AN INVESTIGATION OF VISUAL SEARCH STRATEGIES USED BY INDIVIDUALS WITH AND WITHOUT MILD MENTAL RETARDATION

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AN INVESTIGATION OF VISUAL SEARCH STRATEGIES USED BY INDIVIDUALS WITH AND WITHOUT MILD MENTAL RETARDATION

A Thesis

Presented for the

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Degree

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Begum Yasmin Sarwar

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DEDICATION

This thesis is dedicated to

my husband, Abu K. Sarwar,

and to my children,

Ronnie M. Sarwar and Michelle J. Sarwar,

for their constant love, support and patience.

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I would like to express sincere appreciation to Dr. Charles B. Woods, Chairman of my committee, for his assistance, direction, guidance, and encouragement throughout the study. I would also like to thank the other committee members, Dr. Jean G. Lewis and Dr. Nancy Woods, for their comments and assistance over the past two years. Sincere thanks to Dr. Charles Grah for his assistance in the statistical analysis of this study. My appreciation is extended to Dr. Stephen Oross,III, for including me in his grant. The clients of Progressive Direction who participated in this study are greatly appreciated for their valuable time in making this study a reality. Special thanks to my fellow classmates, Kevin DeFord, Janna Hendrix, Sue Ling Moey and Cindy Anderson for their help. I would like to thank Ms. Mary Williams and Ms. Ritze Forren for their sincere help and support.

ABSTRACT

One of the many functions a visual system must perform is to quickly and accurately locate objects in our visual surroundings. This ability may be measured with visual search tasks which require observers to identify a target randomly placed among distractor items. Two experiments were conducted to investigate the visual search strategies used by individuals with and without mental retardation.

In Experiment 1, participants were required to search for an "O" randomly placed among "Q"'s in one task and to search for a "Q" randomly placed among "O"'s in another task. In both tasks, the dependent measure was the minimum length of time the stimulus must be presented to successfully complete a visual search. Both groups showed evidence of serial and parallel processing. For both tasks, mildly mentally retarded (MMR) participants required significantly longer times to identify the target and showed evidence of subgroups.

In Experiment 2, target saliency was manipulated. In one task participants were required to search for a "C" (with varying size gaps) randomly placed among O's, or vice versa. As in Experiment 1, the MMR group were found to have significantly higher thresholds in both tasks. Both groups showed an effect of target saliency on the serial search task. Target salience affected the performance of MMR group on the parallel task also. Performance of MMR participants on both experiments suggests visual search may be constrained by a limited processing capacity in this group.

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CHAPTER 1

INTRODUCTION

Approximately 3% of the population in this country are diagnosed with mental retardation (Scheerenberger, 1987). Very few studies had been focused to investigate the limitations and abilities of this group. Recent studies suggest that individuals with mental retardation are deficient in their abilities to perform low level sensory tasks (e.g., detection of motion). However, only a limited number of studies have investigated the higher level sensory functioning of this group (Spitz & Blackman, 1959; Spitz, 1967; Spitz & Borland, 1971; Carlin, Soraci, Goldman & McIlvane, in press). Thus, in order to have a more complete understanding of sensory and perceptual function in this group, there is the need to investigate and identify the abilities and limitations that may exist in the higher level tasks. The primary goal of this study was to investigate the ability of individuals with mild mental retardation to perform a task that requires higher level perceptual processing. The visual search task was selected to measure this ability. Previous study findings (Treisman & Gormican, 1988; Wang, Cavanagh & Green, 1994) have shown that visual search tasks require higher level functioning.

Mental Retardation

The American Association on Mental Retardation and the World Health Organization define mental retardation (MR) according to the following criteria: Individuals who have an I.Q. at least 2 standard deviations below the mean, who show deficits in adaptive functions as compared to their peer groups, and for whom these attributes exist prior to the age of 18 (Grossman, 1973). However, there have also been several other criteria used to define mental retardation.

A recent definition focuses mainly on the needs of individuals with mental retardation (Luckasson & Spitalnik, 1994). Depending upon the individuals' ability to perform adequately in the community, they are classified as profound, severe, moderate, or mild in category. According to this need-based classification, the mildly mentally retarded (MMR) group comprises the vast majority of the mentally retarded population. Approximately 80 percent of all mentally retarded individuals with unknown etiology are classified MMR (Chinn, Drew & Logan, 1975). They have an I.Q. ranging from 55 to 75, and these individuals can perform some simple tasks without assistance. The absence of specific identifying criteria and the lack of research study findings make it difficult for this group to be identified at an early age. Individuals with mental retardation are not usually diagnosed before they are ready to enter school (Berkson, 1993).

Several risk factors have been identified as associated with mental retardation (Coulter, 1992; Dupont, 1989; Shepard, 1989). They include low birth weight, mechanical injury at birth, malnutrition, poverty, prenatal exposure to toxins and low socioeconomic status. The importance of early detection is necessary for proper intervention, especially at an early age when most developmental processes take place (Zigler, & Trickett, 1978). If these groups can be identified early, they can be given an opportunity to learn compensatory skills.

Anatomical and Physiological Correlates of MR

Neurophysiological findings suggest that gross brain pathology is present in only a small proportion of individuals with mental retardation (Purpura, 1982). These findings vary as to the type of lesion and the areas involved and have relied on autopsy, brain imaging, and visual-evoked responses to identify the affected areas. Most of the findings are present only in the profoundly and severely retarded. In a study by Purpura (1974), individuals with severe mental retardation were discovered to have abnormal neural structures, such as abnormally thin spines and the absence of thick dendritic spines in cortical neurones. In the case of MR of unknown etiology, Huttenlocher (1991) specifically identified two types of abnormalities in cerebral cortex: the dysgenesis of dendritic spines on cortical pyramidal neurons, and the impaired growth of dendritic trees of pyramidal neurons. However, the percentage of individuals with mental retardation who show this specific pattern of neurological abnormality is not yet known.

Visual Perceptual Abilities of MR Individuals

Very few studies have focused on the visual perceptual abilities of individuals with mental retardation. This is unfortunate, because studies of visual and other sensory function can offer information regarding brain organization and can help characterize the deficiency. During the period of the

1950's through the 1970's, some research studies (Prysiazniuk & Kelm, 1963; Spitz, 1967; Spitz & Blackman, 1959; Spitz & Borland, 1971; Webb, 1972; Winters, 1969; Das, 1971) focused on the different visual abilities of mentally retarded individuals. Recent studies by Davis (1986) and Wade (1990) suggested that individuals with mental retardation exhibit deficiencies that are not global, but local, in nature; that is, they may affect only a subset of perceptual processes. Also, Fox and Oross (1988; 1992; 1990) have demonstrated that individuals with MR had difficulty with depth and motion perception, but had no difficulty with form and color discrimination.

Only recently have studies investigated this local versus global issue. To further investigate this issue, and to measure higher level perceptual processing, this study investigated visual search tasks which required this processing.

Visual Search

Recent studies (Luschow & Nothdurft, 1992; Nothdurft 1993; Treisman & Gormican, 1988; Treisman & Souther, 1985; Wolfe, Cave & Franzel, 1989) suggested that the visual system utilizes two types of processing strategies--either "parallel" or "serial" search--when performing a search of a visual scene.

Parallel Searches. Treisman and Souther (1985) suggested that when several items are presented simultaneously, the visual search for and detection of a particular target item depends upon the type and quantity of distractors present. When the target possesses certain distinctive characteristics in comparison with the distractor items, it may be processed quickly. This rapid category of visual search has been referred to as "pop-out," because many items can be searched for simultaneously or in parallel (Braun, 1994; Luschow & Nothdurftt, 1993; Treisman & Souther, 1985; Wolfe, 1992). For example, consider you have gone to a crowded airport to meet a friend. One of the easiest ways to locate your friend would be to waive your hands. This hand movement would pop-out and would draw attention quickly. A defining feature of parallel processing is that the search time does not depend upon the number of distractors (Julesz, 1984; Treisman, 1988). For example, the number of people in the crowd at the airport would not have any affect on how quickly you would get your friend's attention. Several stimulus features that may be processed in parallel are color, orientation, motion, and familiarity.

Serial Searches. Distinctive features of the target, relative to the distractors, contribute to the "saliency" of the target. Target saliency may be defined by the presence of pronounced or distinctive feature. When the target is less distinctive with respect to the distractors, pop-out may not occur. Search times may be longer, and the search rate can increase steeply along with the number of distractors. This strategy is known as serial processing, because each item has to be processed sequentially, where visual attention scans the stimuli, item by item, until the target is found (Braun, 1994; Wang, Cavanagh & Green 1994). The different stimulus characteristics that may be associated with salient targets are currently being investigated.

Previous Work

Recent studies have extensively examined serial and parallel processing. Findings from several studies show that a distinctive feature of a target can be processed in parallel search (Treisman & Gelade, 1980). A study by Treisman and Souther (1985), supported this notion by proposing the Feature Integration theory. In a visual search task, when the target has a unique distinctive feature, such as when searching for a "Q" randomly placed among "O"'s, the specific feature of the Q makes it unique and allows a parallel search. However, when searching for an "O" among "Q"'s, multiple focused searches are necessary to identify the target. The reason behind is that it is hard to search for absence of feature.

Research indicates that search strategies may also be influenced by what is called Guided Search. A study by Wolfe, Cave and Frenzel (1989) suggests that a guided search may reduce the time needed to identify a target by guiding the attention to the particular item or items in a visual search task.

Target familiarity also can determine whether a target is searched for in parallel or serial. When searching for an unfamiliar target among familiar distractors, it is processed in parallel. When searching among unfamiliar distractors, it is processed serially. Jonides and Gleitman (1972) proposed that this is due to a category effect. When subjects were told that they were searching for the digit "0" among several letter distractors, it took more time than when they were told to search for the same target identified as the letter "O."

Proposed Study

The main purpose of this study was to investigate whether both nonmentally retarded (N) and mildly mentally retarded (MMR) individuals showed similar search strategies (parallel and serial processing) in visual search tasks. If the results indicate that individuals with mild mental retardation and without mental retardation used different search strategies, this might imply a fundamental difference in higher level visual perceptual function between the two groups.

To investigate whether individuals with mild mental retardation used the same visual search strategies as individuals without mental retardation, two experiments were performed. In both experiments visual search performance was quantified by measuring the duration that a stimulus array must be presented in order to allow a target to be detected.

In the first experiment, two types of search tasks were introduced (see Figure 1 for a representation of the stimuli used). The main objective of this experiment was to determine whether individuals with mild mental retardation showed evidence of a parallel or pre-attentive search when the target stimulus had distinctive features in comparison to the distractors, and whether they showed evidence of a serial search strategy when the target did not have distinctive features.

Experiment 2 was conducted to measure and describe the effect of stimulus saliency. The objective of the second experiment was to describe how the visual search strategies of the mildly mentally retarded individuals may be affected by manipulating the saliency of the targets. Previous research has shown that when a target is made less distinctive in comparison to the distractors, search times are affected (Braun, 1994). In Experiment 2, target saliency was manipulated by using a "C" target where the size of the gap in the C could be varied from 45 degrees to 180 degrees (see Figure 2 for a representation of the stimuli used in Experiment 2).

CHAPTER 2

METHODS

Two experiments were conducted: In Experiment 1, the use of parallel and serial visual search strategies were investigated and in Experiment 2, the effects of target saliency were investigated. The stimuli used in both studies were similar to those developed by Treisman and her colleagues to demonstrate serial and parallel search strategies. The history of individuals with mental retardation suggests that they have a deficit in motor and other sensorimotor functions, thus making a reaction time procedure inappropriate. For this reason, an adaptive psychophysical procedure, which was used by Zacks and Zacks (1993) to test an elderly population, was used to measure the threshold stimulus durations required to search for target stimuli.

Experiment 1

In Experiment 1, two tasks required participants to search for an O randomly placed among distractor Q's (Task 1) and to search for a Q randomly placed among O's (Task 2). These tasks were used to investigate the extent to which individuals with mildly mentally retarded (MMR) and without mentally retarded (N) had similar visual search strategies.

Participants. Ten adults (M age = 33 years) with MMR and 12 N adults (M age = 26 years) participated. The MMR adult participants were recruited from a local sheltered workshop and had been diagnosed with mental retardation of unknown etiology. Their I.Q. scores ranged from 56 to 67, as tested with the Wechsler scale (M I.Q.= 61.4). They were paid volunteers and were reimbursed with $3/session for their time. The N participants were recruited from undergraduate psychology classes at Austin Peay State University. They received extra credit points for their participation. To screen for gross visual impairment, all participants were tested on the Snellen Illiterate "E" acuity (N M = 20/20; MMR M = 20/34) and Pelli- Robson contrast sensitivity (N M = 1.70; MMR M = 1.48). All participants performed adequately on these tests. One MMR participant was diagnosed with legal blindness in the left eye. Informed consent was obtained from each participant.

Apparatus. The stimuli were presented using a Toshiba 486-33 Lap-top computer attached to a VGA monitor. The brightness of the white background of the computer monitor was 95 candela per square meter (95 cd/m^2). The computer recorded and stored all data. The testing of MMR participants took place in an available room at the sheltered workshop, whereas testing of N participants took place in a laboratory on campus.

Stimuli. The visual stimuli consisted of two arrays of letters, presented sequentially, with a brief stimulus onset asynchrony (SOA). Both arrays contained 3-20 dark letters on a white background. One of the two arrays, chosen randomly, contained a single target among a variable number of distractors. In Task 1, the target was an O presented in a random position among Q's; in Task 2, a Q target was presented in a random position among O's. Immediately following each presentation, a visual mask consisting of vertical and horizontal lines plus Q's (checker board pattern) was presented for 500 msec to prevent after images. In each task, three array sizes consisting of 3, 12, and 20 elements were used. The order of presentation was counterbalanced across subjects.

Procedure. All testing took place individually, with the participants seated approximately one meter from the visual display. Each participant was introduced to the stimuli and to the tasks. All participants were tested under all experimental conditions (2 task x 3 array sizes).

Both the MMR and N individuals received specific written instructions regarding the tasks, as shown in Appendices A and B. For both the MMR and the N groups, the examiner read the instructions. To further clarify the tasks, they were shown pictures of the stimuli array as shown in Figures 1 and 2. Each participant received several practice trials, and upon reaching criterion performance (seven out of eight correct responses; $p < .05$ binomial probability), was allowed to participate in the experiment. Two MMR participants were unable to meet the criterion performance and were excluded from the experiment.

The dependent measure was the minimum length of time the stimuli must be presented to successfully complete a visual search. Each participant's ability to successfully perform a visual search was measured using a standard variation of a psychophysical staircase procedure (Levitt, 1971). The two-up-and-one-down rule was employed to select the duration of the stimulus array on the next trial. If the subject responded correctly on two successive trials, the duration of the next display was reduced. However, if the subject was wrong once, the display duration increased for the next stimuli. This rule provided the duration which the subject would perform at a fixed level of accuracy (71%).

For selecting the next stimulus durations in the staircase, the basic step size was a 10 percent change in the display duration, but a triple-sized step was used until the staircase reached the first reversal. In the next reversal, a double-sized step was used. Following the third reversal, the staircase was followed by a single-size step until it reached the seventh reversal. The average time required to identify the target in the last six reversals in a staircase provided the estimated threshold duration.

The duration of the stimulus the participants saw on trial 1 was always set to be well above threshold (that is, quite easy to get correct). The experimenter pressed the space bar to present each stimulus. On half of the trials, the array contained a target; on the other half it contained only distractors. Following the presentation of an array, each subject was required to respond verbally. If a participant believed that the target was present in the array, then he/she responded verbally by saying, "Yes." If the participant believed that the target was absent, then the response was, "No." Each participant received auditory feedback from the computer regarding the correctness of his/her response.

Experiment 2

In experiment 2, the effect of target saliency was investigated.

Participants. Nine adults with MMR and 12 N adults participated in Experiment 2. The IQ's, ages and all other aspects were similar to those of Experiment 1.

Apparatus. The same apparatus used in Experiment 1 was used in Experiment 2.

Stimuli. The visual stimuli consisted of circles and semicircles, such as O's and C's. Three different gap sizes, the portion of the C that was open, were used (45, 90, and 180 degrees). In Task 1, the O was the target randomly placed among distractor C's; in Task 2, the C was the target randomly placed among distractor O's. In each condition, three different array sizes of 3, 12, and 20 elements were used. The order of presentation was counterbalanced across participants.

Procedure. The procedures used in Experiment 2 were identical to those used in Experiment 1.

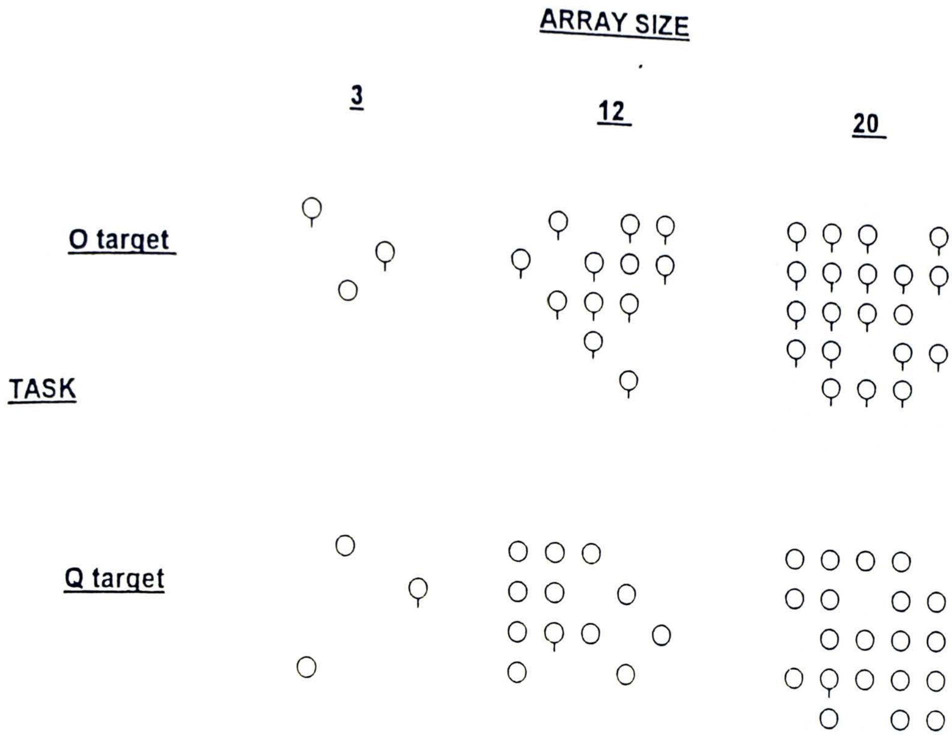


Figure 1. Example of stimuli for Experiment 1.

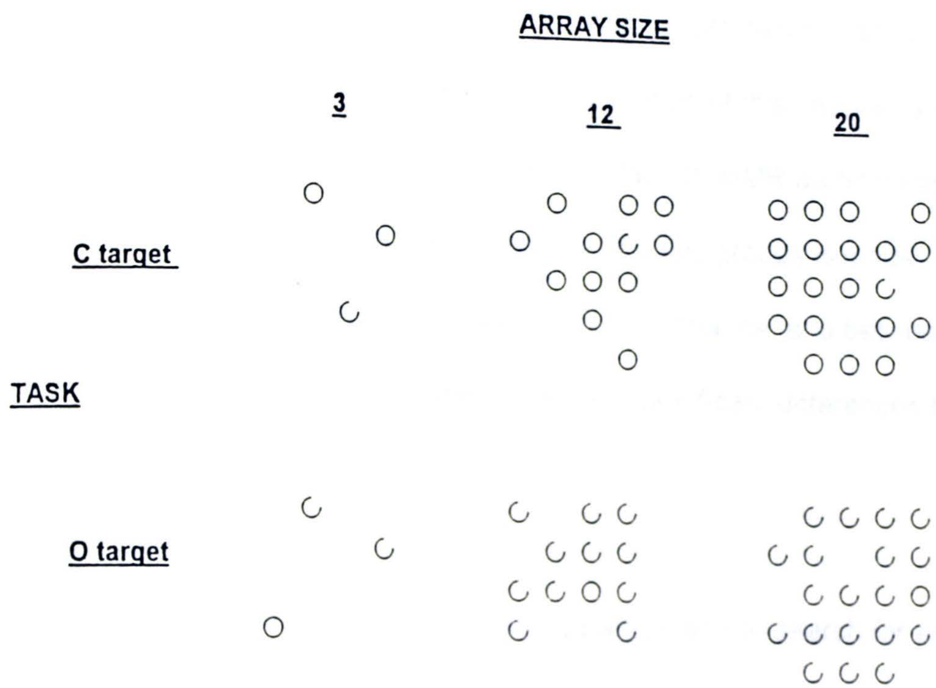


Figure 2. Example of stimuli for Experiment 2.

CHAPTER 3

RESULTS

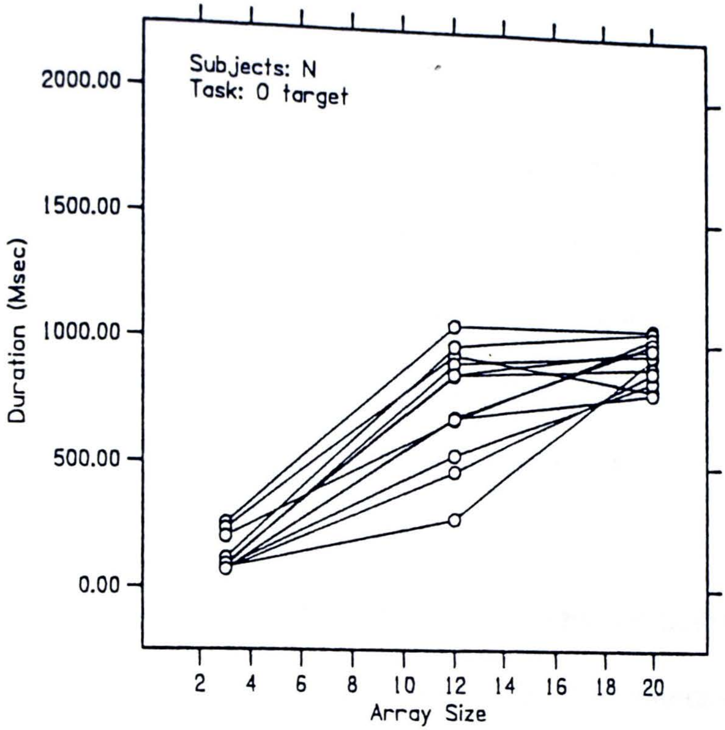
In this chapter the results obtained from Experiments 1 and 2 are presented. For both experiments, the organization of this chapter is as follows: the data on N participants is presented, the data on MMR participants is presented, and then a comparison between the two groups is made. Figures are used to present individual and group mean performance, and between and within ANOVA's are used to show statistically significant differences between experimental conditions.

Experiment 1.

In Experiment 1, one task required participants to search for an O among Q's, and another task required the searching for a Q among O's. The results for Experiment 1 are shown in Figures 3-5. These figures show the threshold duration required to search the array and identify the target (Y- axis) for the three different array sizes (X- axis).

N Participants

Figure 3 presents the individual data for N participants (n=12) on both tasks. The top panel shows the data for N participants when searching for an O among Q's. The bottom panel presents the data when searching for a Q among O's. A different pattern of results can be seen between the top and bottom panel. An ANOVA confirmed that there was a significant effect of task, $F(1,11) =$



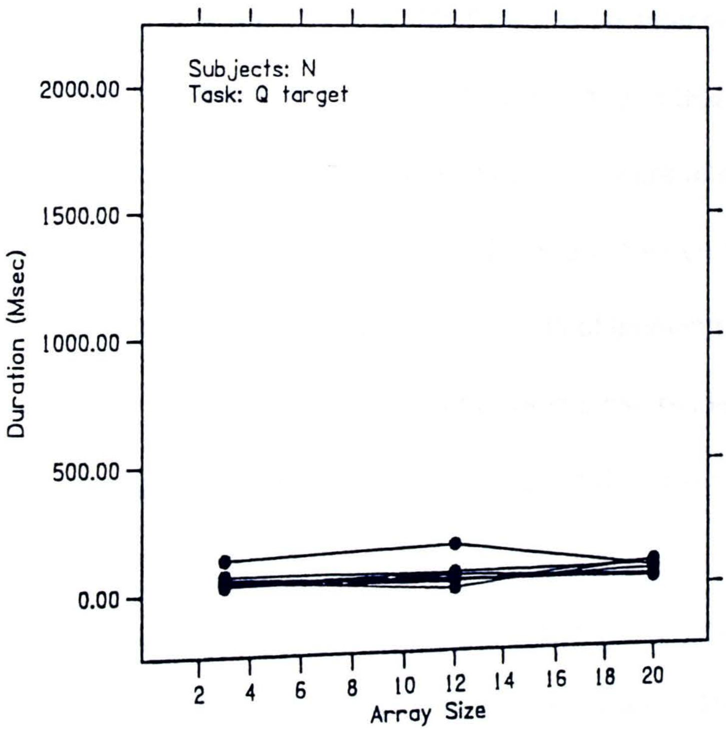


Figure 3. Threshold search times for N participants in Experiment 1. Top panel: Data for N participants when searching for an O among Q's. Bottom panel: Data for N participants when searching for a Q among O's.

341, $p<.05$. When searching for an O among Q distractors (top panel), the duration thresholds were affected by the number of elements in the array. Searching for an O target among Q distractors resulted in longer threshold durations as the numbers of distractors was increased. When searching for a Q among O's (bottom panel), search times were not affected by the number of distractors in the array. These results were significant: Array $F(2, 22) = 131$, $p<.05$ and task * array interaction, $F(2, 22) = 126$, $p<.05$.

MMR Participants

Figure 4 presents the data for MMR participants on both tasks. The top panel shows the data for MR participants (n = 10) when searching for an O among Q's. The bottom panel presents their data when searching for a Q among O's. A significant effect of task was found: $F(1, 9) = 364$, $p<.05$. When searching for an O among Q's, the duration thresholds were affected by the number of elements in the array, $F(2,18) = 502$, $p<.05$. Searching for an O target among Q distractors with increasing numbers of elements resulted in longer threshold durations; just as for N participants these results were statistically significant: Array $F(2,18) = 502$, $p<.05$; task * array: $F(2,18) = 199$, $p<.05$.

Searching for a Q among O distractors (bottom panel) resulted in search times that were not affected by array size for six participants. However, four participants' performance were affected by the array size: They required more

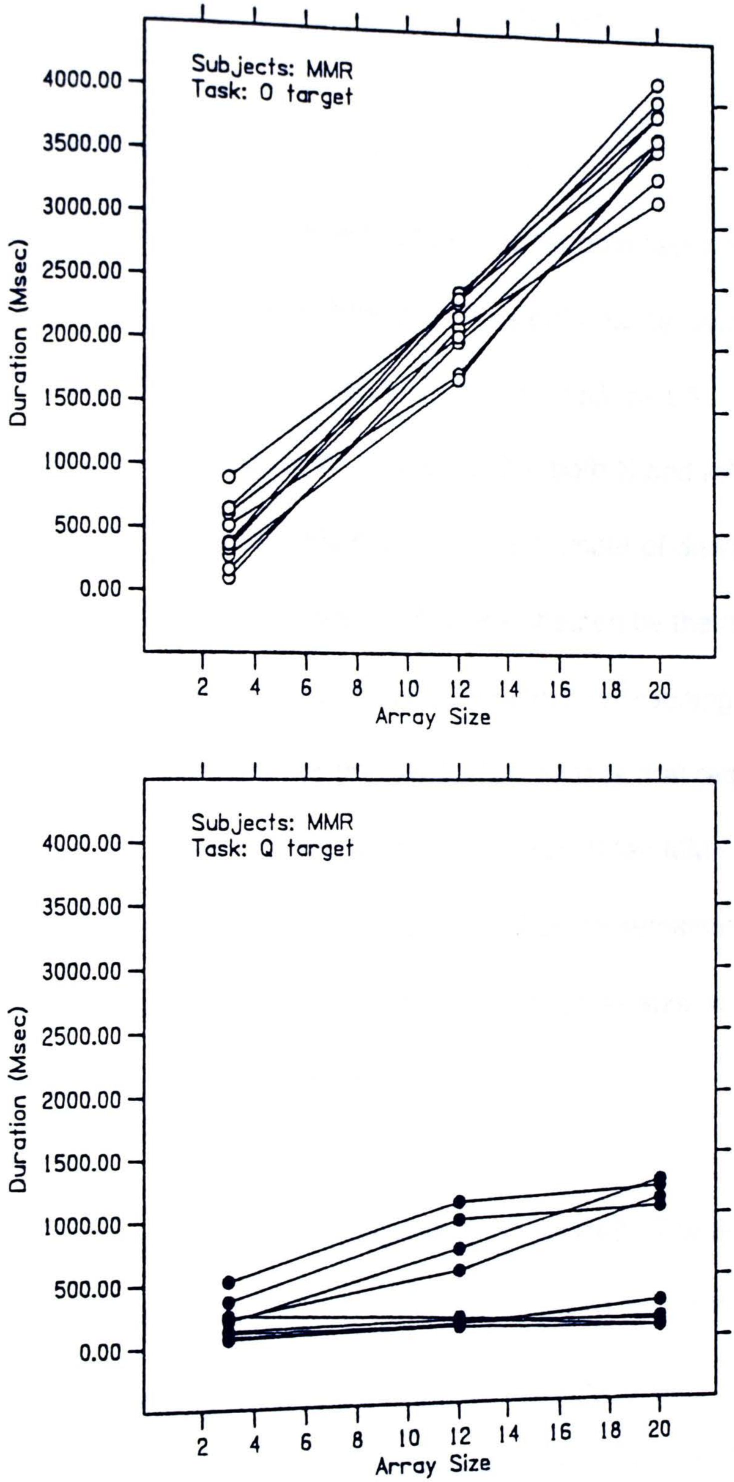


Figure 4. Threshold search times for MMR participants in Experiment 1. Top panel: Data for MMR participants when searching for an O among Q's. Bottom panel: Data for MMR participants when searching for a Q among O's.

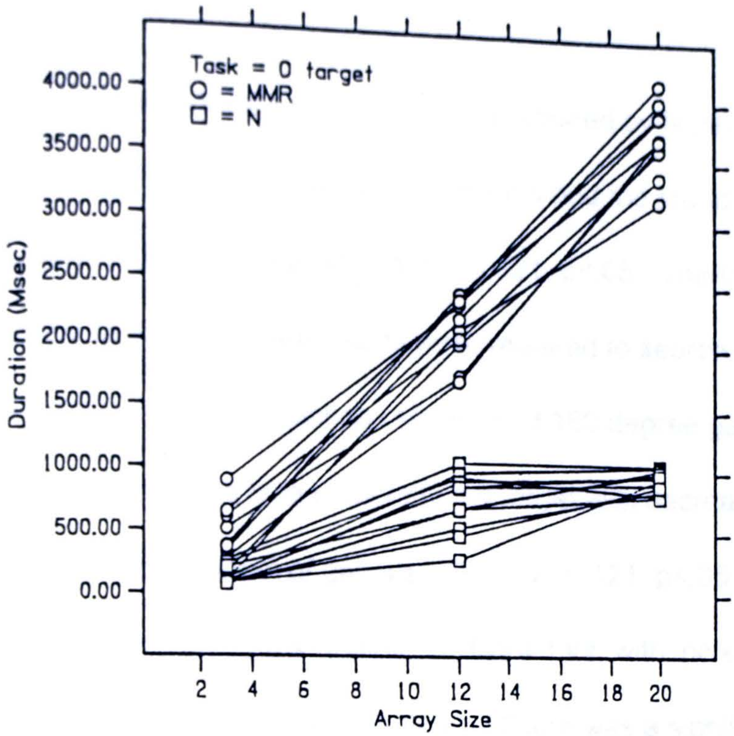
time to identify the target as the number of distractors in the array was increased.

Comparison of N and MMR Group Performance

Figure 5 plots both the N and MMR data for both tasks on the same figure. The two groups clearly show different performance, and an ANOVA confirmed a significant effect of group, $F(1, 20) = 153$, $p<.05$. The top panel shows that when searching for an O among Q's, both N and MMR participants' thresholds became progressively higher as the number of distractors in the array was increased. The duration thresholds were affected by the number of elements, with an increase in the number of elements resulting in longer search times. The bottom panel shows the results for the task that required searching for a Q among O's. For N participants and six out of ten MMR participants, the search times were independent of array size. For the remaining four MMR participants, the search times were influenced by array size, with increasing array size resulting in longer search times

Experiment 2

In Experiment 2, two new tasks were introduced. These tasks allowed target salience to be manipulated. One task involved searching for an O among C's, and another task involved searching for a C among O's. In both tasks the C target/distractor elements had open segments of 45, 90, or 180 degrees. The results for Experiment 2 are shown in Figures 6-11.



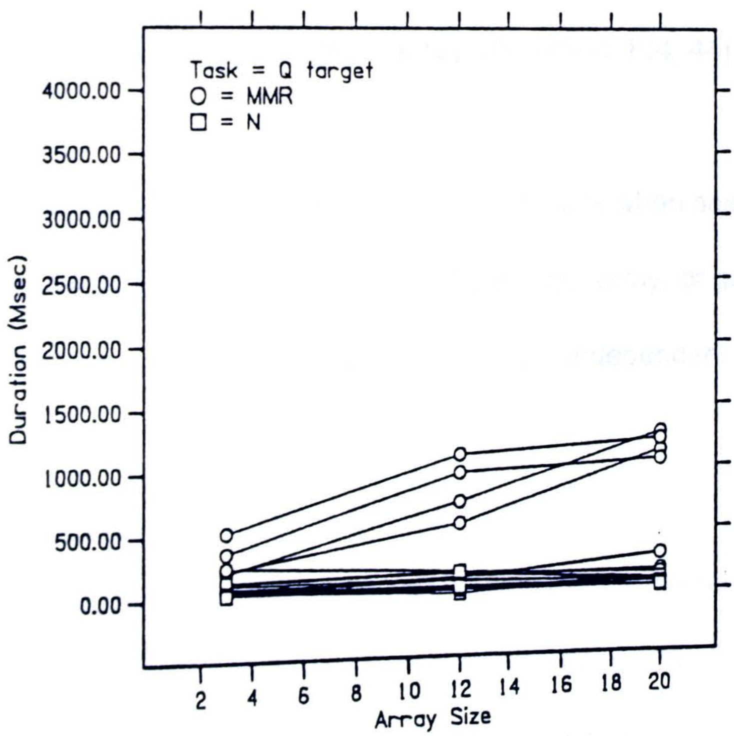


Figure 5. Comparison between N and MMR performance in Experiment 1. Top panel: Search times for N and MMR participants when searching for an O among Q's. Bottom panel: Search times for N and MR participants when searching for a Q among O's.

N Participants

Figure 6 presents the stimulus duration required by N participants for the two different search tasks. Shown are the means and the standard error bars.A significant effect of task was found: $F(1,11) = 121$, $p<.05$. The top panel shows the data for the task where participants were required to search for an O among C's, where the C's varied in salience (45, 90, and 180 degree gap). N participants required more time to identify the target with decreasing gap size. There was a significant effect of gap size, $F(2, 22) = 121$, $p<.05$. The duration thresholds were affected by the number of distractors, with increasing numbers of elements resulting in longer search times. There was a significant effect of array, $F(2, 22) = 64$, $p<.05$ and gap * array interaction, $F(4, 44) = 503$, $p<.05$.

The bottom panel of Figure 6 shows the results when searching for a C among O's. ANOVA's revealed no effect of gap size, array, or gap * array interaction. Threshold durations on this task were independent of gap and array size.

MMR Participants

Figure 7 presents the data for MR participants for the two different tasks. There was a significant effect of task, $F(1, 8) = 16.04$, $p<.05$. The top panel shows the data when searching for an O among C's with varying gap and array size. MMR participants required more time to identify the target with decreasing gap size. There was a significant effect of gap size, $F(2,16) = 14.50$, $p<.05$. The duration thresholds were affected by the number of elements, with increases in the number of elements resulting in longer search times. There was a significant effect of array, $F(2,16) = 6.86$, $p<.05$.

The bottom panel of Figure 7 shows results when searching for a C among O's. No effect of gap size was observed. Threshold duration was independent of gap size. However, a significant effect of array was observed, $F(2,16) = 4.83$, $p<.05$, with increasing array size resulting in longer time to identify the target.

Comparison of N and MMR Group Performance

A comparison between N and MMR participants' performance can be made in Figures 8-9. Figure 8 shows both N and MMR group performance when searching for an O target among C distractors with gap sizes of 45, 90, and 180 degrees (top, center, and bottom panels respectively). When the gap sizes were 45 and 90 degrees, search times for both N and MMR participants increased with increase in array size. This was not true when the gap size was 180 degrees.

Figure 9 shows both N and MMR group performance when searching for a C target among O distractors. When searching for a C with either 45, 90, or 180 degree gap size, N participants' search time was independent of the array size. For MMR participants, they showed quantatively similar results when the target had a 180 degree gap. No increase in threshold was observed with increase in array size. However, when searching for a target with 45, and 90 degree gap size, search time increased with increases in array size.

Because MMR performance in Experiment 1 showed clear evidence of sub-groups, the individual MMR data are plotted in Figures 10 and 11. Individual MMR performance does not show clear evidence of presence of sub-groups. Their performance showed evidence of individual variability. However, it is true that the MMR participants who performed poorly in Experiment 1, also did so in Experiment 2.

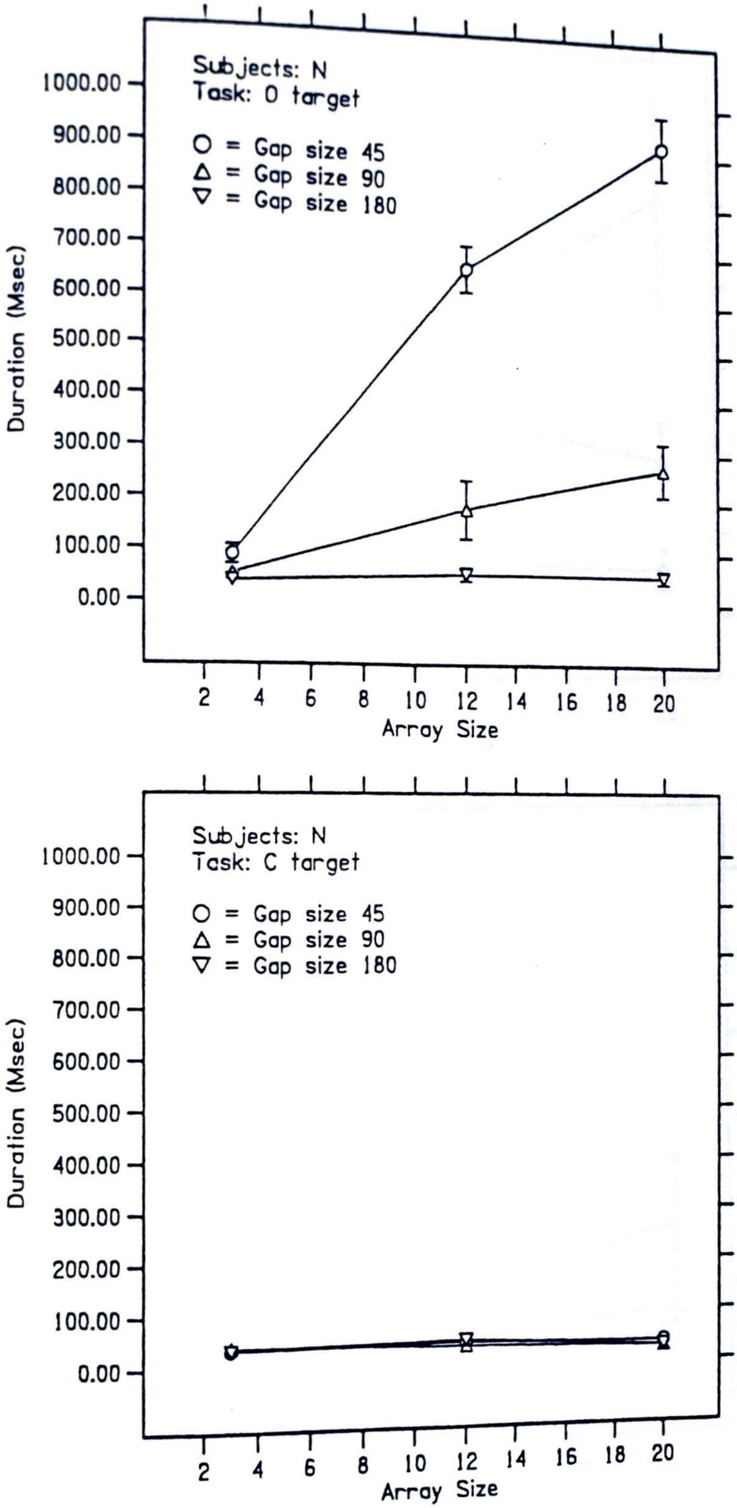
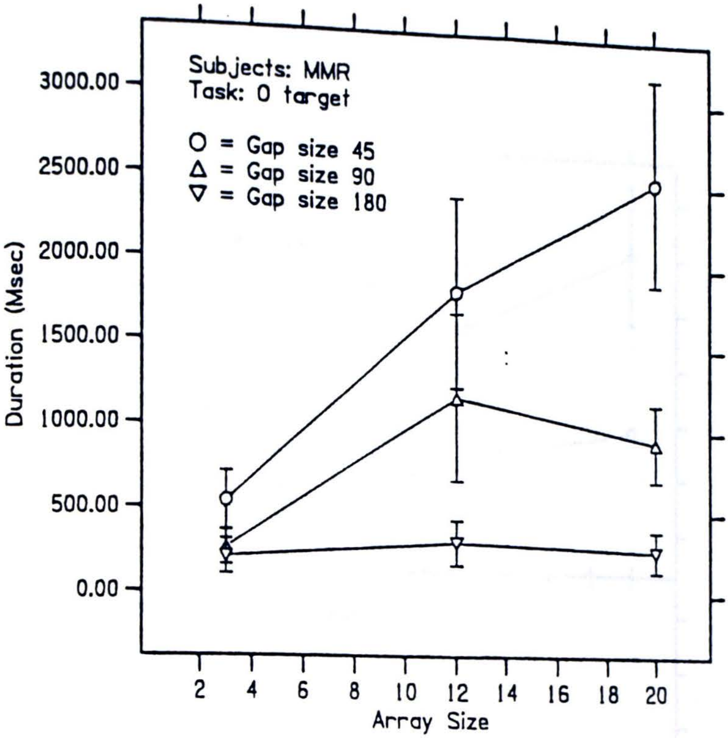


Figure 6. Means and standard errors of the threshold search times for N participants in Experiment 2. Top panel: Search times for an O target among C distractors with gap sizes, 45; 90; and 180 degree. Bottom panel: Search times for C target with 45; 90; and 180 degree gap sizes among O distractors.



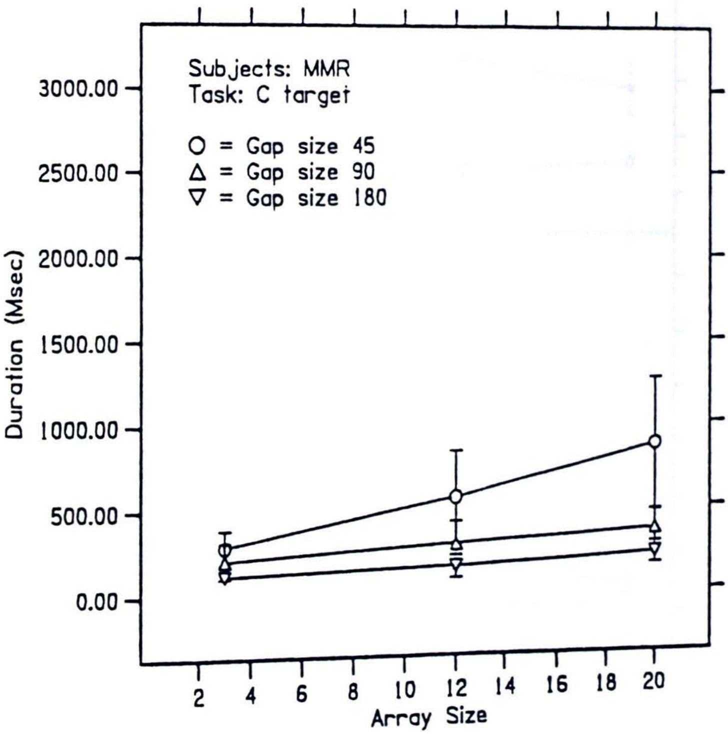


Figure 7. Means and standard errors of the threshold search times for MMR participants in Experiment 2. Top panel: Search times for an O target among C distractors with gap sizes, 45; 90; and 180 degree. Bottom panel: Search times for C target with 45; 90; and 180 degree gap sizes among O distractors.

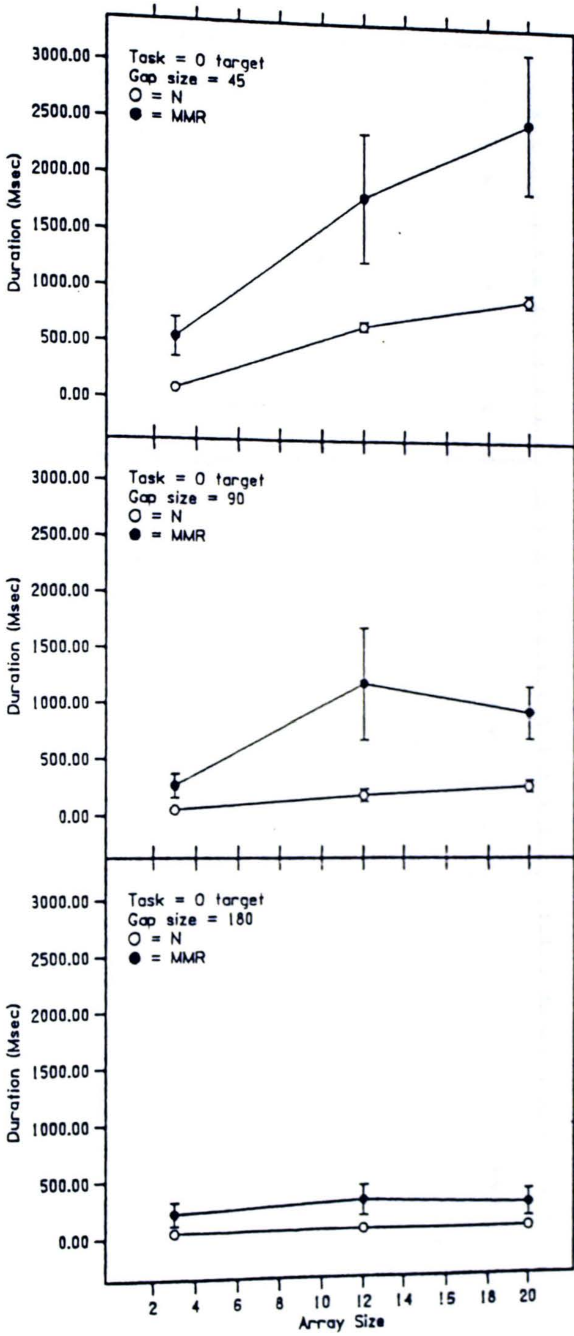


Figure 8. Comparison between N and MMR : O target, C distractors. Top panel: 45 degree gap size. Center panel: 90 degree gap size. Bottom panel: 180 degree gap size.

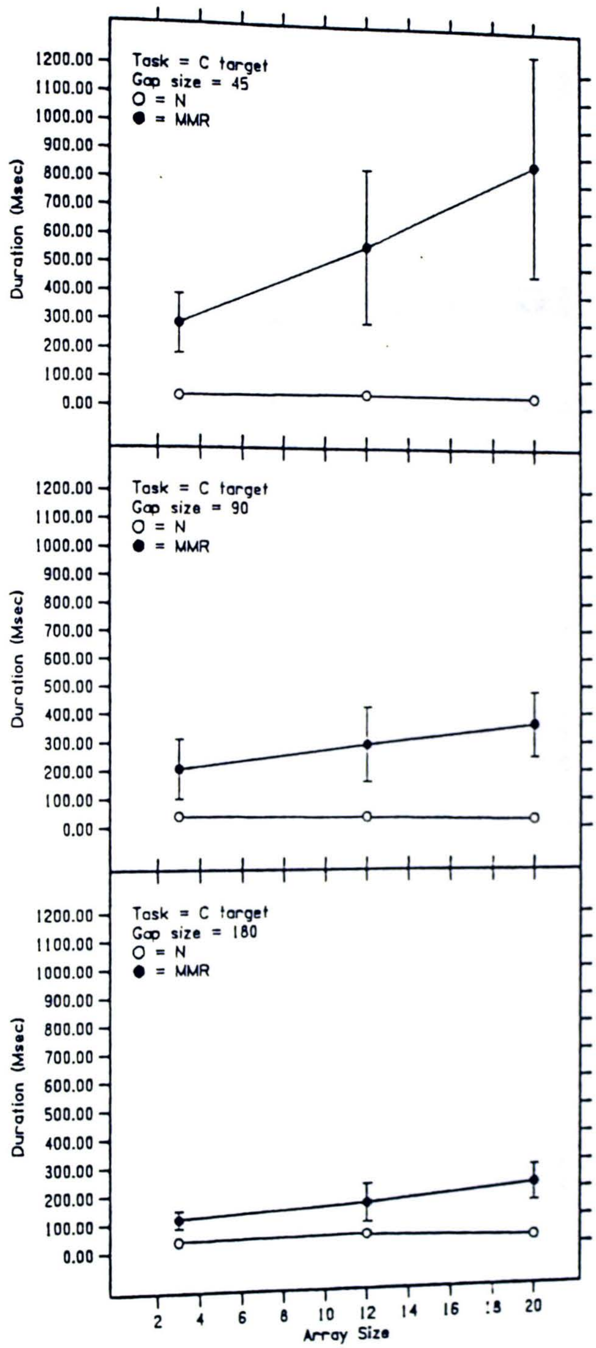


Figure 9. Comparison between N and MMR: C target, O distractors. Top panel: 45 degree gap size. Center panel: 90 degree gap size. Bottom panel: 180 degree gap size.

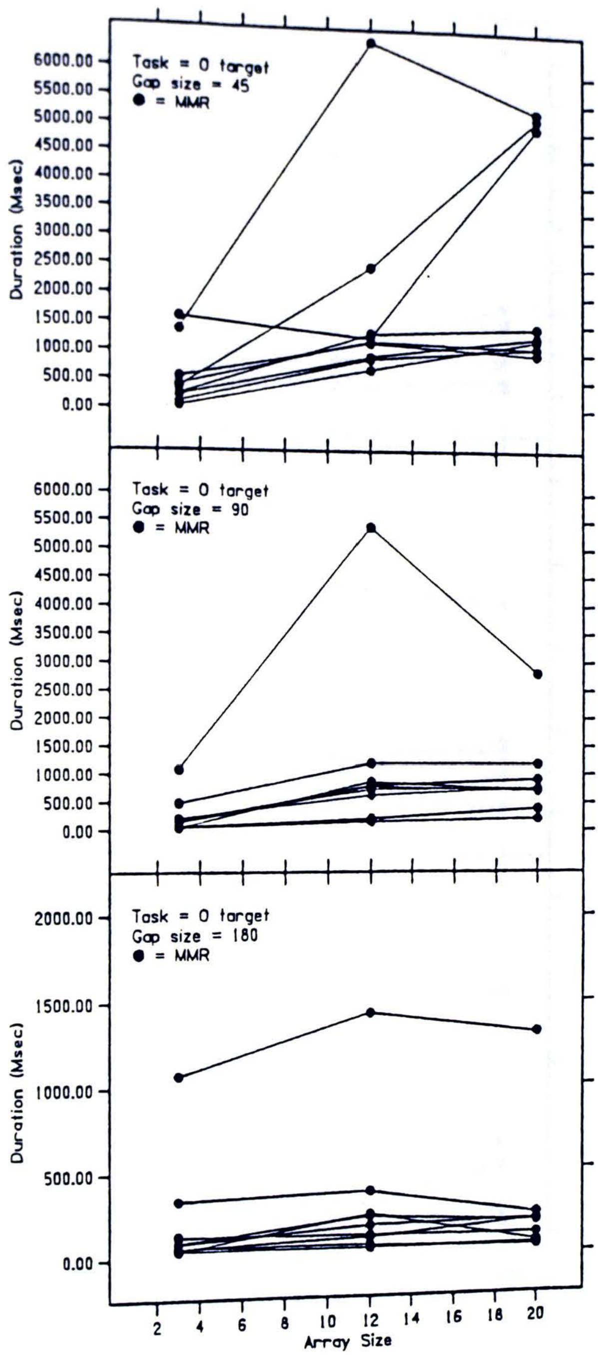


Figure 10. Individual threshold search times for MMR participants: O target, C distractors. Top panel: 45 degree gap size. Center panel: 90 degree gap size. Bottom panel: 180 degree gap size.

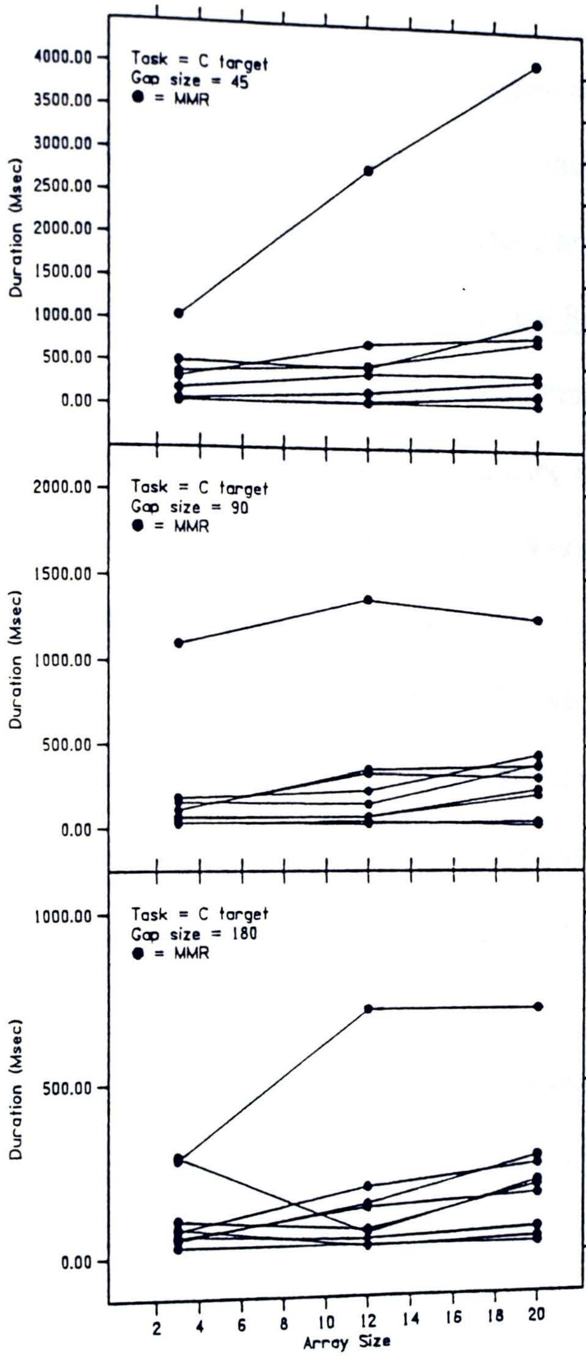


Figure 11. Individual threshold search times for MMR participants: C target, O distractors. Top panel: 45 degree gap size. Center panel: 90 degree gap size. Bottom panel: 180 degree gap size.

DISCUSSION

The findings obtained from this study suggest that individuals with MR have difficulty in higher level visual processing at least as measured with the present tasks. The results obtained from this study are discussed below.

MMR Show Serial and Parallel Processing in Visual Search

The results of the first experiment indicated that both N and MMR participants show both serial and parallel processing in a specific visual search task. When searching for an O among Q's, both N and MMR participants' search time increased steeply with increases in the number of distractors. This defines a serial search process. However, MMR participants took significantly longer times to identify the target: On average about four times longer than N participants. There is a linear relationship between search times and array size; as with N participants, the slope of the line was much steeper for MMR participants.

When searching for a Q among O's, both N and MMR participants' search times were independent of array size (except as discussed below), and this defines a parallel search pattern.

MMR are Affected by Manipulations of Salience

The results of Experiment 2 show both N and MMR participants demonstrated an effect of saliency. That is, as the distinctiveness of the feature that characterizes the difference between the target and the distractors was manipulated, search times were affected. MMR participants took a significantly longer time to identify the target. On the average they took about three times longer than N participants to identify the target. As previous studies have shown in a visual search task, when the target had small gap size it resulted in serial search pattern, and larger gap size resulted in parallel search pattern (Treisman & Souther, 1985).

When searching for a C target among O distractors, N participants did not show an effect of saliency and showed evidence of parallel processing. For MR participants, this parallel task became a serial task when the saliency of the target was reduced. That is, as the gap size was reduced search time increased independent of increases in the number of distractors, suggesting an effect of saliency.

In summary, N participants showed an effect of saliency only in the serial task, whereas MR participants showed evidence of an effect of saliency in the serial as well as in the parallel task.

<u>MMR Performance May Show Evidence of Sub-Groups</u>

In experiment 1, MMR participants appeared to show evidence of sub-groups in the parallel tasks. One group (N = 6) had much better performance than a second group (N = 4). In Experiment 2, this was not clearly evident in the Figures (see Figures 10 & 11), however, individual MMR performance showed suggestive evidence of variability in both parallel and serial tasks. For some individuals, but not all, performance was influenced by increases in array sizes.

MMR Participants who performed poorly in experiment 1 also performed poorly in Experiment 2.

Implications

The primary findings of this study demonstrated similarities and significant differences in the visual search strategies used by N and MMR participants. When performing a visual search task (depending upon the characteristics of the target along with other variables, such as the distinctive feature of the target, distractors, and array sizes), both N and MMR showed evidence of serial and parallel processing. Also, both groups showed evidence of an effect of saliency.

Some of the observed differences are simply quantitative in nature. For example, MMR required more time to perform a visual search task than did adults without mental retardation. Other differences implied qualitative differences, however. For example, the slope of the line that described the relationship between search times and number of distractors was much steeper for MR than N participants. This finding may suggest that MMR performance may have been constrained by a limited processing capacity. If that is the case, then it may be suggestive of a limited ability to process the data among this group. If the differences in search times were due to just a general slowing of processing among MMR, than one would expect MMR search times to be elevated but parallel to that of N participants. If the differences in search times were due to a lack of attention or concentration, than one would expect increased variability in the data rather than a specific pattern. Also, the observed differences simply cannot be explained by their inability to comprehend the task: All participants were required to perform to criterion before participation. Other factors, such as age or I.Q., were investigated and found not to be predictors of performance on these tasks.

Contribution to Knowledge and Future Studies

Findings from this study may benefit educators dealing with MR or MMR groups. Teachers may have a better understanding regarding the abilities and limitations of their students. They can simplify their instructions by keeping them short, concise and free from distractions.

This study examined only a specific aspect of visual search. Other stimulus features, such as motion or color, which are processed by other parts of the brain, may demonstrate similar or perhaps different findings.

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APPENDICES

APPENDIX A

INSTRUCTIONS FOR EXPERIMENT 1

(1). Searching for a "Q" among "O'S"

In this experiment you will be shown a group of letters on the computer screen. Sometimes the group will contain a "Q" surrounded by "O's"; other times, there will be only O's. Your task is to see if you can find the Q. If you find a Q, say, "Yes," aloud. If you do not find a Q, say, "No," aloud. Sometimes you will be shown many letters, and other times only a few letters. Sometimes you will be shown the letters for a long time and other times for a short time.

(2). Searching for an "O" among "Q's"

In this task you will be shown a group of letters on the computer screen. Sometimes the group will contain an "O" surrounded by "Q's"; other times, there will be only Q's. Your task is to see if you can find an O. If you find an O, you say, "Yes," aloud. If you do not find an O, say, "No" aloud. Sometimes you will be shown many letters, and other times only a few letters. Sometimes we will show you the letters for a long time and some other times for a very short time.

APPENDIX B

INSTRUCTIONS FOR EXPERIMENT 2

(1). Searching for a "C" among "O's"

In this experiment you will be shown a group of letters on the computer screen. Sometimes the group will contain a "C" surrounded by "O's"; other times, there will be only O's. Your task is to see if you can find a C. If you find a C, say, "Yes," aloud. If you do not find a C, say, "No," aloud. Sometimes you will be shown many letters and other times only a few letters. Sometimes you will be shown the letters for a long time and other times for a short time.

(2). Searching for an "O" among "C's"

In this task you will be shown a group of letters on the computer screen. Sometimes the group will contain an "O" surrounded by "C's"; other times, there will be only C's. Your task is to see if you can find an O. If you find an O, you say, "Yes," aloud. If you do not find an O, say, "No," aloud. Sometimes you will be shown many letters, and other times only a few letters. Sometimes we will show you the letters for a long time and other times for a very short time.