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Running Head: Effects of Visual Field Size

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Abstract

In the fields of both cognitive development and cognitive aging, similar patterns of performance on selective attention tasks have been found between children and older adults. Presently, there exist few studies of selective attention across the lifespan. A 1995 study by Shapiro, Shapiro, Cointin, and Forbes addressed this absence through investigating search performance in a cross-sectional, life-span study. In the Shapiro et al. study, a compelling pattern of performance was found: in conjunction conditions, which require serial searches, older adults' performance differed significantly from the younger adults' performance across increasing display size only in target absent trials. The present study attempted to determine whether such differences arose from perceptual-motor (physiological) slowing. Four older adults (mean age = 68.25 years) and seven undergraduates (mean age = 19.57 years) volunteered. Participants responded to the presence or absence of targets within conjunction arrays of varying field and display sizes. Both reaction times (RTs) and proportion correct were measured. Overall, it was found that RTs were longest for both older and younger adults when field size and display size were large, and in target-absent trials. These results provide no support for a perceptual-motor explanation of Shapiro et al.'s findings. An alternative explanation, one of cognitive change, is discussed.

The Effects of Visual Field Size on Search Performance

Prior studies conducted in the fields of cognitive development and cognitive aging have found parallel deficits between children and older adults' performance on selective attention tasks. Children's performance has been investigated with such tasks as orienting to visual cues (Enns, 1990), flanker tasks (Enns and Akhtar, 1988), and visual search tasks (Thompson and Massaro, 1989). Older adults' performance has also been examined with orienting to visual cues (Folk and Hoyer, 1992), flanker tasks (Shaw, 1991), and visual search tasks (Plude and Doussart-Roosevelt, 1989). In addition, older adult's performance has been tested with Stroop color tasks (Cohn, Dustman, and Bradord, 1984), memory for words (Hartman and Hasher, 1991), negative priming (Tipper, 1991, McDowd and Oseas-Kreger, 1991, McDowd and Filion, 1995), and reading (Connelly, Hasher, and Zacks, 1991). Comalli, Wapner, and Werner (1962) conducted a lifespan study in which they administered the Stroop color task to children, young adults, and older adults. In order to understand the mechanisms behind the parallel deficits found on these tasks, one must more closely examine selective attention.

The nature of selective attention itself is addressed in a 1994 study by Plude, Enns, and Brodeur. Plude and his colleagues outline four components which comprise selective attention and attentional tasks: <u>orienting</u> (presenting a target for response after the presentation of valid or invalid cues) (Posner, 1980), <u>filtering</u> (allowing only certain stimuli to be processed), <u>searching</u> (attempting to identify both the presence and the location of a target), and <u>expecting</u> (using previous information to predict the presence of a target). Whereas orienting tasks appear stable across the lifespan, Plude et al. report that filtering and searching processes undergo substantial change during life. In developmental studies employing the dichotic listening task, for example, younger children are more susceptible to interruptions and are less accurate in processing the target stimuli (Plude et al., 1994). Though age-related improvements are seen between the ages of 8 and 11, older adults typically exhibit higher error rates than younger adults and are more susceptible to distracting stimuli. We see, then, that these processes are acquired in late childhood and experience variable decline later in life.

A recent study by Shapiro, Shapiro, Cointin, and Forbes (1995) attempted to respond to Plude et al's 1994 findings by investigating performance in one of the components given above: search (Shapiro et al., 1995). Shapiro et al. found significant differences in performance across the lifespan, reporting that ability on visual search tasks seems to improve throughout childhood and into adolescence, peak during young adulthood, then decline later in life (1995).

Researchers have proposed several models and mechanisms of selective attention. Perhaps the most influential of these is the model proposed by Triesman in her feature-integration theory and paradigm (Triesman and Gelade, 1980). Here, participants respond to the presence or absence of a predetermined target among a field of distractors (Shapiro et al, 1995). Two types of trials are involved in Triesman's paradigm. In the first, the feature search trial, the predetermined target both shares one feature and differs by one feature with each of the distractors. Thus, if the target is a sideways "T," then each of the distractors would be upright "T"s; notice that the target shares one feature (form) and differs by one feature (orientation) with each of the distractors. By contrast, the conjunction search trial involves a target (again, a sideways "T") which shares one feature with half of the distractors (say, upright "T"s) and shares another feature with the remaining distractors (sideways "P"s, for example (Shapiro et al., 1995). Notice that the target shares the feature of form with the first half of the distractors and shares a second feature, orientation, with the second half of the distractors.

Triesman's paradigm predicts that feature searches are performed in parallel, with all features being processed at the same moment. Conjunction searches, however, are hypothesized to occur in a serial fashion; because more than one feature of the target may be confused with the distractors, focused attention must be paid as the participant examines each distractor individually (Shapiro et al., 1995). From this, then, it is expected that reaction times (RTs) for feature searches will remain constant with increasing display sizes. Thus, feature searches, when plotted as a function of display size, should produce zero slopes. Conjunction search RTs, however, should increase across display size, producing steeper slopes when plotted as a function of display size.

Two important studies, one in the field of cognitive development and the other in the field of cognitive aging, have employed Triesman's model of selective attention. In their 1989 study comparing younger and older adults' performance on visual search tasks, Plude and Doussart-Roosevelt added a third condition, the unconfounded search, to Triesman's paradigm. Here, the target shares one feature with a small, constant number of distractors in the visual field, regardless of display size. In the unconfounded condition, then, search may occur first in parallel, eliminating that constant number of distractors, and next in series. Plude and Doussart-Roosevelt found little difference between young and older adults in both feature and unconfounded searches, though, in general, older adults did produce longer RTs. In conjunction searches, however, significant differences between the two groups were found, with the older adults showing a greater effect of display size (Plude and Doussart-Roosevelt, 1989). That is, larger display size produced longer RTs.

Thompson and Massaro's 1989 study examining children and younger adults' performance on visual search tasks produced results similar to those found by Plude and Doussart-Roosevelt. Again, significant effects of display size were found only in conjunction searches. We thus find further evidence that predicted age ordering in selective attention task performance is found only in those tasks which require serial searches.

One proposed mechanism for the varying levels of performance found in selective attention tasks involves decreased inhibitory efficiency during older age (Hasher and Zacks, 1988). Serial searches are more susceptible to larger interference. Thus, with larger display sizes producing more potential interference, it is predicted that display size will effect reaction time in those trials which require a serial search. As inhibitory efficiency decreases with age, older adults may be more prone to both distractibility (the inability to suppress irrelevant stimuli) and to perseverative behavior (the inability to inhibit ongoing motor or psychological processes) (Shapiro et al., 1995).

Bjorklund and Harnishfeger (1990) have proposed a cognitive development model in which inhibitory efficiency is low in young children, then increases during childhood and adolescence. Combining this model with the decreased inhibitory efficiency found in older adults, one finds a "last in, first out" (Shapiro et al., 1995) pattern for inhibitory processes.

In an attempt to synthesize the findings of previous research, to produce a study in which performance was investigated using the same *task* as well as the same paradigm, Shapiro et al. (1995) conducted a lifespan study. Here, they investigated the patterns of performance in children, young adults, and older adults. The authors found a significant difference between children and young adults' performance, with children (especially those in the 6-year-old age group) displaying significantly longer RTs across search condition, display size, and target condition. Older adults' performance, too, differed significantly from younger adults' performance, but only on target present (positive) trials versus target absent (negative) trials. Specifically, older adults showed much longer RTs in negative trials than in positive trials.

The present study, then, will attempt to explore the nature of the differences found between older adults' performance on target-present and target-absent trials. Two possibilities exist. The first possibility, the focus of another project currently underway at Illinois Wesleyan University, will attempt to identify a strategy, one which proved successful in target-present trials but which failed in target-absent trials. A second possibility, one being investigated in the present project, will address the notion of whether the increased RTs shown by older adults across increasing display size are due to a perceptual-motor slowing that may occur with advancing age. If indeed the longer RTs are due to such perceptual-motor slowing (i.e. to the fact that it simply takes older adults a longer time to move their eyes) then increasing the area of the screen covered by the stimuli should result in an increase in reaction time. As the participants have a greater total area to search, the effects of perceptual slowing should manifest themselves in longer reaction times as compared to a screen in which the stimuli cover a smaller total area. This effect should be greater for older adults than for younger adults.

Method

Participants

Participants included 4 older adults (2 females, 2 males, mean age = 68.25 years, SD = 2.68 years) and 7 undergraduates (5 females, 2 males, mean age = 19.57 years, SD = 1.10 years). Older adults, recruited from a list of Illinois Wesleyan University Alumni, were paid $10 an hour for their participation while the younger adults, drawn from a pool of undergraduate students enrolled in an introductory psychology course at Illinois Wesleyan University, received extra credit for their participation.

All participants had normal vision, or vision corrected to normal, and were in good health; none reported past or current neurological problems nor differed significantly on a test of intelligence. Mean KBIT score for the undergraduates = 111.14, while the older adult's mean score = 112.75, $t = 0.46$.

Materials and Apparatus

The visual search task was administered on a Macintosh PowerMac 8500. Participants were individually administered three preliminary tests. These included the Kaufman Brief Intelligence Test (K-BIT) as a screening device, the Wisconsin Card Sort Test (WCST) as a measure of perseverative behavior, and the Stroop Color Task as a measure of frontal lobe interference effects.

Participants in the older adult age group had already received the K-BIT and WCST in the 1995 Shapiro et al. study; these individuals were thus given only the Stroop Color Task during testing.

Three field sizes were created for the stimuli presentations in this study. Field size was determined by first measuring the visual angle of a participant located .20m from the PowerMac monitor. From this point, using existing literature as a base (Tipper, 1991), three field sizes were chosen: those subtending visual angles of 14°, 21°, and 28°, respectively.

Stimuli

All trials of the visual search task consisted of arrays of letters including a "target" letter and a differing number of "distractor" letters. Display area, or the portion of the computer screen covered by the stimuli letters, consisted of displays with visual angles of 14°, 21°, and 28°, respectively. Thus, the 14° condition was characterized by a relatively small field size, with the least distance between letters, and the 28° condition was characterized by a relatively large field size, with the greatest distance between letters. The 14° condition represented a contracted version of the stimuli used in Shapiro et al.'s study

(1995), while the 21° condition replicated the visual field size found in Shapiro et al.'s visual search task. The 28° condition represented an expanded version of the earlier stimuli. Pilot studies were conducted to ensure no difficulties arose with the various display areas. Displays varied in size according to the number of distractors present in the trial containing either 5, 10, or 15 letters. As in Shapiro et al.'s study (1995), the target was a sideways "T" in each trial, with distractors being either upright or sideways "T"s or "P"s.

In contrast to Shapiro et al.'s 1995 study, there was only one type of search condition, for each display: the conjunction search condition, in which the target shared one feature (form) with half of the distractors (upright "T"s) and shared another feature (orientation) with the other half of the distractors (sideways "P"s). Search type was limited to one condition to simplify data analysis. The conjunction search trial was chosen as the condition which produced the most significant results in previous studies (Shapiro et al., 1995). All stimuli were 1cm by 2cm in size and were located approximately .2m from the participant. To distribute targets randomly, the visual field was divided into 8 sectors and the target occurred equally in each sector throughout the trials.

Procedure

Each participant was required to read and sign a consent form prior to his or her participation in the study. This form explained both the pre-testing as well as the computer task and informed participants of their rights. Order of pre-testing and visual search task was counterbalanced across participants. For the visual search task, an instructional screen appeared and was read by each participant. Verbal instructions were also given to ensure each participant fully understood the task. Prior to each trial, the computer screen displayed a plus sign in the center of the screen, accompanied by a warning tone. This was followed in five hundred milliseconds by an array of letters. Participants were instructed to press the "yes" key if the target was present and the "no" key if the target was absent. The target remained the same throughout each trial. Participants were instructed to answer as quickly and accurately as possible.

Feedback was given in the form of tones: a high tone (880Hz) indicated a correct response while a low tone (440Hz) indicated an incorrect response (either a "no" when the target was present or a "yes" when the target was absent).

Eighteen practice trials were given before the actual visual search task began. When the participant was comfortable with the task, the study proceeded with 8 blocks of 36 trials per block. A 1-minute break occurred between blocks.

Design

This study involved a 4-way mixed design consisting of three within-subjects factors, display size (5,10, or 15), target condition (present or absent) and field size (14°, 21°, 28°), and one between-subject factor, age group (older adults and undergraduates).

Results

This study measured two dependent variables, those of reaction time (RT) and proportion correct. One mixed analysis of variance (ANOVA) with age group, display size, target condition, and field size, was conducted on each primary dependent variable. Overall, most participants achieved ceiling effects with proportion correct; that is, nearly every participant performed with nearly 100% accuracy. Tables 1 and 2 present older and younger adults' mean proportion correct as a function of the experimental factors. One significant main effect on proportion correct was found, that for target presence/absence, $F(1, 9) = 5.66$, $p = .041$.

No significant differences were found between older and younger adults' RTs, either in the target-present or the target-absent conditions. Tables 3 and 4 display older and younger adult's mean RTs as a function of field size, target presence/absence, and display size. Though no significant differences were found between the age groups, analysis revealed significant main effects of field size, display size, and target presence/absence were found ($p<.001$), F (2, 18) = 18.85, F (2, 18) = 23.49, F (1, 9) = 26.68, respectively. As field size increased all participants produced longer RTs. Similarly, as display size progressed from 5 to 15 letters, individuals took longer to respond. Finally, in accordance with Shapiro et al.'s 1995 findings, target-absent conditions resulted in longer RTs than did target-present conditions.

Three significant interactions occurred in the RT data. First, the effect of field size was enhanced when display size increased, F (4,36) =6.45. Second and third interactions were found as the effects of field size and display size were magnified in target-absent versus target-present conditions, F (2,18) = 11.49 and F (2, 18) = 20.97, respectively. See Figures 1 -3 for graphic depiction of these interactions.

Discussion

Recalling that Shapiro et al. reported significant differences between older and younger adults' RT across increasing display size only in target-absent conditions, the present study tested whether physiological slowing could be the cause of this pattern of performance. Current findings suggest little support for the perceptual-motor slowing explanation of last year's study.

If data had pointed to such an explanation, one would expect to find significant differences between the performance of younger and older adults across increasing field size; that is, if perceptual-motor slowing were indeed the true culprit, older adults' RTs would have been significantly longer in the expanded 28° condition than in normal 21° condition or in the contracted 14° condition, as compared to younger adults' RTs. No such finding was obtained. Indeed, the only significant differences found occurred between the different stimuli (i.e. field size, display size, target presence/absence).

One must turn, therefore, to alternative explanations of Shapiro et al.'s 1995 findings. One explanation lies with the possibility that older adults are experiencing cognitive, not perceptual or motor, changes. This possibility is closely tied to a neurological mechanism proposed by Dempster in 1992. Dempster's mechanism offers a neurological explanation for the "last in, first out" pattern reported earlier (Shapiro et al., 1995). Specifically, this model implicates frontal lobe development in the changes found in inhibitory efficiency. The frontal lobes are both the last to achieve full myelination during childhood and the first to degenerate in older adults. Maturity and/or integrity of the frontal lobes can thus be related to the lifespan changes in inhibitory efficiency as reported by Bjorklund and Harnishfeger (1990).

The frontal lobes play a crucial role in memory, cognition, and affective functioning, being specifically implicated in inhibitory processes and in decision making/planning (Levin, Eisenberg, Benton, 1991). Frontal lobe immaturity or degeneration, therefore, can have several manifestations. Two such manifestations are perseverative behavior (the inability to inhibit ongoing motor or psychological processes) and changes in strategy use. Notice that we now revisit the concept of perseverative behavior discussed earlier. Knowing that the frontal lobes are responsible for inhibitory efficiency and that individuals experiencing decreases in inhibitory efficiency are more prone to perseverative behavior, we conclude that older adults experiencing frontal lobe degeneration may engage in perseverative behavior.

A second manifestation of immature or degenerating frontal lobes stems from a breakdown in the decision making/planning processes (Levin et al., 1991). It is possible that those older adults experiencing frontal lobe degeneration engage in different strategies, or simply employ strategies at a slower pace, than do younger adults whose frontal lobe integrity is preserved. This possibility, as mentioned earlier, is the focus of another study currently underway at IWU.

Several points of concern must be addressed in this study. The data presented here represents an incomplete and admittedly small sample size. Before final submission of this paper, a second analysis will be conducted on the completed sample size: ten older adults and ten undergraduates. As is, however, the small sample size leaves room for a strong effect of one outlying data point. Thus, one must address the results with caution: no definitive conclusions can be drawn until the sample size has been completed.

Questions of external validity must also be addressed. Drawing all undergraduates from the Illinois Wesleyan University student body and all older adults from a list of Illinois Wesleyan University alums may impact the ability to generalize the findings of this study to the overall population. It may be assumed that IWU students and alums have a higher degree of formal education than the general population. Whether or not the present findings are generalizable remains to be seen.

The findings of the present study leave implications for research at both the undergraduate level and at a more overall level. Possible continuations of this study may test participants with frontal lobe damage in an effort to explore the effects of more profound frontal lobe degeneration on visual search performance.

At a broader level, research has shown that frontal lobe degeneration is a slow process (Dempster, 1992). Because of this, research focusing on intervention may prove successful; the race against the clock is a slower one, centered more upon assisting older adults in compensating for their cognitive changes than upon a "cure" for frontal lobe degeneration. Future research in applied settings must therefore identify ways in which to those guide older adults experiencing frontal lobe degeneration to compensate not only for their cognitive changes but for the everyday living problems that result from those changes.

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Table 1.

Older Adults' Mean Percentage Error Rate as a Function of Field Size, Display Size, and Target.

	Field Size					
	14°		21°		28°	
	Target					
Display Size	Present	Absent	Present	Absent	Present	Absent
5	1.563	4.688	1.563	1.563	3.125	1.563
10	1.563	0.000	1.563	0.000	0.000	0.000
15	3.125	0.000	1.563	0.000	1.563	0.000

Table 2.

Younger Adults' Mean Percentage Error Rate as a Function of Field Size, Display Size, and Target.

	Field Size					
	14°		21°		28°	
	Target					
Display Size	Present	Absent	Present	Absent	Present	Absent
5	1.786	0.000	2.679	0.893	2.679	3.571
10	1.786	0.893	2.679	1.786	1.786	0.000
15	1.786	0.893	6.250	1.786	3.571	2.679

Table 3.

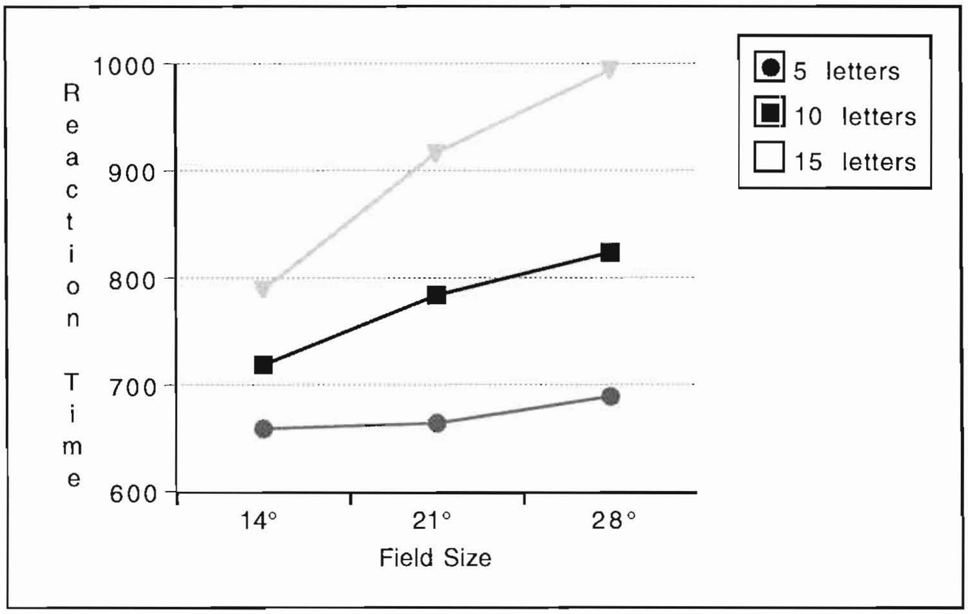
Older Adult's Mean Reaction Times (msec) as a Function of Field Size, Display Size, and Target.

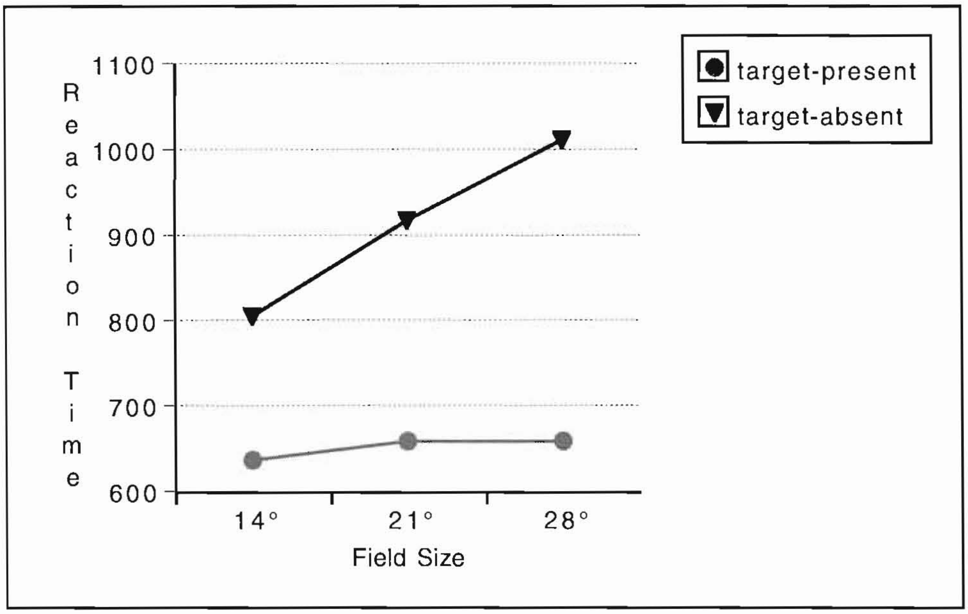
	Field Size					
	14°		21°		28°	
	Target					
Display Size	Present	Absent	Present	Absent	Present	Absent
5	639.000	706.250	623.250	766.500	649.250	800.750
10	656.750	856.000	685.250	920.250	673.000	1044.500
15	675.000	982.000	726.250	1093.250	742.000	1314.750

Table 4.

Younger Adult's Mean Reaction Times (msec) as a Function of Field Size, Display Size, and Target.

	Field Size					
	14°		21°		28°	
	Target					
Display Size	Present	Absent	Present	Absent	Present	Absent
5	626.714	681.000	593.857	701.000	590.857	749.000
10	615.429	779.429	678.714	868.143	636.286	973.429
15	644.286	892.286	666.714	1174.714	708.714	1240.857


1000
900
800
700
600
Reaction Time
14°
21°
28°
Field Size
5 letters
10 letters
15 letters


1100
1000
900
800
700
600
Reaction Time
14°
21°
28°
Field Size
target-present
target-absent

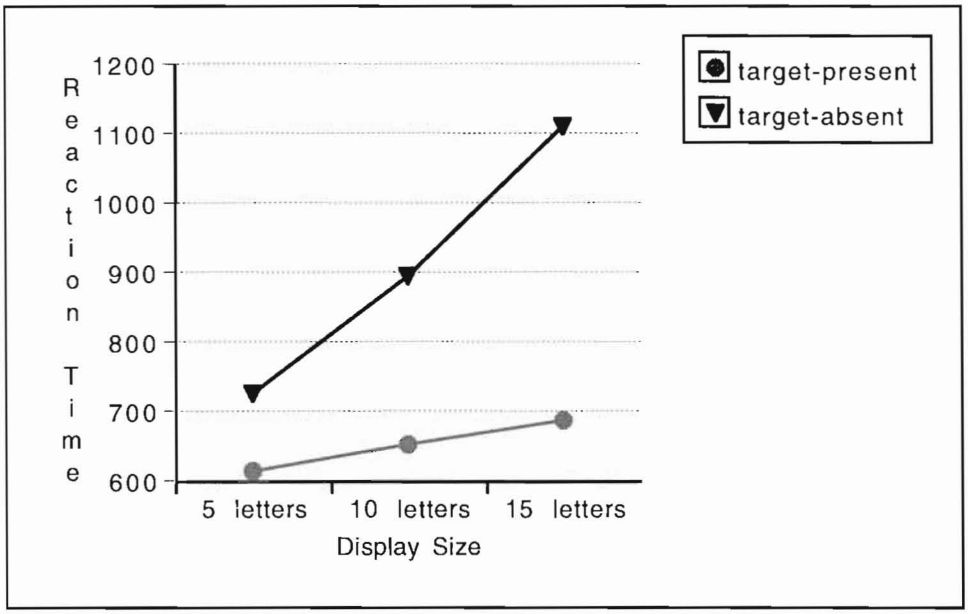

Reaction Time
1200
1100
1000
900
800
700
600
5 letters
10 letters
15 letters
Display Size
target-present
target-absent

Figure Captions

Figure 1. Interaction between field size and display size.

Figure 2. Interaction between field size and target presence/absence.

Figure 3. Interaction between display size and target presence/absence.