SELECTIVE ATTENTION AND DISTRACTIBILITY IN CHILDREN WITH DOWN SYNDROME

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ABSTRACT

SELECTIVE ATTENTION AND DISTRACTIBILITY

IN CHILDREN WITH DOWN SYNDROME

The goal of this study was to examine selective attention and distractibility within the visual modality in children with Down syndrome as compared to children of normal intelligence matched for mental age. Selective attention was defined as the children's abilities to identify and respond to a target stimulus on a forced choice reaction time task. Distractibility was considered to be the extent to which the children's performances on the task were interfered with by extraneous stimuli in the visual field. Conditions on the task varied with regard to the presence or absence and location (close and far) of distracting stimuli and the presence or absence and size (small, medium and large) of boundary cues. Participants included 10 children with Down syndrome and 10 children of normal intelligence matched for mental age. The primary finding of this study was that the performance of children with Down syndrome was more adversely affected by the presence of distractors than that of the children of normal intelligence. This finding indicates that children with Down syndrome suffer from selective attention deficits and increased distractibility. The selective attention of children with Down syndrome is characterized as distractor-controlled as a result of a defective attentional (zoom) lens that "wanders" in visual space.

RESUME

L'ATTENTION SELECTIVE ET LE NIVEAU DE DISTRACTION CHEZ LES ENFANTS ATTEINTS DU SYNDROME DOWN

L'objectif de cette recherche fut l'étude de l'attention sélective et la distraction visuelle chez les enfants atteints du syndrome Down en les comparant aux enfants d'intelligence normale mais d'âge mental égal. Un enfant avec attention sélective peut identifier et répondre à un objet préselectionné lors d'une tâche temporelle nécessitant le choix d'une réponse. Un enfant est considéré distrait lorsque sa performance sur la tâche présente est influencée par des objets visuels distrayants. Les conditions de la tâche de cette étude variaient par rapport à: la présence, ou l'absence et l'emplacement des objets distrayants, la présence ou l'absence et la grandeur de l'objet. Dix enfants atteints du syndrome Down, et dix enfants d'intelligence moyenne et d'âge mental égal ont participé à l'étude. Le résultat principal de cette étude a été que la performance des enfants atteints du syndrome Down fut davantage influencée par la présence d'objets distrayants. Ce résultat nous indique que les enfants atteints du syndrome Down souffre de déficience d'attention sélective et d'une distraction accrue. Les enfants atteints du syndrome Down sont trés sujet aux distractions causées par un centre d'attention errant. Leur centre d'attention est facilement perturbé de l'information pertinente au centre de l'écran

pour être plutôt dirigé vers des détails insignifiants sur l'écran.

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Selective Attention and Distractibility in Children with Down Syndrome

The human brain's finite capacity for information processing (e.g. Broadbent, 1971; Kahneman, 1973; Mesulam, 1985), combined with the infinite amount of information available to sensory systems interacting with the brain, necessitates the efficient operation of selective processes (Enns, 1990). Efficient information processing requires that attentional resources be focused on target information in the environment, and that extraneous information be excluded from processing. The selective processes involved in efficient information processing, however, may be associated with a cost. In the presence of extraneous information, attentional resources may be diverted from a given task and allocated to the processing of irrelevant information (Kahneman, Treisman, Burkell, 1982). Conversely, cues may act to conserve attentional resources by helping focus attention on important information and by preventing the intrusion of potential distractors (Akhtar & Enns, 1989).

The ability to selectively attend to relevant information and to ignore irrelevant information in the environment is essential to intellectual and cognitive development (Lewis & Baldini, 1979). Efficient selective attention requires the intake of information through sensory systems with optimal utility for a given task leaving irrelevant stimuli unprocessed (Gibson & Rader, 1979). In contrast, impaired selective attention involves difficulties in ignoring irrelevant stimuli that interfere with the processing of more meaningful information (Douglas & Peters, 1979). Without selectivity to prevent developing children's sensory systems from being bombarded with an infinite amount of information, it would be difficult for them to make sense of the surrounding world or function competently within it. Accordingly, selective attention is particularly relevant to understanding the delayed and/or impaired intellectual development of children with various types of mental retardation.

Impaired selective attention and difficulty filtering extraneous information have long been cited to be characteristic of children with mental retardation (Crosby & Blatt, 1968; Follini, Sitkowski, & Stayton, 1969; Krupski, 1979; Lunzer & Stratford, 1984). In particular, attentional deficits have been the focus of work with infants with Down syndrome (for a review see Wagner, Ganiban, & Cicchetti, 1990). Although minimal work has been done on selective attention in post-infancy children with Down syndrome, there is some evidence of an impaired ability to selectively attend to relevant sources information and to ignore irrelevant ones. For example, Lunzer and Stratford (1984) observed that children with Down syndrome had difficulties concentrating on a central task when there were competing extraneous stimuli in the environment, and Miezejeski (1974) found that the performances of children with Down syndrome on a visual reaction time task were negatively affected by distracting white noise. Evidence for attentional impairment among individuals with Down syndrome has also emerged from related phy~iological research. For example, problems with habituation mechanisms (Schafer & Peeke, 1982) and evidence of increased amplitude in cortical evoked potentials (Courchesne, 1989) indicate that individuals with Down syndrome are deficient with regard to the inhibitory capacity of their brains.

The primary purpose of this study is to examine visual selective attention in children with Down syndrome as compared to children of normal intelligence. The experimental paradigm used here has been adapted from those used in classical (e.g. Eriksen & Eriksen, 1974) and developmental (e.g. Enns & Akhtar, 1989) studies of attention for use with children with developmental delays such as mental retardation and autism. Specifically, the paradigm is used to address issues regarding the efficiency with which children with Down syndrome, as compared to their normal intelligence peers, focus on relevant stimuli and ignore irrelevant stimuli in their visual field.

Issues in the Development of Selective Attention

Two dichotomous constructs have typically been described as fundamental to selective attention: (a) *selectivity* or the ability to focus on task-relevant information leading to efficient processing, and (b) *distractibility* or the inability to inhibit responding to and processing of irrelevant information (e.g. Crosby, 1972; Kahneman, Treisman, & Burkell, 1983). William James (1890) captured the essence of selectivity and distractibility in attention over a century ago when he wrote:

> Everyone knows what attention is. It is the taking possession of the mind, in clear and vivid form, of one out of what seem several simultaneously possible objects or trains of thought. Focalization, concentration of consciousness are its essence. It implies withdrawal from some things in order to deal effectively with others, and is a condition which has a real opposite in the confused, scatterbrained state which in French is called distraction (James, 1890, pp. 403-404).

In a contemporary approach to issues in the development of visual attention, Enns' (1990) also views selectivity and distractibility as fundamental to attentional processes. Enns conceptualizes visual attention as a hierarchy of mechanisms with selectivity at the highest level. The abilities to focus attention and minimize distraction are encompassed in the filtering component at the next level of the hierarchy. Within this framework, filtering is synonymous with the ability to ignore irrelevant information in order to process other more relevant information efficiently.

The efficiency of visual attention improves with increasing chronological age (for reviews see Day, 1975; Enns & Cameron, 1987; Gibson, 1969; Lane & Pearson, 1982; Pick, Frankel, & Hess, 1975). Young children's performances on visual tasks of selective attention are impaired in the presence of irrelevant information (Day, 1978; Gibson, 1969; Gibson & Yonas, 1966; Hagen & Hale, 1973; Pick & Frankel, 1973), and this impairment is magnified as the amount of irrelevant information in the visual field is increased (Strutt, Anderson, & Well, 1975; Well, Lorch, & Anderson, 1980; Wright & Nurmi, 1979).

Research on the filtering inefficiency of young children has typically focused on developmental changes at the encoding or perceptual level of information processing (e.g. Akhtar & Enns, 1989; Enns & Akhtar, 1989; Enns & Girgus, 1985). Enns and colleagues (Enns & Girgus, 1985; Enns & Akhtar, 1989) argue that the poor filtering of young children is related to the inefficiency with which they are able to voluntarily focus attention in visual space. This argument is strengthened by the finding that the automatic focusing of children's visual-spatial attention by a salient locational precue greatly facilitates selective processing (Akhtar & Enns, 1989). Reminiscent of early-selection theories (see Broadbent, 1958; 1971; Treisman, 1964), children's inabilities to ignore irrelevant information in their visual fields has been traced to difficulties in allocating attentional resources by way of a visual "spotlight" (Johnston & Dark, 1986; LaBerge, 1983; Posner, 1980; Posner, Synder, & Davidson, 1980) or "zoom lens" (Eriksen & St. James, 1986; Eriksen & Yeh, 1985; Murphy & Eriksen, 1987).

Evidence for visual-spatial attention having the physical and sensory characteristics of a zoom lens comes from a study by Enns and Girgus (1985). They found that the performance of young children, as compared to older children, was affected by the presence of an irrelevant stimulus in the visual field to a greater extent and over a larger distance from the target stimulus on a selective attention task and, that, their performance was more adversely affected by increases in interstimulus separation on an integrative task. The young children's inefficiency in the filtering and integration tasks represent difficulties in respectively contracting and expanding a camera-like lens to focus on task-relevant information.

In the spotlight analogy, spatial attention involves: (a) the engagement of attention by a stimulus; (2) the disengagement of attention from the stimulus; and (3) the movement of attention to a new stimulus location (Brodeur, 1990; Posner, Nissen, & Ogden 1978). Evidence for the spotlight analogy derives from the finding of age differences in performance due to the presence of a spot of light used to *invalidly* precue a target location, as opposed to, the finding that children as young as five years were able to filter distracting stimuli as efficiently as adults with the aid of *valid* locational precues (Akhtar & Enns, 1989). Thus, in the absence of valid locational cues, young children can be viewed as having difficulties in disengaging their attentional spotlight from distracting stimuli in order to move it to a target location.

Although neither analogy provides a definitive framework (Johnston & Dark, 1986), both the attentional spotlight and the zoom lens analogies are helpful in portraying attentional processes and mechanisms. The essential aspect preventing either metaphor from prevailing is that both the adjustability (zoom lens analogy) and the movement (spotlight analogy) of attention in visual space are integral to visual selective attention. For the purposes of this study, the spatial region of attention will heretofore be discussed within the context of an attentional (zoom) lens that is both adjustable (i.e. expands and contracts) and capable of movement in visual space.

The competition between target and extraneous information in the visual field for the same attentional resources is often associated with a filtering "cost". The appearance of non-target stimuli interferes with performance by drawing available attentional resources away from target information, thereby, diminishing the efficiency of selective attention and the subsequent processing of information (Enns & Girgus, 1985; Kahneman, Treisman, & Burkell, 1983). In research with adults, however, performance is only impaired when extraneous information is displayed in relatively close proximity to the relevant information to be processed (Broadbent, 1991). In particular, when adults' attentional resources are focused on a specific location, non-target stimuli are only distracting if they fall within the spatial region highlighted by the attentional lens (Eriksen & St. James, 1986; Posner, Snyder, Davidson, 1980). Conversely, irrelevant stimuli appearing outside or in the periphery of this area are easily filtered out (D'Alosio & Klein, 1990). Stimuli farther than 2 degrees of visual angle from the focal point of attention have no significant distracting effect on perceptual processing (Eriksen & Hoffman, 1973).

Selective attention "benefits" are associated with the appearance of visual-spatial cues that help to focus attention on relevant information in the visual field and, thereby, prevent extraneous information from interfering with efficient processing. Locational cues, such as a spot of light, have been found to highlight relevant information in visual space and to help filter extraneous information leading to efficient processing (Akhtar & Enns, 1989, Enns & Girgus, 1985). Similarly, a window borderline that limits the size of the target area to be attended has been related to enhanced processing (Burack, 1991).

Developmental Issues in the Selective Attention of Children with Mental Retardation

Researchers of attention in mental retardation (e.g. Fisher & Zeaman, 1973; Heal & Johnson, 1970; Zeaman & House, 1963; 1979) have typically proposed defect models of attention that do not take developmental changes in selective attention into consideration. Fundamental to defect models is that children with mental retardation, regardless of mental age (MA) or etiology, suffer from one or several specific defects that are biological and/or cognitive in nature (e.g. Ellis & Cavalier, 1982; Spitz, 1979; Zeaman & House, 1979). Defect theorists of attention hypothesized that individuals with mental retardation, as opposed to nonretarded individuals, are more distractible and are less able to maintain attention to task-relevant stimuli that is largely a consequent of an inadequate inhibition of response to irrelevant stimuli. For example, Terdal (1967) found that adolescents and young adults with mental retardation, as compared to nonretarded controls, had more difficulty inhibiting responses to unimportant extraneous stimuli.

Attention research by defect theorists is plagued by two flaws. The first flaw is their failure to control for developmental changes in selective attention. The need to control for developmental level in studies comparing persons with and without mental retardation (Mundy & Kasari, 1990; Zigler, 1967; 1969) is supported by changes in children's abilities to selectively attend with increasing chronological age (Day, 1975; Enns & Cameron, 1987; Gibson, 1969; Lane & Pearson, 1982; Pick, Frankel, & Hess, 1975) and the relationship between developmental level and differences in cognitive performance (Flavell, 1985). Specifically, neglecting to control for mental age allows for differences on tasks of selective attention to be due to the higher level of cognitive development reached by children of normal intelligence as opposed to specific deficits inherent in children with mental retardation. This is supported by researchers findings that children with mental reta. ation, as compared to MA-matched children of normal intelligence, are no more affected by distractors on a variety of tasks of selective attention (e.g. Crosby, 1972; Ellis, Hawkins, Pryer, & Jones, 1973; Zekulin-Harlley, 1982).

The second flaw is defect theorists' belief that all children with mental retardation, regardless of etiology, suffer from similar deficits. In contrast, developmental theorists have emphasized the need to differentiate amongst various etiologies of mental retardation (e.g. Hodapp & Zigler, 1990; Mundy and Kasari, 1990). Although children with mental retardation, regardless of etiology, progress through the same universal stages of development that children of normal intelligence matched for mental age traverse (Weisz & Zigler, 1979; Kopp, 1983), etiology appears to play an important role in the structure of intelligence of children with mental retardation. In particular, there is considerable diversity in levels of functioning across developmental domains within the various etiological groups of children with mental retardation (for reviews see Burack, Hodapp, & Zigler, 1988; Burack, 1990; for a review of work specifically with children with Down syndrome see Cicchetti & Beeghly, 1990) as represented by the unique patterns of relative strengths and weaknesses displayed by the various etiological groups.

Although children with Down syndrome are a relatively large and easily identified population of individuals with organic mental retardation (see Cicchetti & Beeghly, 1990), minimal work on selective attention has involved differentiating children with Down syndrome from those with other forms of organic retardation and from those with familial retardation. In one exception, Miezejeski (1974) found that the performances of children with Down syndrome were negatively affected by white noise on a simple visual reaction time task while those of children with familial retardation were not. The paucity of work on attention that differentiates amongst children with various etiologies of mental retardation remains a serious limitation of selective attention research in children with mental retardation.

The purpose of the present study is to examine whether children with Down syndrome differ from children of normal intelligence matched for mental age with regard to their abilities to selectively attend to a target stimulus in the presence of distracting stimuli and boundary cues. The following issues will be specifically addressed: (a) the cost of selective attention associated with the presence of distracting stimuli at varying distances from the target stimulus; (b) the benefit associated with the presence of boundary cues of various sizes; and (c) the interaction effect of the presence of both distractors and boundary cues (i.e. can boundary cues facilitate selective attention by making distractors easier to ignore).

The dependent variables considered in this study are the reaction times of the subjects' responses to a target stimulus in the presence or absence of distracting stimuli that vary in proximity (close or far) to the target stimulus, and in the presence or absence of boundary cues that vary in size (small, medium, large). Costs and benefits associated with selective attention in the presence of distractors and boundary cues will be examined. *Cost* is operationalized as a relative increase in reaction time associated with the presence of distractors, while *benefit* refers to a relative decrease in reaction time related to the presence of boundary cues. The general hypotheses are that the presence of distractors should slow down reaction times, particularly when the distractors are in close proximity to the target stimulus. In contrast, boundary cues are expected to help the subjects attend to the target stimulus, thereby, resulting in faster reaction times. Also of interest, is the effect of the various sizes of the boundary cues on reaction time and whether or not reaction times are affected by the presence of both cues and distractors. Finally, group differences are expected to address developmental issues in selectivity and distractibility in children with Down syndrome as compared to children of normal intelligence.

Method

Subjects

The subjects who participated in the present study included 10 (6 male, 4 female) children with Down syndrome and 10 (7 male, 3 female) children of normal intelligence. The children with Down syndrome were recruited from a private school for children with developmental delays and the children of normal intelligence were recruited from a public school.

Background information on etiology of mental retardation, level of cognitive functioning, visual and gross motor functioning, and chronological age (CA) was gathered from the school files of the children with Down syndrome. Those children whose files did not contain appropriate information on their level cognitive functioning were given the Matrices subtest of the Kaufman Brief Intelligence Test (Kaufman & Kaufman, 1990). Matrices items of the Kaufman Brief Intelligence Test (K-Bit) are considered to be excellent measures of general ability with split-half and test-retest reliabilities of .85 and a construct validity of .56 with the Wechsler Intelligence Scale for Children - Revised (WISC-R) Full Scale Intelligence Quotient (IQ) (Kaufman & Kaufman, 1990). The Matrices subtest of the K-Bit was also used to assess the level of cognitive functioning in the nonhandicapped children. The average CA, MA, and IQs of the two groups can be found in Table 1. Children with MAs less than 5 years were generally found to be unable to perform the task. Children with severe gross motor and visual difficulties did not participate in the study.

Experimental Task

The experimental task used in this study was a modified version of the one developed by Burack (1991) to assess selective attention in children with mental ages of 4.5 years and older. Burack's experimental paradigm is similar to those used in classical (e.g. Eriksen & Eriksen, 1974) and developmental (e.g. Enns & Akhtar, 1989) studies of attention adapted for use with children with autism and mental retardation.

Table 1

Average Chronological Age (CA), Intelligence Quotient (IQ), and Mental Age (MA) of Subject Groups

Group	CA		IQ		MA	
	M	*SD*	*M*	*SD*	*M*	*SD*
Down syndrome	14.38	2.68	46.29	9.69	6.45	0.83
Normal IQ	6.34	0.58	98.24	4.80	6.23	0.71

Note. The average IQ and MA scores for the children with Down syndrome were based on the scores of 7 out of the 10 children. Although the other 3 children were unavailable for formal IQ testing, teacher and psychologist's reports place them in the same mental age range as reported here.

All stimuli were presented on a 14 inch IBM color monitor to which a mouse with two response buttons was attached. Subjects sat approximately 50 cm from the screen. There were two types of stimuli, target and distracting. Target stimuli consisted of a circle (O) and an "X" 7 mm high. There was a picture of a circle on the left response button and a picture of an X on the right one. Distracting stimuli were comprised of eight graphic symbols 3 to 6 mm high (£, ¥, μ, $\pm$, ~, β, $\varnothing$, Π). All stimuli were magenta in color. Boundary cues varied in size and consisted of a solid square border line around the target stimulus. The small boundary cue was 1 cm squared, the medium boundary cue was 2.9 cm squared, and the large boundary cue was 6.4 cm squared (see Figure 1 for dimensions of target stimuli and boundary cues).

On each trial, one of the target stimuli was presented in the center of the screen. The presence or absence and location (close or far) of distracting stimuli and the presence or absence and size (small, medium, and large) of a boundary cue varied by condition. On a given trial there could be 0 or 2 distractors. In the close distractor conditions the distractors were 1 cm to the right and to the left of the target stimulus, while far distractors were 4 cm to the right and to the left of the target stimulus.

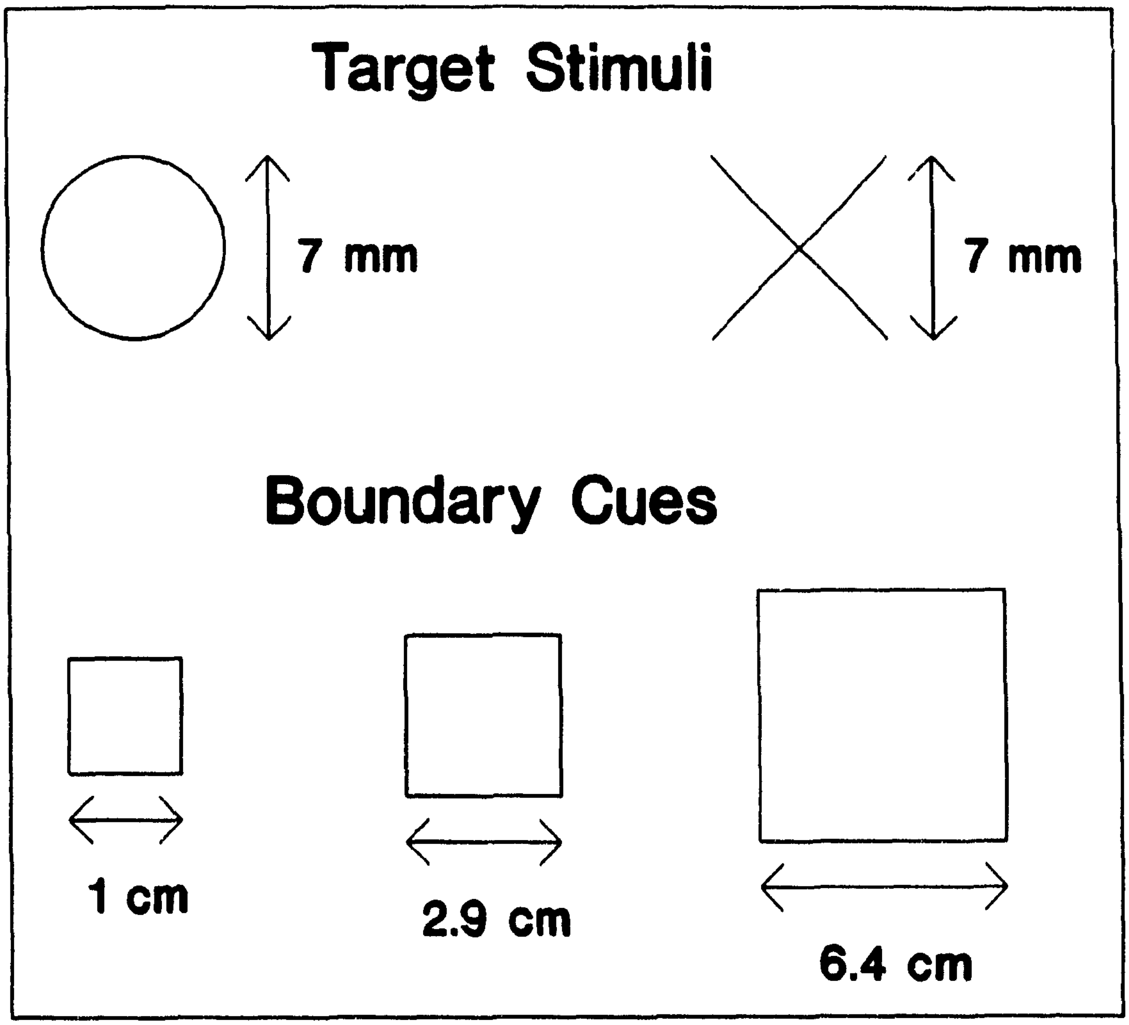

Figure 1. Dimensions of target stimuli and boundary cues.

There were 12 conditions: (a) baseline (0 distractors and no boundary); (b) near distractors and no boundary; (c) far distractors and no boundary; (d) 0 distractors and small boundary; (e) near distractors and small boundary; (f) far distractors and small boundary; (g) 0 distractors and medium boundary; (f) near distractors and medium boundary; (g) far distractors and medium boundary; (h) 0 distractors and large boundary; (i) near distractors and large boundary; and (j) far distractors and large boundary (see Table 2 for a chart and Figure 2 for graphic illustrations of these conditions). There were 16 trials of each condition for a total of 192 trials. The 192 trials were administered over 2 testing sessions. Each session consisted of 2 sets of 48 trials with a 5 minute break between sets. Four trials (2 with a circle target stimulus and 2 with an X stimulus) of each of the 12 conditions were presented randomly in each of the sets of 48 trials. Prior to both testing sessions the children completed 20 practice trials to ensure they understood the task.

Procedure

The children were individually tested on three occasions. On the first two testing sessions subjects were seated in front of the computer monitor with the response buttons in front of them. They were told by the experimenter:

> We are going to play a computer game today. Is

Table 2

Test Conditions

	Presence of Boundary	Size of Boundary	Number of Distractors	Location of Distractors
1	no	___	0	___
2	no	___	2	close
3	no	___	2	far
4	yes	small	0	___
5	yes	small	2	close
6	yes	small	2	far
7	yes	medium	0	___
8	yes	medium	2	close
9	yes	medium	2	far
10	yes	large	0	___
11	yes	large	2	close
12	yes	large	2	far

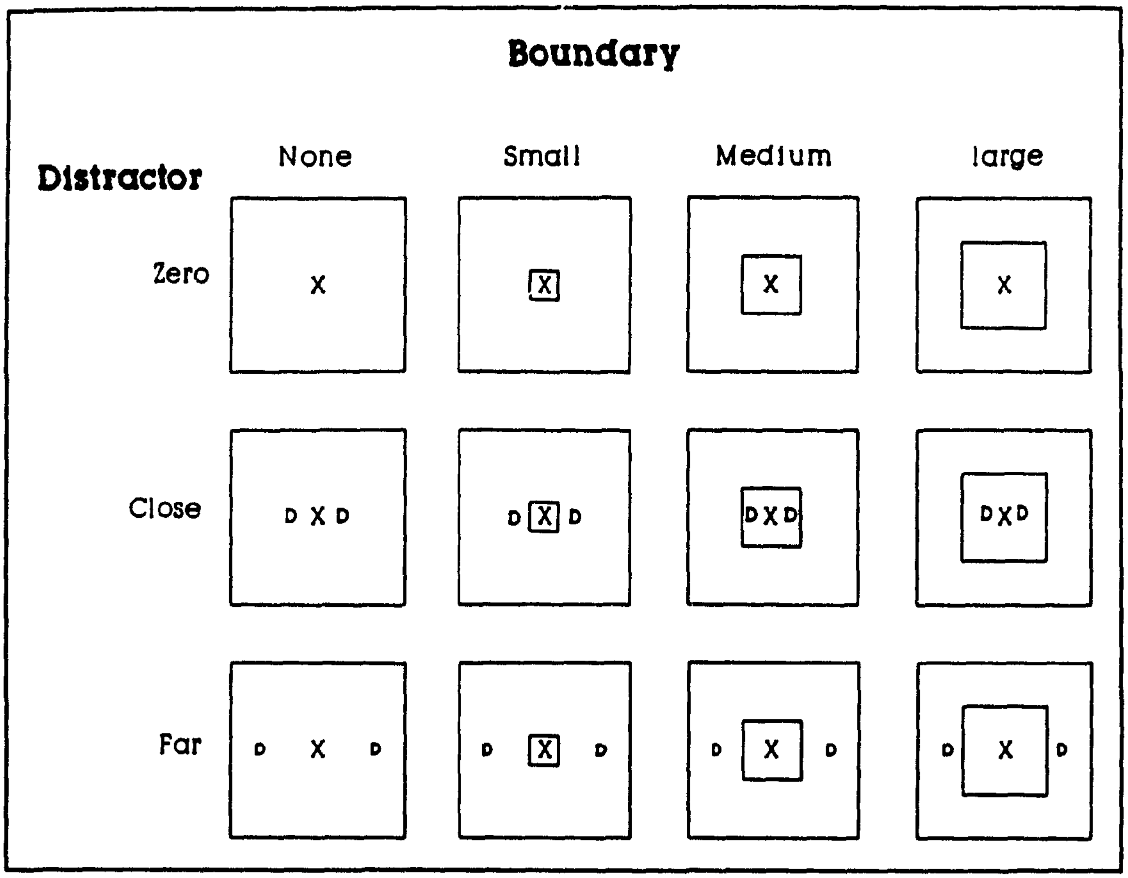

Figure 2. Test conditions.

that OK? If you like it we'll play it again next week (examiner omitted this sentence at the second session). Your job is to push the circle button (experimenter pointed to the circle response button) as fast as you can every time you see a circle in the middle of the screen and to push the X button (experimenter pointed to the X button) as fast as you can every time you see an X in the middle of the screen. The circles and X's will only appear in the middle of the screen (experimenter pointed to the middle of the screen). Do not pay attention to any other shapes that you see on the screen. We'll first do some practice trials together and then you'll play the game by yourself for real. OK? When you are finished you will get a small prize.

The children were first administered two sets of 10 practice trials. The first set consisted of trials with no distractors. The second set of 10 practice trials included trials with distractors. Each trial was preceded by a tone that sounded to alert the child to the presentation of stimuli. The tone was one second in duration. At the offset of the tone, a precue consisting of a spot of light 1 mm in diameter appeared in the middle of the screen. The precue indicated the location that the target stimulus was to appear. The target stimulus remained on the monitor until the child responded by pressing one of the two response buttons. After each trial, there was approximately a one second wait before the tone sounded again to begin the next trial.

If a child was judged by the experimenter to be unable to do the task (e.g. unable to sustain attention to complete practice trials, committed too many errors) the child selected a small prize and returned to class without participating in the rest of the study. During the practice trials all children were given verbal feedback as to the accuracy of their performance. Task instructions were also reiterated when deemed necessary by the experimenter. The practice trials were followed by two sets of 48 test trials. The presentation of trials during the testing session was similar to that of the practice trials, except that no feedback was given during the test trials.

In the third session, the child was administered the Matrices subtest of the Kaufman Brief Intelligence Test (K-Bit). Special care was taken to assure that the children were attending to the test and were responding to the best of their ability.

Measuring Performance

Reaction time was the dependent variable considered in the discussion of the results of this study. Although reaction time tasks often provide interesting information about accuracy versus speed trade-offs, the minimal number of errors committed by the children participating in this study precludes an examination of this phenomenon. This low error rate was largely a consequent of two factors. First, a simple forced-choice task was designed for this study in order to ensure that even nonverbal subjects could easily understand what was required of them. Second, potential subjects were excluded from the study if they could not demonstrate a better-than-chance proficiency in performing the task during the preliminary practice trials.

It is common practice in studies examining reaction time scores to use median reaction times, especially when the subjects can be expected to display great variability in responding such as children with mental retardation. Accordingly, the median reaction time of each subject for each of the 12 experimental conditions and across the two testing sessions were considered in the analyses. The average reaction times presented here represent the means of these medians.

Results

The average reaction times (RT) by group for each of the twelve conditions is presented in Table 3.

A test of homogeneity of variance revealed that the median RT's of the children with Down syndrome were more variable than those of the children of normal intelligence, $F(18,18) = 3.15$, $p < 0.025$. Extreme outliers were removed

Table 3

Group Average Reaction Times by Condition

Condition	Down syndrome	Normal Intelligence
1. Baseline - No Distractors - No Boundary	886.95	895.05
2. Close Distractors - No Boundary	968.70	911.20
3. Far Distractors - No Boundary	963.15	918.40
4. Small Boundary - No Distractors	931.45	872.00
5. Small Boundary - Close Distractors	970.30	922.40
6. Small Boundary - Far Distractors	906.90	858.65
7. Medium Boundary -No Distractors	870.50	877.70
8. Medium Boundary - Close Distractors	944.950	894.70
9. Medium Boundary - Far Distractors	917.60	914.25
10. Large Boundary - No Distractors	883.90	922.85
11. Large Boundary - Close Distractors	959.55	927.45
12. Large Boundary - Far Distractors	881.90	879.85

to test whether the increased variability amongst the median reaction times of the children with Down syndrome was the result of their observed difficulty relative to the children of normal intelligence in continually sustaining attention to the task over a large number of trials. The outliers were interpreted to be evidence of the children's off-task behaviour and were therefore not directly relevant to the hypotheses of the present study. Far outside outliers were removed using Systat's BOX plot (Wilkinson, 1990). Reaction time scores falling far outside +/- 1.5*Hspread were deleted. Removal of the outliers, however, did not decrease error term variance in the group with Down syndrome and the assumption of homogeneity of variance between the groups remained violated. All further analyses were performed on the data with the outliers removed.

A further attempt at reducing the error term variance involved a log transformation of the median RT's to the base 30. Although the data transformation resulted in similar median RT distributions for both groups, it did not reduce the amount of variance in the error terms of the groups of children with Down syndrome. As a result of the violation of the homogeneity of variance assumption, no analyses were conducted using a single variance estimate from the pooled sums of squares of both groups.

Gender Analyses

Three-way (Distractor X Boundary X Gender) repeated measures analyses (ANOVA's) were performed on both groups. Neither a main effect of gender nor an interaction between gender and experimental conditions was found in these preliminary analyses. Gender was not considered in the remainder of the analyses.

General Analyses

Two-way (Distractor X Boundary) repeated measures ANOVA's were performed separately on both the median RT's of the children with Down syndrome and on those of the children of normal intelligence. A main effect for distractor was found for the children with Down syndrome but not for the children of normal intelligence, $F\ (2,18) = 4.72$, $p < 0.025$.

The possibility that the distractor main effect may have been the spurious result of the reaction times of the children with Down syndrome being slower than those of the children of normal intelligence was ruled out. The design of the study included a baseline condition (0 distractors and no boundary) to measure general level of arousal and to control for group differences in general reaction time. Children with Down syndrome were not found to differ from children of normal intelligence with regard to their average RT's on the baseline condition (refer to Table 3). These findings indicate that the performance of children with Down syndrome on this task of selective attention is more affected by the appearance extraneous stimuli in the visual field than is the performance of children of normal intelligence.

Post Hoc Comparisons

The average RT's of the children with Down syndrome on conditions with 0, close, and far distractors (collapsed across boundary conditions) are presented in Figure 3. Tukey post hoc comparisons ($p < .025$) performed on these RTs revealed that the children's reaction times were slower in conditions with near distractors than in conditions with 0 distractors, $q\ (18,3) = 4.29$, $p < 0.025$. There were no differences in RT's on far versus 0, and near versus far distractor conditions.

Discussion

The goal of the present study was to examine selective attention and distractibility within the visual modality in children with Down syndrome and in children of normal intelligence. Selective attention was operationalized as the children's abilities to identify and respond to a target stimulus. Distractibility was considered to be the extent to which the children's performances on the task were interfered with by extraneous stimuli in the visual field. Although deficits in selective attention and increased distractibility have both been implicated in the impaired academic and behavioral functioning of children with mental retardation (Crosby, 1972: Crosby & Blatt, 1968; Follini,

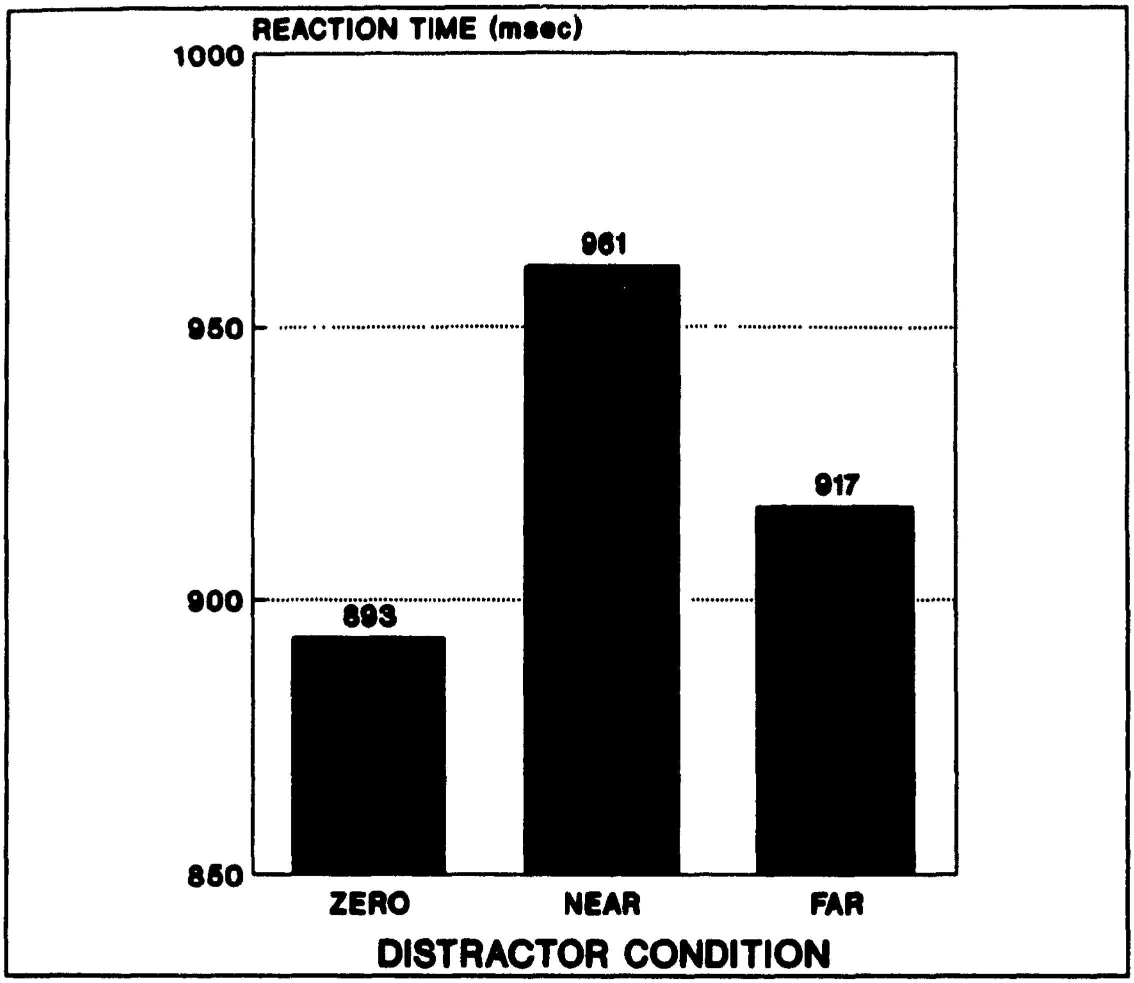

Figure 3. Average reaction times for children with Down syndrome on Distractor conditions collapsed across Boundary conditions.

Sitkowski, & Stayton, 1969; Krupski, 1979; Lunzer & Stratford, 1984), there has been minimal work done specifically with children with Down syndrome. The present study was designed to assess the effects of distractors and boundary cues on the performances of MA-matched children with Down syndrome and children of normal intelligence on a visual forced-choice reaction time task. Costs related to the presence and location of distractors and benefits associated with the presence and size of boundary cues were examined.

The primary finding of this study was that children with Down syndrome, but not children of normal intelligence, were adversely affected by the presence of distractors. A finding that a cost is associated to selective attention in the presence of distracting stimuli indicates that children with Down syndrome, as opposed to children of normal intelligence, suffer from selective attention deficits and increased distractibility. Another finding revealed that the selective attention of children with Down syndrome and of normal intelligence was not benefited by the presence of boundary cues surrounding the area to which the children needed to attend. Finally, no interaction effects between distractors and boundary cues were found. In the remainder of this discussion, these findings will be addressed within a developmental framework of selective attention.

General Effect of Distractors

The finding of a distractor effect for children with Down syndrome, but not for MA-matched children of normal intelligence, is concordant with earlier findings of concentration difficulties and increased distractibility in children with Down syndrome (Lunzer & Stratford, 1984; Miezejeski, 1974). This finding is also concordant with the developmental perspective that children with organic forms of mental retardation differ from nonhandicapped children with regard to intellectual structure (e.g. Weisz, Yeates, & Zigler, 1982; Zigler & Hodapp, 1986). Children with Down syndrome are not merely developing at a slower rate and reaching a lower asymptote than children of normal intelligence. Rather, children with Down syndrome differ from children of normal intelligence with regard to their functioning across a wide range of cognitive and information processing abilities (for a review see Hodapp & Zigler, 1990). Specifically, these results indicate that children with Down syndrome, as compared to those of normal intelligence, are more adversely affected by distractors on a task of selective attention.

The lack of a distractor effect in children of normal intelligence is in contradiction to the findings that the performances of young children of average intelligence are impaired by the presence of irrelevant information in their visual fields (e.g. Day, 1978; Gibson, 1969; Gibson & Yonas, 1966; Hagen & Hale, 1973; Pick & Frankel, 1973). The lack of a distractor effect in this study was most likely related to the appearance of a spot of light locational precue prior to target presentation. Valid precues, such as a spot of light indicating where the target stimulus is to appear, have been found to help children as young as five years to filter distracting stimuli and respond to target stimuli as efficiently as adults (Akhtar & Enns, 1989). The similar valid locational precue used in this study may have served to automatically *contract* the young children's attentional (zoom) lens to focus solely on the target stimuli preventing outside distracting stimuli from interfering with information processing.

The inability of children with Down syndrome to similarly benefit from the presence of a locational precue is of particular interest. As evidenced by the increased distractibility of the children with Down syndrome, their performance may be described as distractor-controlled in that their attention is drawn to distractors even in the presence of a visual precue indicating the location of the target stimulus (Burack, 1991). Whereas, a locational precue serves to automatically contract and keep contracted the attentional lens of children of normal intelligence, the spatial attention of children with Down syndrome is not effectively contracted and is, subsequently, more easily disengaged from the target information and drawn to extraneous information.

An appropriate analogy for the inefficient selective attention of children with Down syndrome is that of a defective attentional lens that "wanders" in visual space. The spatial region of attention of children with Down syndrome either does not sufficiently contract in the presence of a precue or, alternatively, is unable to remain contracted once the precue has been removed. Furthermore, it is expected that the attentional lens of children with Down syndrome is easily disengaged from the center of the screen and moves around in visual space alternately focusing on extraneous stimuli appearing there. The slower reaction times of children with Down syndrome on distractor conditions, therefore, is indicative of: (a) their inability to maintain a contracted attentional lens on targeted information; and, (b) the wandering of their lens in visual space resulting in the perceptual intake and processing of information outside the originally highlighted visual field. In contrast, on distractor-free conditions performance is not associated with a cost as there are no stimuli present for perceptual pick-up by the wandering lens.

The Effect of Distractor Proximity

Post hoc comparisons of the distractor main effect in children with Down syndrome revealed that reaction times were significantly slower only on conditions with distractors close in proximity to the target stimulus and not on conditions with far distractors. If children with Down syndrome are distractor-controlled due to a defective attentional lens that wanders in visual space, however, both close and far distractors would be expected to interfere with selective attention.

There are two possible explanations for this finding. In the first explanation, the finding that only near distractors adversely affect task performance of children with Down syndrome is likely related to a defective (but not wandering) attentional lens. The locational precue, although unable to effectively contract the attentional lens of children with Down syndrome to focus solely on the target information, is able to maintain their attention at the center of the screen. As the far distractors subtend a 2 degree visual angle (i.e. 4.57) of the precued target location, performance is only impaired by the close distractors (1.15 degrees) that are within the visual field (Eriksen & Hoffman, 1973). Thus, the far distractors were outside the children's visual fields and as a result remained unprocessed (for a graphic representation of the visual angles of target and distracting stimuli see Figure 4).

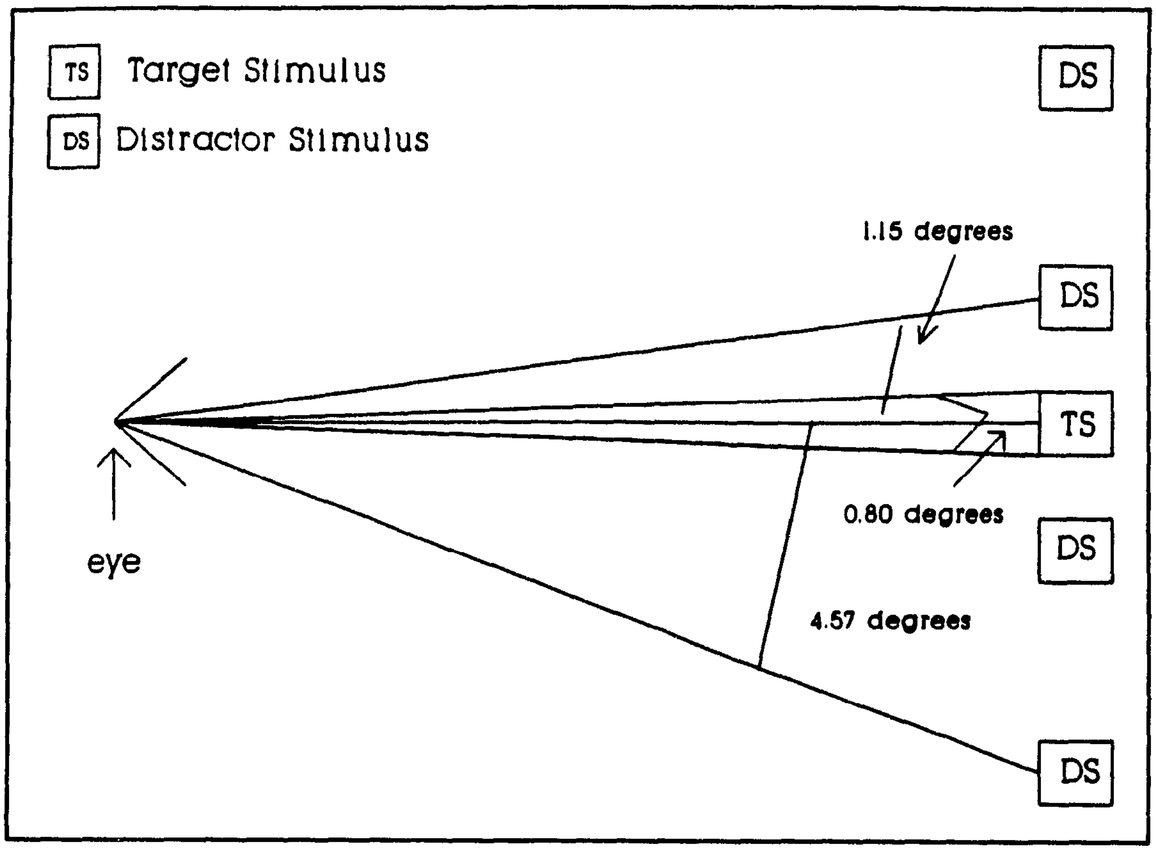

Figure 4. **Visual angles of near and far distractor conditions.**

The second explanation is concordant with the wandering lens analogy. Although the Distractor X Boundary interaction did not reach significance, there is some evidence that in the absence of boundary cues, close and far distractors tend to be equally as distracting for children with Down syndrome. Conversely, in the presence of boundary cues, far distractors do not appear to be as distracting as near distractors. As presented in Figure 5, the average reaction times of the children with Down syndrome on the far distractor/no boundary condition was similar to that on the near distractor/no boundary condition. The presence of boundary cues, in contrast, was related to reduced average reaction times on far but not near distractor conditions. This effect suggests that boundary cues may act as a visual "blinder" that keeps attention within a confined space and prevents distracting stimuli lying outside that space from being processed.

This second interpretation of the effect of distractor proximity on the performance of children with Down syndrome appears to contradict the earlier conclusion that the spatial attention of children with Down syndrome, as opposed to children of normal intelligence, is not benefited by a visual-spatial precue. Why would a boundary cue help children with Down syndrome to focus on target information and ignore irrelevant information, and a locational precue not benefit selective attention? The answer may be related

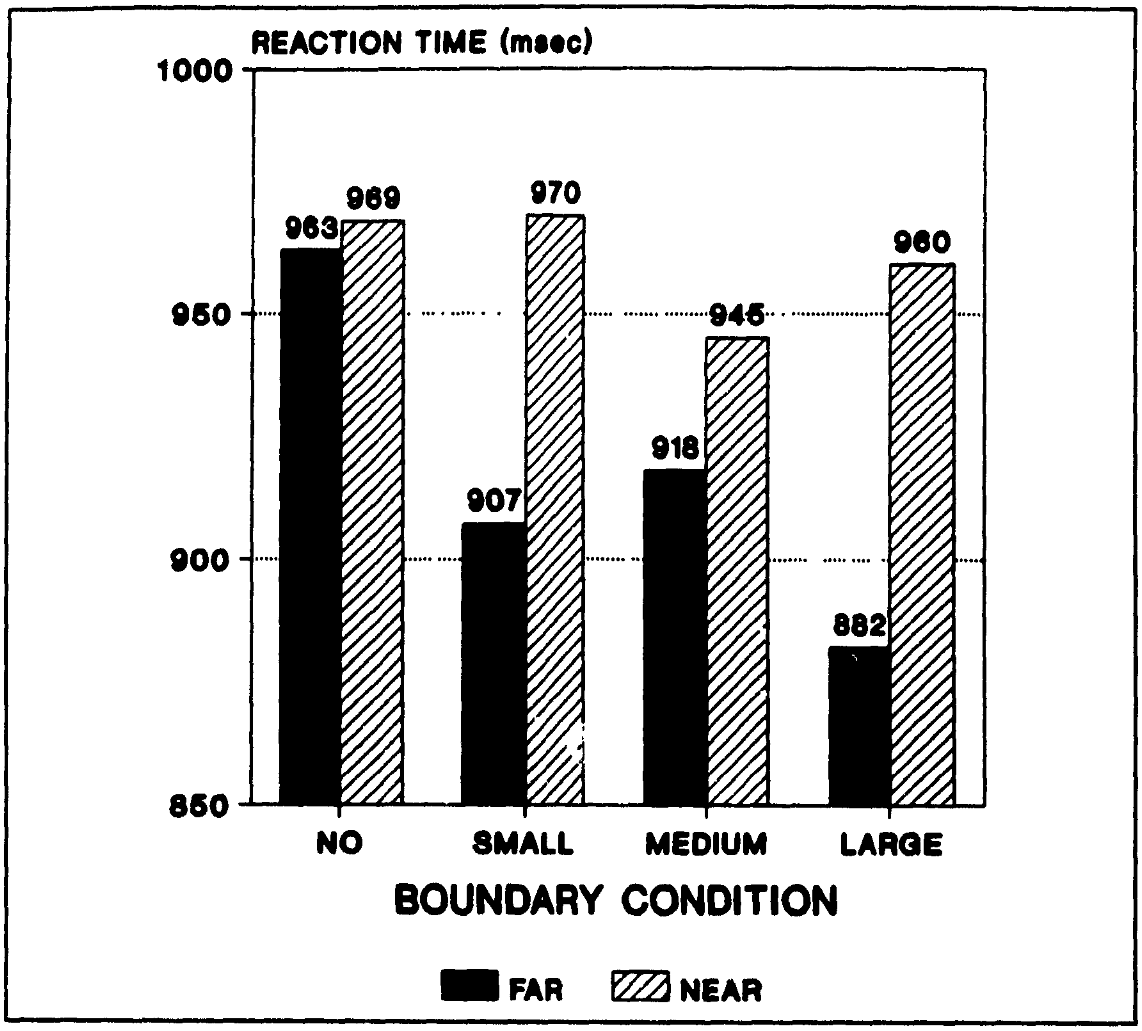

Figure 5. The effect of the absence and presence of boundary cues on the RTs of children with Down syndrome on near and far distractor conditions.

to factors such as the temporal display, nature, and size of these alternate visual-spatial cues. Although both types of cues were designed to serve the same purpose (focusing visual attention in space), the boundary cue appears on the screen simultaneously with the target and distracting stimuli, while the spot of light precue is displayed in advance of the presentation of these stimuli. The boundary cues are also larger in size and form a border around the stimuli making them conducive to acting as a physical barrier confining spatial attention to the area within, while the spot of light precue acts to contract attention to a much smaller spatial region.

General Effect of Boundary Cues

The lack of enhancement in reaction times associated with boundary cues is not concordant with findings in a similar study by Burack (1991). The discrepant finding reported here may be related to a number of factors. One, the boundary cue used here was qualitatively different from the one used by Burack. The screen area falling outside Burack's boundary cue was shaded, whereas, both the areas inside and outside the boundary cues in the present study were the color of the screen. Two, the present study's use of both a locational precue and a boundary cue may have resulted in decreasing the benefits of the boundary cues. As demonstrated by Akhtar and Enns (1989), the use of a spot of light precue indicating the location at which the target stimulus will appear was effective in focusing attention in visual space (i.e. helped young children to process information as efficiently as adults).

Conclusions

The results of the present study depict children with Down syndrome as more adversely affected by the presence of distracting information in visual space than children of normal intelligence. This finding can be viewed within the framework of a defective attentional lens that wanders in visual space. The visual-spatial attention of children with Down syndrome is characterized by: (a) an inability to sufficiently contract even in the presence of facilitating precues or, alternatively, an inability to remain contracted once the precue has been removed; and, (b) spontaneous movement or wandering throughout visual space. Together the ineffective contraction and wandering of the attentional lens are hypothesized to be associated with a filtering cost. A defective lens that wanders in visual space results in visual attention being easily disengaged from the target information and drawn to irrelevant information outside the originally highlighted visual field.

Although the effect of boundary cues on selective attention was not statistically significant, there was some evidence that children with Down syndrome were benefited by boundary cues when distracting stimuli lay outside the cues. This suggests that a border line surrounding an area to be attended helps to confine attention within that area and prevent the processing of information falling outside.

The results of the present study represent preliminary findings of the effects of distractors and visual-spatial cues on selective attention in children with Down syndrome and children of normal intelligence. Future research is required to replicate and expand on the findings presented here. Future studies should involve examining the effects of distractors and cues across a variety of age groups and in groups of children with mental retardation of varying etiologies (i.e. familial retardation, Down syndrome, and other organic etiologies such as phenylketonuria and anoxia) and in children of normal intelligence matched for mental age. Modifications of the present experimental design should include a more systematic examination of the abilities of locational precues as opposed to boundary cues to focus attention in visual space and the effect of visual angle on selective attention. Another important modification would involve increasing the number of subjects per group.

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