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Intact Covert Orienting to Peripheral Cues among Children with Autism

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The focus of the present study was to examine covert orienting responses to peripheral flash cues among children with autism in a situation where attentional processes were taxed by the presence of distractors in the visual field. Fourteen children with autism (MA = 6–7 years) were compared to their MA-matched peers without autism on a forced choice RT covert orienting paradigm. The task conditions varied with regard to the target location, the validity of the cue, and the presence or absence of distractors. The results showed no group differences as both children with autism and their MA-matched peers showed similar effects of cue validity and distractors. These findings are inconsistent with the view that orienting is generally impaired in children with autism.

KEY WORDS: Selective attention; visual orienting; filtering; autism.

REFLEXIVE COVERT ORIENTING AND FILTERING IN AUTISM

Anecdotal observations that persons with autism commonly display an intense and apparently perseverative focus on certain, often seemingly irrelevant, stimuli in the environment suggest impairments in the abilities both to shift visual attention from one object to another and to ignore visual information that is extraneous to a task (Burack, Enns, Stauder, Mottron, & Randolph, 1997). These aspects of visual attention, referred to as orienting and filtering in the experimental literature, are both constructs that include a variety of related but distinct processes (Enns, 1990). For example, the visual orienting of attention in space may be overt and occur simultaneously with eye movements or covert and independent of eye gaze. Orienting may be reflexively elicited by a peripheral physical cue (e.g., flash) that moves attention to a specific location or voluntarily initiated by a central symbolic cue (e.g., arrow) that directs attention to a specific location. The different orienting components involve qualitatively different mechanisms, recruit different resources (Klein, 1993), develop along different trajectories (Akhtar & Enns, 1989), and may interact differently with other attentional processes (Brodeur, Trick, & Enns, 1997). Accordingly, the identification of the specific contributions of these components to adaptive or maladaptive development among persons with autism is contingent on a more precise delineation of each and the relation to other processes such as filtering (Burack *et al.*, 1997; Enns & Burack, 1997). In an early attempt to provide a profile of attentional functioning among persons with autism, we examined reflexive, covert orienting, considered to be the most basic form of orienting (Brodeur, 1990), in relation to filtering, which is deficient among persons with autism under certain circumstances (Burack, 1994).

The initial empirical evidence for the notion of orienting deficits among persons with autism was

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found in studies of cross-modal orienting (Courchesne *et al.*, 1994) and seemed consistent with notions of the lack of flexibility in switching attention from one object or location to another. Within the visual modality, high-functioning adolescents and adults with autism showed difficulty orienting attention under a variety of conditions. For example, in a simple target detection or identification task, adults with autism oriented faster to central than to lateral (left or right of central fixation) stimuli as compared to MA-matched peers (Wainright & Bryson, 1996). In a cueing paradigm, adolescents with autism showed difficulties disengaging attention when centrally fixated, arrow cues were used to predict target location with brief (100 milliseconds) exposures of the cue, but displayed performance that was comparable to their typically developing peers with extended exposures (800 milliseconds) of the cue (Wainright-Sharp & Bryson, 1993). When cue-processing time and attention-shifting time were examined separately, adults with autism were able to process brief flash cues (50 milliseconds) but oriented attention more slowly and showed benefits of increasing cue-to-target delays (800–1200 milliseconds), whereas typically developing persons oriented attention quickly and showed maximal performance facilitation at a cued location within 100 milliseconds (Townsend, Courchesne, & Egass, 1996).

The findings from these and similar studies were interpreted as indicative of a general impairment among high-functioning persons with autism (Townsend *et al.* 1999; Harris, Courchesne, Townsend, Carper, & Lord, 1999; Townsend *et al.*, 1996; Townsend *et al.*, 2001; Wainright-Sharp & Bryson, 1993; Wainright & Bryson, 1996), although they may better reflect a pattern of orienting that is intact in some cases and impaired in others (Burack *et al.*, 1997; Pascualvaca, Fantie, Papageorgiou & Mirsky, 1998). For example, the orienting paradigms used in previous studies included meaningful cues and/or cue–target relationships known to engage more complex voluntary orienting processes but not automatic reflexive processes. Thus, conclusions regarding orienting impairments among persons with autism must be limited to the voluntary aspects of orienting rather than orienting in general. This is consistent both with the notion that persons with autism primarily show impairments in higher-order rather than lower-order processes (Minshew, Goldstein, & Siegel, 1997; Minshew, Johnson, & Luna, 2001) and Burack *et al.*'s (1997) suggestion that automatic visual reflexive orienting processes may be intact, despite impairments in the more intentional voluntary orienting processes.

The various aspects of orienting are part of a hierarchy of selective attentional processes that both function cooperatively and compete for resources (Enns, 1990). For example orienting is influenced by filtering component which is used to inhibit the processing of task-irrelevant information in order to focus on task-relevant information. Evidence from developmental studies of covert orienting suggest that children orient attention less efficiently when they must also inhibit distracting information due to the availability of fewer, or inefficient, attentional resources (Akhtar & Enns, 1989; Brodeur & Enns, 1997; Enns, Brodeur & Trick, 1998). The implication of these findings is that orienting and filtering may rely on the same attentional resources and impaired performance may be most evident in tasks that require the two components to interact. This issue is especially pertinent to the study of orienting among persons with autism whose filtering performance was found to be deficient under at least certain circumstances that entail adjusting attentional focus (Burack, 1994).

In the present study, the notion of intact reflexive orienting is challenged in a context designed to maximize the chances of finding differences between persons with autism and MA-matched typically developing peers. In contrast to previous studies in which the focus was voluntary orienting methods including central arrow cues that require interpretation to direct attention to the target and/or expectations with regard to the cue–target relationship, we used a reflexive orienting paradigm to elicit the involuntary movement of attention by a peripheral flash cue (Wainright-Sharp & Bryson, 1993; Harris *et al.*, 1999; Townsend *et al.*, 1996; 1999; 2001). The task necessitated covert orienting and filtering processes that are both associated with deficits among persons with autism (Burack, 1994; Courchesne *et al.*, 1994; Townsend *et al.*, 1996), and was administered to participant groups with average developmental levels of 7 years, an age in which adult levels of reflexive orienting are just attained and, therefore group differences are more likely to be found.

METHOD

Participants

The participants included 14 children with autism (11 male) and 14 typically developing children

(9 male). The children with autism were recruited from private schools for children with developmental delays, and the children without autism were recruited from private and public schools. All the children were screened for severe visual and gross motor difficulties according to information attained from school and medical records. No child was excluded due to severe or gross motor difficulties. Children with autism received diagnoses based on the DSM-IV (APA, 1994) criteria by psychiatrists working in clinics for children with autism at local hospitals.

The matrices subset of the Kaufman Brief Intelligence Test (K-BIT) (Kaufman & Kaufman, 1990) was used to obtain general cognitive functioning with split-half and test–retest reliabilities of .85 and a concurrent validity of .56 with the Full Scale Intelligent Quotient (IQ) of the Wechsler Intelligent Scale for Children. For the children with autism, the average CA was 11.6 ($SD = 4.9$) years and the average MA was 7.2 ($SD = .99$) years. For the typically developing children, the average CA was 5.7 ($SD = .64$) years and the average MA was 6.4 ($SD = .29$) years. The difference in MA between the groups was not statistically significant.

Apparatus Stimuli and Design

In order to assess reflexive covert orienting, we used a task based on one initially used by Akhtar and Enns (1989) for the study of typically developing children and later adapted for the study of persons with developmental disabilities (Randolph & Burack, 2000). The task conditions varied with regard to the location of the target, the location of the cue that preceded the target, and the presence of distractors. In each condition, one target stimulus appeared either to the right or left of the center of the screen and was presented either with distractors that flanked it on both the right and the left or without distractors. In order to ensure the reflexive nature of the task, the cue was a simple flash of light designed to draw attention to a location by spatial position rather than by inherent information and there was no predictability between the cue and target (Enns & Brodeur, 1989). And, in order to ensure that covert orienting was assessed, the interval between the offset of the cue and the presentation of the target was 150 milliseconds, within which time the shift of attention is independent of head or eye movements (Akhtar & Enns, 1989). The task required participants to identify rather than simply detect the target.

All stimuli were presented on an IBM PS2 386/20 portable computer connected to a SVGA 14 inch (35.5 cm) IBM color monitor, to which two response buttons were attached. The left response button was marked by a circle (◯) and the right response button was marked by a plus sign (+). Each trial began with a tone that signaled the presentation of the stimuli. At the offset of the tone, a locational cue, a spot of light 1 mm in diameter, appeared for 50 milliseconds in one of three locations on the screen—the midpoint of the screen, directly to the right of the midpoint (6.87° visual angle from the midpoint of the screen), or directly to the left of the midpoint (6.87° visual angle from the midpoint of the screen). A target stimulus appeared on the screen 150 milliseconds after the locational cue disappeared.

The target stimuli consisted of a circle (◯) and a plus sign (+) that appeared either directly to the left or right of the midpoint of the screen (or at a 6.87° visual angle from the midpoint of the screen). In half of the trials, the target stimulus was flanked on either side by distracting stimuli (1.15° visual angle from the target). The distracting stimuli were four graphic symbols [✳ △ ⧣ ☰]. All stimuli were 9 mm in height, white in color, and were presented on a black background.

Conditions varied with regard to the position of the location cue in relation to the position of the target. In the valid cue condition, the cue appeared in the same position as the subsequent target (e.g., cue right, target left). In the neutral cue condition, the cue appeared in the center of the screen. On half the trials, the target was presented with distractors that flanked it on both the right and the left. The 6 Distractor × Locational Cue combinations are displayed in Fig. 1.

Thirty-two trials were presented in each of the six conditions for a total of 192 trials. The trials were administrated over two testing sessions, with each session consisting of two sets of 48 trials seperated by a 5-minute break. Eight trials (four with a circle target stimulus and four with a plus sign target stimulus) of each of the six conditions were presented randomly in each of the sets of 48 trials. Each of the three validity conditions (neutral, valid, invalid) were presented with equal frequency.

The presentation of cues preceded that of the target, and provided three types of information. As a valid cue, it appeared at the same location of the

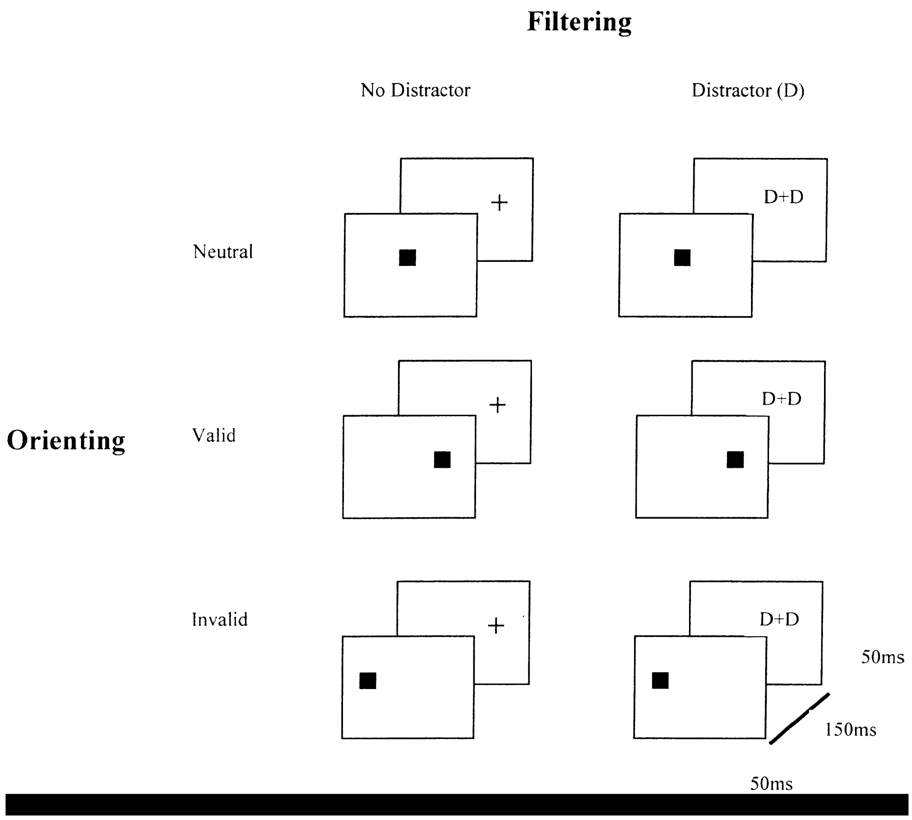

Fig. 1. Targets (+, O) were presented at 150 milliseconds following a valid, invalid and neutral flash cue. In the valid cue condition, the cue appeared in the same position as the subsequent target (e.g., cue right, target right). In the invalid cue condition, the cue appeared in the position opposite to that of the subsequent target (e.g., cue right, target left). In the neutral cue condition, the cue appeared in the center of the screen. On half the trials the target was presented with distractors that flanked it on both the right and the left.

target, as an invalid cue it appeared at the opposite side of the location of the target, and as a neutral cue it appeared at a location at which targets could not appear (center of the screen). The efficiency of orienting was assessed with comparisons of performance among the conditions with valid, invalid, and neutral distractors, whereas efficiency of filtering was assessed with comparisons of performance on conditions with and without distractors.

Procedure

Participants were individually tested in a quiet room for approximately 40 minutes including practice trials and breaks. They were seated 50 cm from the computer screen and instructed to place their right hand on the right response button and their left hand on the left response button. The participants were then asked to press the button marked by a circle as soon as they saw a circle on the screen, and press the button marked by a plus sign as soon as they saw a plus sign on the screen. They were informed that the circles and plus signs would appear on either the left or right side of the screen. The experimenter instructed the participants to focus on the center of the screen after every trial and sat beside them during the task.

In each testing session, the experimental task began with two sets of 10 practice trials. Participants were included in the study if they responded correctly on more than 80% of the practice trials, a rate which reflects performance that is better than chance and is a typical rate of accuracy used for inclusion in studies of attention. One participant was excluded due to a lack of willingness to continue after the practice session. Accuracy was generally high for all participants. The experimental trials were the same as the practice trials except that no feedback was provided and more trials were included.

RESULTS

The dependent measure was mean correct RT (a combined measure of errors and RT) for each participant for each of the six experimental conditions (Akhtar & Enns, 1989). Trials were deleted if the participant made an error, responded with the wrong key press, failed to respond within 3000 milliseconds or responded faster than 300 milliseconds. The mean error rate was 0.5% for the children with autism and 0.8% for the typically developing children. Anticipations (latency < 300 milliseconds) accounted for 0.1% of the trials for children with autism and 0.3% of the trials for the typically developing children. The mean errors across experimental conditions are presented in Table I. No speed–accuracy trade-offs were found. Similarly, type of errors/deletions (latency > 3000 milliseconds, < 300 milliseeconds) were examined across conditions and revealed no differences between the groups. Since error rates were generally low and did not interact with the experimental conditions, they were not considered in the subsequent analyses.

Analyses

A $2 \times 3 \times 2$ (Group × Orienting × Filtering) repeated measures ANOVA revealed main effects of orienting [$F(2, 52) = 11.85$, $p < .0001$] and fitering [$F(1, 26) = 20.78$, $p < .0001$]. There was a significant difference between valid and invalid cueing conditions for both groups. RT costs (invalid − neutral) and benefits (neutral − valid) were calculated (Akhtar & Enns, 1989). Significant benefits were found as RTs were longer in conditions with neutral cueing as compared to those with valid cueing (mean difference = +100.05 milliseconds, $p < .001$) but the costs were not reliable as invalid and neutral cueing did not differ significantly (mean difference = −10.59 milliseconds, $p < .67$). The lack of attentional cost (RT at the neutral location = RT at the uncued location) is consistent with previous studies of reflexive orienting and supports the contention that the measured effect is due to reflexive and not voluntary orienting (Posner & Snyder, 1975). The RTs by group and condition are presented in Table II. The filtering main effect indicated generally longer RT scores with distractors present. Fishers PLSD *post hoc* analyses revealed that, across groups, RT scores were longer in conditions with distractors (mean difference = +120.82 milliseconds, $p < .0001$). No interactions were found.

In order to rule out the possibility of a type II error, a confidence interval (CI) was calculated. The

Table I. Indicates Mean Errors as a Function of Group, Orienting and Filtering Conditions

		Distractor			No distractor		
Group		Neutral	Valid	Invalid	Neutral	Valid	Invalid
Children with autism	Mean Errors	1.5	0.9	1.0	1.0	1.3	0.7
	SD	1.9	1.3	1.5	1.2	1.5	1.2
Children without autism	Mean Errors	1.6	1.6	2.1	1.8	1.6	1.9
	SD	1.4	1.6	2.5	1.8	1.8	2.3

Table II. Indicates Mean Correct Reaction Times as a function of Group, Orienting and Filtering Conditions

		Distractor			No distractor		
Group		Neutral	Valid	Invalid	Neutral	Valid	Invalid
Children with autism	RT correct (milliseconds)	1363.7	1153.8	1299.2	1204.2	1101.8	1190.6
	SD	473.1	288.2	390.7	359.1	299.0	300.3
Children without autism	RT correct (milliseconds)	1240.3	1227.9	1322.9	1141.3	1065.8	1179.1
	SD	297.7	241.7	321.2	320.0	236.6	261.5

CI provides a more meaningful and precise measurement than a power estimate for post hoc decision-making (Smithson, 2000). The CI is based on the premise that the dependent variable units are easy to interpret and small differences may be readily determined. The CI is a distance measure of mean differences in the numerator and a standard deviation of mean differences in the denominator that are both estimated from the units of data (Cumming & Finch, 2001). Thus, the CI width reflects the amount of variability in the population, the sampling size and error, and the amount of error in the dependent variable (Fidler & Thompson, 2001). The CI should be sufficiently narrow and close enough to zero to allow the researcher to confidently conclude that the results were not due to insufficient sample size (Cumming & Finch, 2001). In the present study, the CI for the RT units (CI = 11.53 −10.62) was sufficiently narrow and close enough to zero to conclude with 95% certainty that the effect is in the estimated range and it is negligible. This further supports the finding of no group differences.

DISCUSSION

A group of lower functioning children with autism and a group of typically developing peers matched on MA (approximately 7 years) showed similar effects of cue validity and distractors on a RT task of visual reflexive covert orienting and filtering. Orienting effects of the flash cue were evidenced in both groups as they showed faster RTs when the target was preceded by a valid locational cue, but slower RTs when the target was preceded by an invalid locational cue. Since the relationship between the location of the cue and the location of the target was not predictive, this pattern of performance reflects apparently intact reflexive orienting among children with autism with an MA of approximately 7 years on a task designed to maximize group differences. These findings are consistent with earlier reports of intact basic cognitive (Minshew *et al.*, 2001) and attentional (Burack *et al.*, 1997) processes. However, contrary to evidence from a previous report (Burack, 1994), no differences were found between the groups on the filtering component of the task as the groups displayed similar patterns of longer RT scores when distractors were present in the visual field.

The effect of cue validity on performance for both the children with autism and their MA-matched peers suggests that the visual cues were effective in directing attention among the children in both groups. The children with autism were as able as their typically developing peers to process flash cues, direct their attention to task relevant targets, and filter distractors that flanked the target. They did not display deficits in orienting attention in response to flash cues. The findings are inconsistent with the commonly held view that orienting is generally impaired among persons with autism, and highlight the need to differentiate among the various components of orienting. A key methodological feature of the present study was that attention was involuntarily moved by the location cue, whereas previous studies of orienting among persons with autism employed voluntary orienting methods. For example, Wainright-Sharp and Bryson (1993) used central arrow cues to direct attention to the target, and similar to Harris *et al.* (1999) and Townsend *et al.* (1996, 1999, 2001) presented the target at the cued location 80% of the time, thereby, setting a predictive relationship between the cue and the target (Brodeur & Boden, 2000). Wainright and Bryson (1996) presented a central fixation asterisk for 1–2 seconds and a target on the left or right of the screen. Thus, the observers had sufficient time to overtly orient their attention to the target. Overt and covert orienting rely on different mechanisms and therefore children with autism would not be expected to show similar performance on these tasks (Akhtar & Enns, 1989; Enns & Cameron, 1987). The findings in the present study and evidence from previous studies are consistent with the notion that lower-order reflexive orienting may be spared whereas higher-order voluntary orienting may be deficient (Burack *et al.*, 1997; Minshew *et al.*, 1997).

The findings were not entirely consistent with our hypotheses. In general, the presence of distractors in the visual field was associated with slowed performance but did not interfere with the orienting abilities of either the children with autism or the MA-matched typically developing children. Contrary to evidence from Burack's (1994) study, the children with autism did not show an impaired ability in filtering. This discrepancy between studies may be due to differences between tasks, especially as the one used in this study did not include manipulations to assess the efficiency of adjusting the size of the attentional lens, the source of the primary deficit among children with autism in the earlier study (Burack, 1994). Consistent with evidence from a previous study of persons with Down Syndrome with the same paradigm (Randolph & Burack, 2000), filtering did not interfere with the orienting performance of either the children with autism or the MA-matched typically developing children. However, previous findings of filtering interference on orienting were found among young typically developing children under conditions of invalid cueing and when incompatible distractors (target cross and square distractors) as compared to no distractors flanked the target. In the present study, distractors were unfamiliar graphic symbols that had no relationship to the targets, thus, the interference effect may be, in part, due to the familiarity of the distractor and its relationship to the target. In future studies more attention to the validity of the cue, type of distractor and relationship to the target will be needed in order to more fully explore the relationship between orienting and filtering among children with autism.

In sum, the primary findings of this study are that the children with autism at MAs of approximately 7 years perform similarly to MA-matched typically developing children on a task of both visual reflexive, covert orienting and filtering. This evidence is consistent with the notion of intact basic processes of visual orienting among children with autism (Burack *et al.*, 1997; Minshew *et al.*, 2001), even in a situation where attentional processes are taxed by the presence of distractors in the visual field. This argument is strengthened by the use of a task that incorporates both orienting and filtering demands among children at a MA that is most likely to be associated with group differences. Yet, these findings must be considered within the limitations of the specific parameters of the paradigm and the participants of the study. As with any study in which the performance of children with autism (or any other disorder) is compared to that of typically developing children, the findings of any single study are specific to the methodology and the developmental level of the participants (Burack *et al.*, 2001, 2002). Thus, the efficacy of general claims of intact visual reflexive, covert orienting must be further examined with other paradigms and with children at different MAs. Further research is needed to elucidate the role of orienting in terms of its various functions.

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