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Selective Attention Deficits in Persons With Autism: Preliminary Evidence of an Inefficient Attentional Lens

Jacob A. Burack

A forced-choice reaction time (RT) task was used to assess the filtering component of selective attention in mental-age (MA) matched groups of persons with autism (n = 12), organic mental retardation (n = 32), familial mental retardation (n = 30), and no handicap (n = 34). Conditions varied with regard to the presence or absence of a window and number (zero, two, or four) and location of distractors. The RTs of the persons with autism improved relative to the other groups in the presence of the window without distractors, but this effect was negated when distractors were also presented. The performance of the persons with autism was the most impaired in the presence of distractors. These findings represent preliminary behavioral evidence of an inefficient attentional lens among persons with autism.

The ability to attend selectively to meaningful sources of information while ignoring irrelevant ones is essential to competent and adaptive functioning (Lane & Pearson, 1982). The task of attending is particularly challenging in that the human mind has a finite capacity, but is faced with infinite amounts of information from surrounding environments (e.g., Broadbent, 1971; Enns, 1990; Kahneman, 1973; Pearson & Lane, 1990). Thus, efficient filtering of extraneous information facilitates the processing of information with maximum utility for a given task (Enns & Cameron, 1987; Enns & Girgus, 1985; Gibson & Rader, 1979). Conversely, impaired selective attention leads to increased distraction and diminished cognitive functioning as responses to irrelevant stimuli interfere with the processing of targeted information (Douglas & Peters, 1979; Lane & Pearson, 1982).

Without efficient filtering and selectivity the developing child has little chance to make sense of the surrounding environment or to function competently within it. Accordingly, the study of selective attention is a particularly poignant focus of study among persons with autism who are characterized by lower levels of intellectual, academic, and adaptive functioning (e.g., Volkmar, Burack, & Cohen, 1990).

There is little empirical evidence of attentional impairment and increased distractibility among persons with autism (Wainwright-Sharp & Bryson, 1993), although peculiarities and deficits in attention in this group have often been cited (e.g., Bryson, Wainwright-Sharp, & Smith, 1990; Dawson & Lewy, 1989a). For example, persons with autism appear to ignore salient stimuli in the environment in favor of relatively obscure and apparently meaningless stimuli (e.g., Bryson, Wainwright-Sharp, & Smith, 1990; Rosenblum et al., 1980) and typically cannot focus attention on educational tasks (Hayes, 1987). In the few relevant empirical reports, their visual attention has been characterized as overfocused (Rincover & Ducharme, 1987; Wainwright-Sharp & Bryson, 1993), and an inability to process complex, unpredictable, and novel information has been cited (Dawson & Lewy, 1989a, 1989b). These attentional deficits have been attributed to a variety of physiological factors, including chronic overarousal (Dawson & Lewy, 1989a; Hutt, Hutt, Lee, & Ounsted, 1964; Kinsbourne, 1987), deficits in arousal modulation (Kinsbourne, 1987), atypical event-related brain potentials (e.g., Courchesne & Yeung-Courchesne, 1988), spatial neglect (Bryson, Wainwright-Sharp, & Smith, 1990), and right-hemisphere overactivation (Dawson & Lewy, 1989a, 1989b).

This study is an early attempt to adapt a classic psychological paradigm to examine the effectiveness of visual selective attending in persons with autism who function in the range of mental retardation (heretofore referred to as persons with autism) as compared with nonautistic persons with organic retardation, familial retardation, and no handicaps who are of the same mental age (MA). Issues regarding the efficiency of focusing on relevant stimuli while ignoring irrelevant stimuli in the visual field are considered.

Selection and Distraction: Role of Visual Filtering

The tension between effective selective attention and distraction has long been considered basic to information processing.

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Correspondence concerning this article should be addressed to Jacob A. Burack, Department of Educational Psychology, McGill University, 3700 McTavish Street, Montreal, Quebec, Canada H3A 1Y2.

This is reflected in William James's (1890) often-cited quote that attention "implies withdrawal from some things in order to deal effectively with others, and is a condition which has a real opposite in the confused, dazed, scatter-brained state which in French is called distraction" (pp. 403–404). Contemporary researchers have addressed the ability to focus attention and minimize distraction within the framework of the filtering component of visual attention. In this context, filtering is the ability to ignore irrelevant and potentially distracting stimuli to effectively process other, more relevant information (Enns, 1990; Enns & Akhtar, 1989).

Much of the research on filtering has focused on early selection theories, in which this process is thought to occur at the encoding or perceptual level (e.g., Broadbent, 1958, 1971; Johnston & Dark, 1986; Kahneman & Treisman, 1984). The effectiveness of the early selection process is related to the availability of resources for perceptual analysis and processing of stimuli (Enns & Cameron, 1987; Enns & Girgus, 1985; for reviews of both early and late selection theories, see Allport, 1989; Enns & Akhtar, 1989). In early selection theories, attention is viewed as a single and finite cognitive resource that is shared by several components among which filtering plays a major role (Enns & Akhtar, 1989; Kahneman, 1973; Schneider & Shiffrin, 1977).

Attention is typically thought to take the form of an "attentional spotlight" (Johnston & Dark, 1986; LaBerge, 1983; Posner, 1980; Posner, Snyder, & Davidson, 1980) or "zoom lens" (Eriksen & St. James, 1986; Eriksen & Yeh, 1985; Murphy & Eriksen, 1987) that, based on physical and sensory attributes, selects items from a precategorical level of representation for identification within a given spatial region (Broadbent, 1982; Brodeur, 1990; Driver & Baylis, 1989). Although both of these analogies are helpful in portraying attentional processes and mechanisms, neither provides an incontrovertible framework (Johnston & Dark, 1986). As issues regarding the adjustability in size of a visual field to a fixed target are central to this study, the spatial region of attention will be discussed within the context of an attentional lens that can be contracted and expanded.

The effectiveness of attentional selection can be understood in relation to the filtering costs that are incurred when interfering extraneous information is present in the visual field simultaneously with relevant information. The appearance of nontarget stimuli interferes with performance by adding demands to available attentional resources, thereby diminishing the efficiency of attention and the subsequent processing of information (Enns & Girgus, 1985; Kahneman, Treisman, & Burkell, 1983). However, performance is impaired only when the nontarget stimuli appear in relatively close spatial proximity to the target stimuli (Broadbent, 1991). Thus, nontarget stimuli are distracting only if they fall within the spatial region covered by the attentional lens that is directed at the target stimulus (Eriksen & St. James, 1986; Posner et al., 1980). If stimuli appear outside or in the periphery of this area, they are easily filtered (D'Alosio & Klein, 1990). Smaller spatial ranges are also generally considered better for both the processing of relevant and filtering of irrelevant information (e.g., Brodeur, 1990), although the excessive narrowing of attention is detrimental (e.g., Rincover & Ducharme, 1987).

Issues in the Study of Persons With Autism

Certain methodological issues need to be considered when studying selective attention, or any aspect of cognitive functioning, in persons with autism. For example, because as many as 85% of persons with autism function in the mentally retarded range (Volkmar & Cohen, 1986) and developmental level is associated with differences in cognitive performance (Flavell, 1977), researchers need to use comparison groups that include, at the very least, MA-matched nonhandicapped subjects (Baron-Cohen, 1989; Frith & Baron-Cohen, 1987; Yule, 1978). Yule (1978) and Baron-Cohen (1989) also recommended the inclusion of MA-matched comparison groups of subjects with mental retardation. Burack and Volkmar (1991) further specified that this MA-matched group should be composed of participants with various types of organic mental retardation, as autism appears to be related to a variety of organic etiologies. However, researchers have long acknowledged differences in functioning among persons with organic retardation and those with familial retardation (for reviews, see Burack, 1990; Weisz, Yeates, & Zigler, 1982). Thus, MA-matched groups of (a) persons with autism (functioning in the range of mental retardation), (b) (nonautistic) persons with various types of organic retardation, (c) (nonautistic) persons with familial retardation, and (d) nonhandicapped children were included in this study. In addition, baseline conditions that allow for within-group analyses were included in the design, as task performance of children with mental handicaps can be deleteriously affected by various motivational factors related to the testing experience (Mundy & Kasari, 1990; Weiss, Weisz, & Bromfield, 1986; Zigler & Burack, 1989).

Experimental Paradigm and General Hypotheses

The specific task used here was a forced-choice reaction time (RT) task adapted for use with persons with autism and mental retardation. All stimuli were in the form of simple geometric designs, as opposed to letters, to avoid confounding effects related to group differences in familiarity with letters (Enns & Akhtar, 1989).

The conditions varied with regard to (a) presence or absence of a spatial window highlighting the central area of the screen in which the target stimulus was presented, (b) number of distractors (zero, two, or four), and (c) proximity of the distractors to the target stimulus. Both the window and the distractors were presented simultaneously with the target stimulus. The location of the target stimuli was kept constant to eliminate the need to search for the target (Enns & Girgus, 1985) and to reduce the unpredictability of stimulus presentation that is thought to be associated with impaired attentional functioning and arousal modulation in persons with autism (Dawson & Lewy, 1989a).

In general, we expected the presence of a window to be related to faster RTs (D'Alosio & Klein, 1990; LaBerge & Brown, 1986). The costs of focusing on the target stimulus should be minimized in a smaller spatial area. Consequently, more resources should be available for filtering, thereby diminishing the effects of the distractors.

With regard to number of distractors, we expected that more distractors would incur greater filtering costs and lead to greater

Table 1
Average Chronological Age, IQ, and Mental Age of Subject Groups

Subjects with	Chronological age		IQ		Mental age	
	M	*SD*	*M*	*SD*	*M*	*SD*
Autism	20.15	4.33	49.50	17.97	8.35	3.17
Organic retardation	15.34	3.73	56.41	12.06	8.16	1.82
Familial retardation	12.07	3.07	65.53	5.33	7.87	2.03
No handicap	8.21	1.98	103.65	11.46	8.43	1.90

Note. IQ = intelligence quotient.

interference with performance. Conversely, we expected that distractors farther from the target would interfere less with performance in that the cost of visual filtering would be minimized with distractors in the periphery of the attentional lens (Broadbent, 1991; Eriksen & St. James, 1986). The conditions with zero distractors represented baseline conditions against which interference effects of the various distractor conditions were assessed (for a discussion of the role of baseline conditions, see Well, Lorch, & Anderson, 1980).

We examined differences among groups in relation to the effectiveness of filtering in the various conditions. In particular, we compared group differences on RT performance between the two baseline conditions (with and without window) and between each distractor condition and the baseline condition of the corresponding window status.

Method

Subjects

Participants included 12 persons with autism (10 male and 2 female), 32 with organic mental retardation (28 male and 4 female), 30 with familial mental retardation (15 male and 15 female), and 34 with no handicap (20 male and 14 female). Although we tried to recruit equal numbers of females and males for each group, we could not. Preliminary analyses indicated, however, that there were neither main nor interaction effects of gender.

Information from school and medical records was used to assign children with autism or mental retardation to their respective groups. Persons with autism had all received diagnoses based on the *Diagnostic and Statistical Manual of Mental Disorders,* Third Edition (*DSM-III;* American Psychiatric Association, 1980) criteria in recent extensive psychiatric evaluations. Children with organic retardation were included if their records contained medical indication of organic impairment related to mental retardation (Grossman, 1983). If there was uncertainty regarding the group assignment of a person, he or she was excluded from the study.

The intelligence quotients (IQs) of the persons with autism and mental retardation were obtained from school records. In all cases, the IQ scores were based on testing carried out within the three years before participation in this study. The Matrix Analogies Test—Short Form (Naglieri, 1985) was used to obtain general estimates of MA of the children with no handicap. The average chronological ages (CAs), MAs, and IQs of the persons in the four groups are presented in Table 1.

Experimental Task

All stimuli were presented on an IBM XT computer, with a color monitor, to which a keyboard with two response buttons was attached. There was a picture of a circle (O) on the left response button and a picture of a plus (+) sign on the right response button.

There were two types of stimuli: target and distracting. Target stimuli consisted of a circle and a plus sign. Distractors were composed of four shapes (pound sign, #; asterisk, *; triangle, △, and dove, ⌒. All stimuli were magenta in color and 8.5 mm high.

In each trial, one of the target stimuli was presented in the center of the screen. The presence or absence of a window and the number and location of distractors varied by condition. In half of the trials, a window was imposed in the center section of the screen. In these trials, the window area was light gray, and the outer section of the screen was black. In the other half of the trials, there was no window, and the entire screen was light gray. The areas of the screen and window are depicted in Figure 1.

In a given trial, there could be zero, two, or four distractors, all either close to or far from the target stimulus. Distractors were located in one of four positions relative to the target: directly (a) above, (b) to the right, (c) below, or (d) to the left. In the conditions with four distractors, a distractor was presented at each of these positions. In the conditions with two distractors, the distractors were either (a) above and below the target or (b) to the right and to the left of the target. In the close conditions, the distractors above and below the target were 2.1 cm (approximately 2° of visual angle) from the center of the screen, and those to the sides were 3.2 cm (approximately 3° of visual angle) away. In conditions with the window, these distractors appeared within the window. The far distractors situated above and below the target were 6.3 cm (approximately 6° of visual angle) from the center, and those to the sides were 9.6 cm (approximately 9° of visual angle) away. In conditions with the window, these distractors appeared outside the window. Distractors

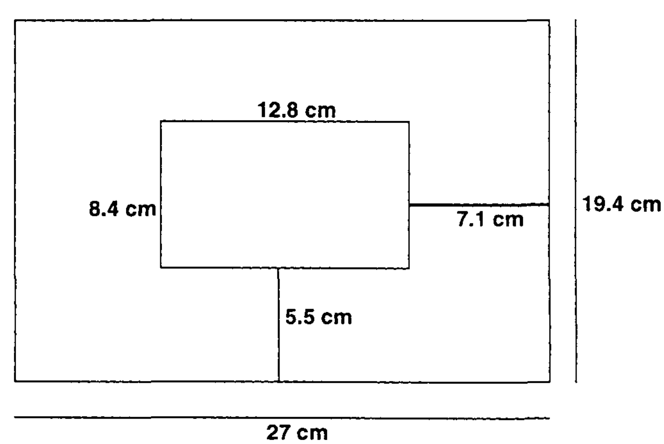

Figure 1. Dimensions of the screen and window.

both within and outside the window could easily be seen, as they were magenta in color. In all conditions, the window and distractors were presented simultaneously with the target stimulus.

The conditions with no distractors precluded a complete factorial design, as issues of location could not be considered in these cases. Thus, there were a total of 10 rather than 12 conditions, although there were 2 window, 3 number-of-distractor, and 2 location-of-distractor conditions.

There were 18 trials of each condition, for a total of 180 trials. The trials were presented in 3 testing sessions, with 60 test trials per session. Six trials (3 with a circle target and 3 with a plus target) of each of the 10 conditions were presented randomly in each of the 3 sessions.

Procedure

Participants were individually tested four times within a 1-week period. The first session was a practice session, in which participants were taught the basic requirements of the task. In a very few cases, subjects participated in an extra practice session. Sessions 2–4 were the testing sessions.

The participants were seated in front of the computer monitor, with their eyes approximately 60 cm from the screen. The response buttons were placed in front of them. They were told that they were going to play a game on the computer. The object of the game was to push the button with the plus sign as fast as possible every time they saw a plus sign in the middle of the screen and to push the button with the circle as fast as possible every time they saw a circle in the middle of the screen. They were told the plus signs and circles would appear only in the middle of the screen and that they should not pay attention to other shapes that appeared on the screen. They were also told that they would receive a prize at the end of the game.

In the practice session, the participants were administered 50 trials with baseline conditions. Each trial was preceded by a tone approximately 1 s long that sounded to alert the child to the presentation of the stimuli. The stimuli were displayed immediately on termination of the tone and remained on the monitor until the subject responded by pressing one of the two response buttons. After each trial, there was a delay of approximately 1 s before the tone sounded to begin the next trial.

During the first 20 trials, participants were given verbal feedback on the accuracy of their responses. After the session, subjects were offered a choice of small prizes, regardless of level of performance.

The test sessions began with 10 practice trials, with each of the 10 test conditions being presented once. These practice trials served to reacquaint the participant with the task and to allow for questions. The practice trials were followed by 60 test trials. The presentation of trials during the testing session was similar to that of trials in the practice session. Trials in the testing session, however, were terminated after 6 s if there was no response.

During the testing sessions, the experimenter sat to the left of the subject. He noted at the beginning of each trial whether or not the subject was looking at the computer monitor. In addition, he noted any occurrences that may have distracted the subject from the experimental task. Trials were deleted if non-task-related distractions interfered with the subject's performance. In deleting trials, the experimenter was blind to the condition of the trial. Trials were also deleted if the subject responded incorrectly or failed to respond within 6 s.

Results

Measuring Performance

RT is the dependent variable considered in the discussion of the results of this study. Although RT tasks often provide interesting information about accuracy versus speed trade-offs, the minimal number of errors committed by the subjects in this study precludes an examination of this issue. The low error rate resulted from the relative simplicity of the forced-choice task, which was designed to ensure that even nonverbal subjects could participate in the study. The average reaction times, percentages of errors, and percentages of other deletions by group for each of the conditions are presented in Tables 2–5.

It is common practice in studies examining RT scores to use median RTs, especially when the subjects include children or other persons who typically display considerable variability in their RTs. Accordingly, the analyses were based on median RTs of each subject for each of the 10 experimental conditions across the 3 sessions. Average RTs presented are means of these medians.

Planned Comparison Analyses

The design of this study was not a simple factorial one, as the factor of location cannot be considered in the baseline conditions. As a result, we conducted three planned comparison analyses to consider the effects of various experimental conditions by group.

Planned Comparison 1. Comparison 1 included all conditions with distractors. The factors considered were window (window and no window), number of distractors (two and four), and location of distractors (close and far). Thus, this compari-

Table 2
Reaction Times and Percentages of Errors by Window Condition and Number of Distractors for Subjects With Autism

	Window							
	Absent				Present			
Distractors	*M*	*SD*	% errors	% deletions	*M*	*SD*	% errors	% deletions
Zero	973.63	310.25	1.39	3.70	876.79	311.75	2.78	2.78
Two								
Close	1,037.38	324.21	1.39	4.63	1,001.42	365.03	3.70	0.46
Far	917.17	243.65	0.93	3.24	932.04	299.17	1.39	1.39
Four								
Close	976.71	351.44	3.24	3.24	987.71	373.61	2.31	2.31
Far	930.58	301.75	1.85	3.24	937.58	322.70	1.39	3.70

Table 3
Reaction Times and Percentages of Errors by Window Condition and Number of Distractors for Subjects With Familial Retardation

	Window							
	Absent				Present			
Distractors	*M*	*SD*	% errors	% deletions	*M*	*SD*	% errors	% deletions
Zero	801.12	248.47	0.93	0.37	766.28	264.17	0.93	0.19
Two								
Close	840.02	267.68	1.85	0.19	804.77	269.10	1.85	0.37
Far	798.60	261.95	2.04	0.37	747.88	256.88	1.85	0.56
Four								
Close	832.03	285.21	0.74	0.19	786.75	294.52	1.67	0.19
Far	798.72	290.38	0.69	0.37	737.53	253.71	2.78	0.56

son was conducted as a 4 × 2 × 2 × 2 (Group × Window × Number × Location) repeated measures analysis of variance (ANOVA).

Planned Comparison 2. Comparison 2 included baseline conditions and conditions with close distractors. The factors considered in this analysis were window (window and no window) and number of distractors (zero, two, and four). This comparison was conducted as a 4 × 2 × 3 (Group × Window × Number) repeated measures ANOVA.

Planned Comparison 3. Comparison 3 included baseline conditions and conditions with far distractors. The variables in this analysis were window (window and no window) and number of distractors (zero, two, and four). This analysis was conducted as a 4 × 2 × 3 (Group × Window × Number) repeated measures ANOVA.

Main effects of window. Main effects of window were found for each of the three general analyses: Comparison 1, $F(1, 104) = 21.50, p < .001$; Comparison 2, $F(1, 104) = 36.85, p < .001$; Comparison 3, $F(1, 104) = 30.18, p < .001$. In each case, RTs were faster when the window was present.

Main effects of number. Main effects of number were found for both Comparison 1, $F(1, 104) = 6.86, p < .05$, and Comparison 2, $F(2, 208) = 28.78, p < .001$. In Comparison 1, RTs were faster with four than with two distractors. In Comparison 2, a series of paired-comparison t tests indicated that RTs were faster in baseline conditions than in conditions with either two, $t(106) = 7.02, p < .001$, or four, $t(106) = 4.32, p < .001$, distractors. RTs were also faster with four distractors than with two, $t(106) = 3.29, p < .01$. No main effect of number of distractors was found in Comparison 3.

Main effect of location. A main effect of location was found in Comparison 1, $F(1, 104) = 67.93, p < .001$. RTs were slower with close than with far distractors.

Number × Location interaction. An interaction effect of Number × Location, $F(1, 104) = 5.97, p < .05$, was found in Comparison 1. There was no difference between two and four distractors when the distractors were far from the target stimulus, but RTs were faster with four distractors than with two when the distractors were close to the target stimulus.

Group × Number interaction. A Group × Number interaction was found in Comparison 2, $F(0.9816, 208) = 2.56, p < .05$ (with Greenhouse-Geisser epsilon correction). Compared with their RTs on the baseline conditions, the RTs of the persons with autism and organic retardation showed the greatest increase in the presence of close distractors.

Group × Window × Number interaction. A Group × Window × Number Interaction was found in Comparison 3, $F(0.91536, 208) = 2.31, p < .05$ (with Greenhouse-Geisser epsilon correction). The RTs of the persons with autism decreased the most in the presence of the window when there were no

Table 4
Reaction Times and Percentages of Errors by Window Condition and Number of Distractors for Nonhandicapped Subjects

	Window							
	Absent				Present			
Distractors	*M*	*SD*	% errors	% deletions	*M*	*SD*	% errors	% deletions
Zero	737.16	263.72	0.98	0.33	701.93	265.28	1.96	0.16
Two								
Close	783.72	313.75	0.98	0.65	717.62	289.48	1.31	0.49
Far	736.56	292.28	1.14	0.65	696.26	274.43	2.29	0.33
Four								
Close	758.66	319.66	1.63	0.16	716.40	292.38	1.63	0.49
Far	722.54	322.14	0.98	0.49	692.79	294.51	2.45	0.00

Table 5
Reaction Times and Percentages of Errors by Window Condition and Number of Distractors for Subjects With Organic Retardation

	Window							
	Absent				Present			
Distractors	*M*	*SD*	% errors	% deletions	*M*	*SD*	% errors	% deletions
Zero	922.97	296.52	1.91	1.39	895.02	340.59	2.26	1.91
Two								
Close	1,010.75	390.22	2.08	0.35	998.38	400.01	2.60	1.04
Far	941.94	371.32	2.08	0.52	922.30	298.14	2.43	0.17
Four								
Close	965.00	320.23	1.91	0.87	987.71	373.61	2.60	0.52
Far	938.48	344.04	2.26	0.35	896.98	339.78	2.26	0.87

distractors. However, unlike those of the persons in the other groups, the RTs of the persons with autism did not improve with the presence of the window when distractors were also present.

T tests were performed in the few cases where the RTs of a group on a specific distractor condition were slower with the window than without. These cases included those with four close distractors for the persons with organic retardation and two far, four close, and four far distractors for the persons with autism. In none of these cases were there significant differences in RT between the conditions with and without the window.

Planned Comparisons of Group Effects

Planned comparison analyses were used to assess expected differences among the groups with regard to the effects of the window and distractors on performance. In order to account for initial group differences in baseline RTs (Miller, Chapman, Chapman, & Kwapil, 1993), a series of analyses of covariance (ANCOVAs), with baseline RTs covaried out, were conducted on the mean differences between RTs on specified conditions and the appropriate baseline conditions for each group. When significant group differences ($p < .05$) were found, Newman-Keuls analyses were conducted using the adjusted means of the difference scores.

Effects of window in the absence of distractors. A main effect of group, $F(3, 104) = 3.08, p < .05$, was found in an ANCOVA with difference scores in RT from the no-distractors conditions with and without the window (covarying RT on the no-distractors condition without the window). The subsequent Newman-Keuls analysis ($p < .05$) revealed that the RTs of the autistic group decreased the most with the presentation of the window and that there were no differences among the other groups.

Effects of distractors. The conditions in a given ANCOVA included a single-distractor condition and a baseline condition of the same window status (window or no window).

No group differences were found in the analyses that included the distractor conditions without the window. However, group differences were found in the analyses of each of the four distractor conditions with the window.

An ANCOVA revealed a main effect of group, $F(3, 104) = 4.49, p < .01$, when the condition with two close distractors was considered with the baseline with the window. A Newman-Keuls analysis ($p < .05$) indicated that the persons with autism showed a greater increase in RT with the distractors present than either the persons with familial retardation or those with no handicaps. The persons with organic retardation showed a greater increase than the nonhandicapped persons. There were no differences between the persons with organic retardation and those with autism or familial retardation, nor was there any difference between the persons with familial retardation and those with no handicaps.

An ANCOVA revealed a main effect of group, $F(3, 104) = 2.86, p < .05$, with the condition with two far distractors and the baseline condition with the window. The Newman-Keuls ($p < .05$) analysis indicated that the RTs of the persons with autism showed a greater increase in the presence of two far distractors than did the RTs of persons with familial retardation and no handicaps. The increase in RT of the persons with organic retardation did not differ significantly from the RT increase of any of the other groups. There were no differences between the persons with familial retardation and those with no handicaps.

An ANCOVA revealed a main effect of group, $F(3, 104) = 3.03, p < .05$, when the condition with four close distractors was considered with the baseline with the window. The Newman-Keuls analysis ($p < .05$) indicated that the RTs of the persons with autism increased the most with the distractors present. There were no differences among the other groups.

Finally, an ANCOVA revealed a main effect of group, $F(3, 104) = 4.00, p < .01$, with the condition with four far distractors and the baseline condition with the window. The Newman-Keuls analysis ($p < .05$) indicated that the RTs of the autistic group increased the most with the distractors present. There were no differences among the other groups.

Discussion

Visual selective attention and distraction were examined in persons with autism functioning in the range of mental retardation, as compared with nonautistic persons of the same MA with organic retardation, familial retardation, and no handicaps. Subjects were required to identify and respond to one of two possible target stimuli that were always presented in the same location. A forced-choice RT task was used to assess the effects of a window, and the number and proximity of distracting stimuli on subjects' abilities to focus on a target stimulus and filter extraneous stimuli.

In general, RTs were faster in the presence of a window, slower with distractors close to the target stimulus, and unaffected by distractors far from the target. Apparently, the presence of a window diminishes the costs related to size adjustments or focusing of the attentional lens, or both. Conversely, the filtering of distractors close to the target entails costs that are reflected in slower RTs.

Attention Deficits Among Persons With Autism

The primary findings regarding group differences reflect a filtering deficit among persons with autism that might best be viewed within the contexts of insufficient attentional resources and an inefficient attentional lens. In the absence of distractors, the persons with autism showed the most improvement in RT when the window was imposed on the center of the screen. The improvement in RT reflects an inability to focus optimally on a target stimulus that can be ameliorated when the size of the visual field is diminished. It is likely indicative of an attentional lens that is inefficient in contracting its focus to a narrow and more optimal visual field, but whose efficiency can be enhanced by minimizing the visual area to which attention must be directed. The benefits of the window can therefore be viewed as external facilitation of the adjustment of the size of the attentional lens.

The persons with autism did not benefit, however, from the presence of the window when distractors were present. Rather, their RTs, as compared with those of the persons with familial retardation and no handicaps, were more adversely affected in all distractor conditions when the window was also present. Conversely, no differences of effects of distractors were found between persons with autism and those in the other groups when distractor and baseline conditions were compared without the window. Thus, the benefits of the window were essentially negated for the persons with autism when the task required filtering distractors, whereas they were maintained among persons in the other groups. The findings are especially compelling for the conditions with distractors far from the target stimulus, which had little effect on the performance of the other groups. This is consistent with the notion of an inefficient attentional lens among persons with autism, as the facilitation of attending is superseded by distraction from irrelevant stimuli.

The finding of an inefficient attentional lens among persons with autism reflects impaired attentional functioning at the early-selection stage of processing, which is likely related to reduced levels of available attentional resources. The longer RTs in conditions with the window and distractors, especially with distractors far from the target stimulus, provide compelling evidence that persons with autism reach the limit of their available resources at relatively low demand conditions.

These deficiencies in attention appear to be specifically related to autism rather than to the associated mental retardation. Groups were all matched for MA, so lowered MA could not be considered a factor. Although there were IQ differences among the groups, IQ was not related to differences in performance. For example, no differences were found between persons with familial retardation and those with no handicaps, although there was a considerable difference in IQ between these groups. Furthermore, the performance of persons with organic retardation was generally similar to that of the persons with familial retardation and those with no handicaps (although their performance was somewhat more similar to that of the persons with autism than that of the other two groups). Thus, the deficits in performance evidenced in the persons with autism appear to be more related to autism than to organicity.

Implications for Understanding Autism

Our findings reflect impairments in the abilities of persons with autism to focus on a target stimulus and to filter extraneous stimuli. They are concordant with pathophysiological event-related brain potential (Courchesne & Yeung-Courchesne, 1988) and autonomic nervous system responsivity (Zahn, Rumsey, & Van Kammen, 1987) evidence indicating impaired selective enhancement of attention in response to important information. Although these data are consistent with the general hypothesis of a spatial defect in the attentional functioning of persons with autism (Bryson, Wainwright-Sharp, & Smith, 1990; Wainwright-Sharp & Bryson, 1993), they necessitate reexamination of the common view that this group suffers from overfocused attention (Bryson, Wainwright-Sharp, & Smith, 1990; Dawson & Lewy, 1989a; Rincover & Ducharme, 1987). The deleterious effects of distractors, especially those far from the target stimulus, are indicative of a range of visual attention that is overly extended in certain circumstances.

Their impaired ability to filter extraneous information may also be a primary source of overarousal in persons with autism (e.g., Dawson & Lewy, 1989b; Kinsbourne, 1987), because their failure to inhibit the intake of extraneous stimuli could expose persons with autism to a bombardment of information from the environment. Contrary to the notion that overarousal and attentional difficulties in persons with autism arise from encounters with information that is complex, unpredictable, and novel (Dawson & Lewy, 1989a, 1989b), impaired attentional functioning was found with simple, redundant, and nonnovel presentations of stimuli. Accordingly, the attentional difficulties of persons with autism appear to originate at a more primitive level of information processing, commensurate with the related notions of early selection deficits and an inefficient attention lens.

Impaired attentional functioning may be central to many social and cognitive deficits observed in persons with autism, as efficient attending is clearly essential to the development of all aspects of functioning. Although the effectiveness of the attentional lens can apparently be enhanced by artificially highlighting the relevant information and eliminating sources of distraction, real environments do not provide such facilitation, as they are typically large and inundated with information. Accordingly, consistent with the early selection model of attention, an inefficient lens can be viewed as detrimental to the effective processing of information in the real world for two reasons: (a) The intake of relevant information from the environment is less than optimal. Therefore, persons with autism are less able to learn from and relate to the surrounding environment. (b) The additional costs incurred in focusing and filtering deplete resources for other aspects of attending and information processing. With a combination of these deficiencies, persons with autism are unable to attend efficiently to the most relevant information in the environment and therefore do not effectively learn from and relate to their surroundings. This may contribute to the overall impaired functioning that is typically observed in the development of persons with autism.

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