, despite a default orientation toward the local level of visual scenes (Wang et al. 2007), can modify their visual processing strategy to take into account any implicit information that can be gleaned from the environment. Alternatively, as in all cases when no differences in performance are found between persons with ASD or other developmental disabilities and TD individuals, the findings here should be considered with regard to developmental theory and methodology (Burack et al. 2002, 2004) as well as to the appropriateness of applying typical models and measures of cognition to persons with ASD (Mottron et al. 2008).

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