Developmental Psychology
1983, Vol. 19, No. 4, 499-507

Aging and Distraction by Highly Familiar Stimuli During Visual Search

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An influential theory regarding age-related changes in cognition proposes that aging is accompanied by a decreased ability to ignore irrelevant information (perceptual noise). The present experiment examined age differences in the extent to which highly familiar stimuli when used as perceptual noise could disrupt visual search performance. On Days 1–4, 10 young (M = 20.3 years) and 10 older (M = 69.4 years) adults performed a search task with specific, unchanging sets of target and nontarget stimuli (letters). Performance on a subsequent search task (Day 5) was disrupted when these familiar stimuli appeared as noise items in the displays, as compared with trials on which only new, unpracticed stimuli were used. The magnitude of the distraction associated with the familiar stimuli on Day 5 was equivalent for the two age groups. However, age differences in Day-5 search performance did increase as more items in the stimulus display required inspection. Age differences in the present search task were thus influenced more by the requirement to attend to relevant information than by distraction from irrelevant information.

Although an age-related decline in the speed of performance has frequently been observed in tasks measuring reaction time (RT), this decline is closely related to the attention and memory demands of the tasks and is not simply a slowing of sensorimotor functioning (Cerella, Poon, & Williams, 1980; Fozard, 1981; Hoyer & Plude, 1980). When subjects must search a visually presented display for the presence of a target item, for example, the rate of search (i.e., the duration of the comparison stage of the task) is reflected in the degree to which RT increases with the number of stimulus comparisons required for a decision (Chase, 1978). Older individuals have a slower rate of search than younger individuals, when either the number of targets held in memory (Anders, Fozard, & Lillyquist, 1972; Rabbitt, 1964) or the number of items in the stimulus display (Rabbitt, 1965) are varied.

This research was supported by National Institute on Aging Grant AG02163-02. I am grateful to Leslie O'Toole for invaluable technical assistance.

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An influential hypothesis regarding these age differences in search performance was Rabbitt's (1965, 1968) claim that older adults are less efficient than young persons in ignoring irrelevant information. The later proposal by Layton (1975) that aging is accompanied by a decreased ability to ignore "perceptual noise" was a more generalized version of Rabbitt's hypothesis. Recent evidence, however, has suggested that some revision of the perceptual noise hypothesis may be necessary. When the single display position that can potentially contain a target is specified in advance, older individuals are no more susceptible (under some conditions) than young individuals to distraction by items located in the nonspecified positions (Farkas & Hoyer, 1980, Experiment 2; Wright & Elias, 1979). It may thus be more accurate to characterize age differences in search performance as a deficit in attending to relevant information than as a deficit in ignoring irrelevant information.

In spite of these age differences in information-processing efficiency, older adults appear to resemble young persons in the ability to improve search performance. When, for example, the particular stimuli assigned to

the *yes* and *no* responses in a search task are held constant (i.e., consistent stimulus-response mapping is maintained), the effects of memory-set size and display size on RT become greatly diminished over practice (Schneider & Shiffrin, 1977). Such practice-related improvement with consistent mapping has been reported for both older and young adults in a pure memory-search task (Salthouse & Somberg, 1982) and in hybrid memory-search/visual-search tasks (Madden & Nebes, 1980; Plude & Hoyer, 1981). This improvement apparently depends on the constant stimulus-response relationship: Plude and Hoyer (1981) found little improvement for either age group when the stimulus-response assignment was not consistent (i.e., varied mapping was employed); and the search rate of both age groups was significantly slowed when new, unpracticed stimuli were substituted for the familiar items in the Madden and Nebes (1980) and Salthouse and Somberg (1982) studies. According to the Schneider and Shiffrin (1977) framework, these results indicate that for both age groups, the targets began to elicit the appropriate response in an "automatic" manner that did not require substantial attentional control.

Given that both young and older individuals are successful in improving their search performance through practice with consistently mapped stimuli, are the consequences of this improvement equivalent for the two age groups? The present experiment investigated age differences in the extent to which highly familiar stimuli, employed during a prior search task, could disrupt subsequent search performance when used as perceptual noise. On Days 1–4 (approximately 2,000 trials), young and older adults performed a hybrid memory-search/visual-search task, with two distinct sets of items (letters) consistently assigned as targets and nontargets. On Day 5, the subjects were given a similar search task with new, unpracticed stimuli. The Day-5 search task contained both noncued trials (on which all four items of a visual display required inspection) and cued trials (on which only two specified display positions could possibly contain a target). The highly familiar (Days 1–4) stimuli occasionally appeared in the stimulus displays, although they were never assigned as targets and never appeared in the target-relevant display positions on the cued trials. The *specific effect* (Taylor, 1977) of the familiar stimuli on search performance is defined by the change in decision RT associated with the presence of the familiar items, as compared with control trials on which only new items are present in the display. Previous findings (Shiffrin & Schneider, 1977, Experiment 4d) indicate that the presence of highly practiced target items can significantly disrupt performance on a subsequent search task by drawing attention away from the other (new) items in the display. According to the perceptual noise hypothesis, when these stimuli are located only in the irrelevant display positions, the presence of the familiar stimuli on Day 5 should be more distracting for the older than for the young subjects, especially on the cued trials.

The present experiment was also designed to provide information regarding the perceptual learning that occurs in a consistent mapping search task. Shiffrin and Schneider (1977) assume that an automatic response that is specific to the target items is learned during practice: "In our CM [consistent mapping] studies, only the memory-set items can come to elicit automatic responses, because distractors [nontarget items] are presented on every trial" (p. 149). As a result of this assumption, these authors failed to examine the degree to which the highly practiced nontargets could also demand attention during a subsequent search task. The attentional effects of the familiar nontargets could be substantial if an important aspect of improvement in search is learning to discriminate the target and nontarget sets efficiently (e.g., Prinz, 1977; Rabbitt, Cumming, & Vyas, 1979) and not just acquiring an automatic response to the target items. The present experiment thus included separate assessments of the distraction provided by familiar targets and nontargets.

Method

Subjects

Ten young and 10 older adults were paid participants in the experiment; each age group contained 5 males and 5 females. The young subjects were Duke University students ranging in age from 19 to 27 years (M = 20.3); their average number of years of education was 14.7. The

older subjects were healthy, community-dwelling members of the Duke Aging Center subject pool, a group of over 800 adults who have volunteered to participate in studies of aging. The older adults participating in the present experiment ranged in age from 63 to 77 years (M = 69.4); their average number of years of education was 15.4. Both the young and the older subjects possessed corrected binocular visual acuity of at least 20/30.

Procedure

Subjects were tested individually and performed the present experiment in five consecutive daily sessions of approximately 1 hour each. During the first four sessions, subjects performed a hybrid memory-search/visual-search task in which memory-set size was either two, three, or four items, and display size was always two items. On Days 1–4, consistent mapping was maintained for five target and five nontarget letters. On the fifth session, subjects performed a new search task with 10 new (i.e., unpracticed) letters defined as the five target and nontarget items. On Day 5, memory-set size was always two items, and display size was always four items.

Several aspects of procedure were common to the two search tasks: Before each block of trials, subjects were assigned a memory set of letters selected from the five targets. Subjects were permitted to view the memory set as long as they wished. Each trial required subjects to respond "yes" or "no" as to whether a single, visually presented display of letters contained any one of the memory-set letters associated with the current trial block. Target letters that were not members of the memory set for a particular trial block did not appear in the stimulus displays of that block. On the *yes* trials, exactly one of the letters in the display was a member of the current memory set. On the *no* trials, only the nontarget letters were present in the display. No letters were repeated in either the memory sets or the displays. Each block contained an equal number of randomly ordered *yes* and *no* trials, with the constraint that a particular response type not occur more than four times in succession.

In both tasks the stimulus displays were presented in a Scientific Prototype three-channel tachistoscope in which the luminance level was set at approximately 55 cd/m^2. The displays were composed of black uppercase Chartpak 72 point Zentak Grotesk letters mounted on white tachistoscope cards. Each letter subtended approximately .75° wide × 1° high. Subjects viewed the stimuli binocularly and indicated their decision on each trial by moving a paddle switch mounted on a board in front of the tachistoscope. Each subject used his or her preferred hand throughout the experiment. Half of the subjects in each age group moved the switch toward themselves for a *yes* decision and away for a *no* decision; half had the reverse arrangement. The response direction assigned to a particular subject remained constant across the two search tasks. Movement of the switch from a central resting position stopped a digital clock that had begun running at the onset of the stimulus display.

On Day 1, subjects were given written instructions that described the search task for Days 1–4 and stated that speed and accuracy were equally important. On Day 5, subjects were instructed that they would be performing a similar search task with new stimulus letters. They were informed that the targets and nontargets used on Days 1–4 might occasionally appear in the stimulus displays but that these items would never be members of the Day-5 memory sets. On Day 5, subjects were also informed of how a visually presented cue, preceding each trial, could reduce the number of display positions requiring inspection.

Stimuli and Design

Days 1–4. The target letters for the first four experimental days were *G, M, S, L, R,* and the nontargets were *B, V, Z, Q, A.* On each day subjects performed 492 trials: A practice block of 24 trials followed by 12 blocks of 39 trials (4 blocks for each of the three memory-set sizes). The first three trials of each block were considered as practice, leaving 18 *yes* and 18 *no* test trials per block.

The stimulus display presented on each trial contained two letters vertically arranged in the center of the tachistoscope card. The inner edges of the two letters were separated by .75°. On the 18 *yes* trials of a block, one of the two letters in the display was a member of the current memory set. The items in each memory set were counterbalanced as closely as possible for their frequency of occurrence in the display. The 18 *yes* trials of each block contained 9 trials in which a memory-set item appeared in the upper position of the display and 9 trials in which a memory-set item appeared in the lower position. On the 18 *no* trials within a block, the display was composed of two different nontarget items; these items were also counterbalanced as closely as possible for frequency of occurrence and display position. Each stimulus display was presented for 100 msec and was preceded by a 500 msec central fixation dot.

Six different sequences of the three memory-set sizes were arranged in a Latin square design. During each experimental session, one of these sequences was repeated four times, with different memory-set items assigned to the recurrence of each set size. (Since there were only five target items, the four memory sets of a particular size were not completely orthogonal. Each of the five target letters was used as a memory-set item at least once for each set size.) The same group of 468 trials (excluding the practice block) was used on each day, but each subject received four different memory-set sequences across days. Two different practice blocks were alternated within subjects over days, as were the particular memory sets assigned to the first versus the second half of the trial series. Across subjects, all six of the memory-set sequences were used at least once on each day within each age group. The order of the individual trials within the blocks was reversed for all subjects on Day 3.

Day 5. The target letters for Day 5 were *J, C, K, H, Y,* and the nontargets were *N, F, T, D, P.* The trial sequence on Day 5 contained 288 trials: one practice block plus seven test blocks of 36 trials each. Two different orders of the seven trial blocks were alternated across the subjects in each age group. The memory set associated with each trial block contained two different target letters. Across the seven test blocks, each of the five target letters served either two or three times as a memory-set item.

The stimulus display presented on each trial contained four letters, whose midpoints were located at the corners

of an imaginary square that subtended 1.75° × 1.75°. On the 18 *yes* trials of each block, each of the two memory-set items appeared 9 times, at least twice at each of the four display positions. Each of the nontarget items appeared at least 3 times at each display position on these trials. On the *no* trials, each nontarget letter appeared at least 14 times within a block, at least 3 times at each of the display positions.

The effects of distraction associated with highly familiar stimuli were examined by comparing the RTs associated with three types of trials: those on which a prior (i.e., Days 1–4) target letter was present as one of the four display letters, those on which a prior nontarget was present, and those on which the display was composed of only new (i.e., Day 5) items. The 18 *yes* and 18 *no* trials within a block each contained six instances of these three trial types, with each of the five targets and nontargets from Days 1–4 being used as a noise item at least once. No more than one prior target or nontarget was ever present in the display.

The six instances of the three noise-item trial types each contained four cued and two noncued trials. On the cued trials a diagonally positioned, double-headed arrow preceded the stimulus display for 1 sec. This arrow indicated the two display positions that could potentially contain a memory-set item. The two possible orientations of the diagonal arrow (pointing either to the upper left and lower right display positions, or to the upper right and lower left display positions) were equally represented on the four cued trials. The instructions informed subjects that on the cued trials, a memory-set item could appear *only* at one of the two positions indicated by the arrow. The arrow thus partitioned the display into two relevant and two irrelevant items. The prior targets and nontargets never appeared in the relevant display positions on the cued trials. On the noncued trials, two crossed diagonal arrows were presented for 1 sec, which meant that a memory-set item could appear at any one of the four display positions.

Each trial block on Day 5 was thus a randomized factorial combination of the variables of response type (*yes, no*), cue (cued, noncued), and noise item (prior target, prior nontarget, new item). The duration of each stimulus display was 250 msec.

Results

Days 1–4

A split-plot univariate analysis of variance (ANOVA) was performed on subjects' mean RT on the test trials for Days 1–4. Age (old, young) was a between-subjects factor; memory-set size (2–4), response type (*yes, no*), and day (1–4) were within-subjects factors. Trials with abnormally short (less than 200 msec) or long (greater than 2,300 msec) RTs were excluded from analysis, as were error trials; error rates are reported below. (The .05 significance level is adopted throughout the present article.)

All main effects in the overall ANOVA were significant. The effects of age, $F(1, 18) = 18.82$, $MS_e = 162{,}205.5$, and response type, $F(1, 18) = 73.20$, $MS_e = 10{,}071.9$, represent relatively longer RTs for the older subjects and for the *no* trials. There was also a significant increase in RT over memory-set size, $F(2, 36) = 40.83$, $MS_e = 1{,}382.5$, and a significant decrease in RT over days, $F(3, 54) = 56.78$, $MS_e = 9{,}759.8$.

The primary purpose of Days 1–4 was to give subjects extensive practice with specific stimuli in visual search. The expected change in search performance over days is reflected in the significant Memory-Set Size × Day interaction, $F(6, 108) = 4.61$, $MS_e = 810.5$. This interaction represents an improvement in the average rate of search from 32.0 msec per memory-set item on Day 1 to 19.6, 12.0, and 11.5 msec per item on successive days. The degree of improvement in search performance was apparently equivalent for the two age groups, however, as all of the interactions that involved both age and day were nonsignificant ($p > .10$ in each case). The improvement in search rate over practice was corroborated by a significant effect of day, $F(3, 54) = 7.46$, $MS_e = 493.5$, in a separate ANOVA that used the slope of RT over memory-set size for each subject as the dependent variable. The present results are thus consistent with those of Madden and Nebes (1980), Plude and Hoyer (1981), and Salthouse and Somberg (1982), all of whom found that older subjects improve their search performance over practice in virtually the same manner as young subjects.[1] The RT functions ob-

[1] In the Madden and Nebes (1980) and Salthouse and Somberg (1982) studies there was also a significant Age × Memory-Set Size interaction for RT, which was not significant in the analysis of the present data for Days 1–4. The reason for this discrepancy is not obvious, but it should be noted that the average slope values of the RT functions in the present study are substantially lower than those of the previous experiments. Salthouse and Somberg (1982) found that age differences in search rate decreased as the absolute value of these rates decreased (i.e., as performance improved). Plude and Hoyer (1981) noted that age differences in search rate were less pronounced with consistent mapping than with varied mapping. Thus whatever factors lead to reductions in slope values may also reduce the age differences associated with those values. The similarity in search rate for the two age groups on Days 1–4 did not extend to the new

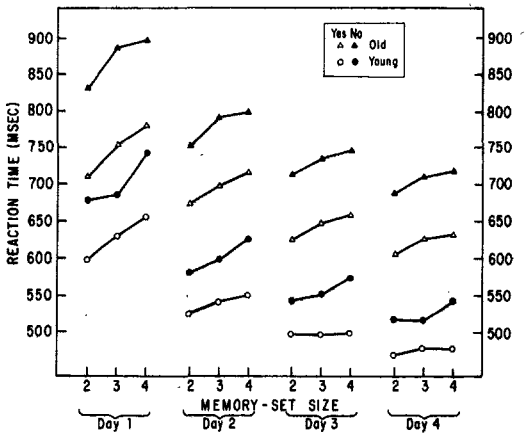

Figure 1. Mean reaction time for Days 1–4 as a function of memory-set size (2, 3, 4). (The two age groups [old, young] and response types [*yes, no*] are plotted separately. Each point is based on a maximum of 720 observations.)

tained on Days 1–4 are plotted for each age group and response type in Figure 1.

In the overall ANOVA, the Response Type × Day interaction, $F(3, 54) = 6.50$, $MS_e = 783.8$, was significant, which reflects a greater difference between *yes* and *no* RTs on Day 1 (97 msec) than on Days 2–4 (74, 73, and 68 msec, respectively). The Age × Response Type × Memory-Set Size interaction, $F(2, 36) = 4.54$, $MS_e = 529.9$, was also significant. This interaction resulted from the fact that the older subjects exhibited a higher RT slope than the young subjects (22.0 vs. 12.1 msec per item) on the *yes* trials but not on the *no* trials (20.4 vs. 20.5 msec per item). A simple effect test, however, indicated that the age difference in slope on the *yes* trials was not significant.

Errors. A univariate ANOVA was also performed on subjects' mean percentage error for Days 1–4. This analysis yielded significant main effects of response type, $F(1, 18) = 28.15$, $MS_e = 62.2$, and day, $F(3, 54) = 5.99$, $MS_e = 13.5$. The three-way interaction of Age × Response Type × Day, $F(3, 54) = 2.84$, $MS_e = 13.8$, was also significant. As is evident in Table 1, this pattern of results occurred because the miss rates of the older subjects were particularly pronounced on Days 1 and 2. The two-way interactions contributing to this pattern were Age × Response Type, $F(1, 18) = 4.49$, $MS_e = 62.2$, Age × Day, $F(3, 54) = 5.20$, $MS_e = 13.5$, and Response Type × Day, $F(3, 54) = 7.09$, $MS_e = 13.8$. Neither the main effect of memory-set size nor any of its associated interactions was significant. There was thus no suggestion from the error data that the improvement in search performance observed for RT was the result of a trade-off between speed and accuracy.

Day 5

A split-plot univariate ANOVA was performed on subjects' mean RT (excluding practice and error trials) for Day 5. Age (old, young) was a between-subjects factor; and cue (noncued, cued), response type (*yes, no*), and noise item type (prior target, prior nontarget, new item) were within-subjects factors.

All main effects were significant. The effects of age, $F(1, 18) = 6.10$, $MS_e = 260{,}623.7$, and response type, $F(1, 18) = 38.70$, $MS_e = 22{,}224.2$, replicate the relatively longer RTs of the older subjects and the *no* trials that were observed on Days 1–4. The main effect of cue, $F(1, 18) = 121.75$, $MS_e = 5{,}724.4$, represents a 107 msec RT advantage on the cued trials ($M = 687$ msec) as compared with the noncued trials ($M = 794$ msec). The noise item main effect, $F(2, 36) = 3.19$, $MS_e = 2{,}592.3$, is the result of an overall longer RT associated with the presence of a prior target (752 msec) than with the pres-

Table 1
Mean Percentage Error For Each Age Group on Days 1–4

	Day				
Age group	1	2	3	4	*M*
Old					
Misses	11.86	9.82	7.14	5.29	8.53
False alarms	3.52	2.97	2.88	3.35	3.18
Young					
Misses	5.29	2.98	4.18	3.72	4.04
False alarms	1.40	1.40	2.23	1.95	1.74

task presented on Day 5, however. The Age × Cue interaction obtained on Day 5 (see Table 2) resulted from a relatively greater increase in older subjects' RT, as the number of display items requiring comparison increased.

ence of either a prior nontarget (735 msec) or a new, unpracticed item (734 msec).

Only two interactions were significant. The Age × Cue interaction, $F(1, 18) = 10.85$, $MS_e = 5{,}724.4$, suggests age differences in using the cue during the search task (see Table 2). Simple effect tests demonstrated that although the RT facilitation associated with the cued trials was highly significant for both age groups, $F(1, 9) > 25.0$, in each case, the absolute magnitude of the cuing effect was larger for the older subjects (140 msec) than for the young subjects (75 msec). It is also appropriate to view the Age × Cue interaction as a change in the magnitude of the age difference as a function of the cue. The age difference in RT was significant on both the noncued trials, $F(1, 18) = 7.18$, $MS_e = 158{,}851.8$, and the cued trials, $F(1, 18) = 4.76$, $MS_e = 107{,}496.3$, although this difference was larger in magnitude on the noncued trials (195 msec) than on the cued trials (131 msec). Since all of the display items require inspection only on the noncued trials, this change in the size of the age difference is consistent with the increased vulnerability to display-size effects previously reported for older subjects (Rabbitt, 1965). Since the stimulus duration (250 msec) employed on Day 5 was relatively brief, the increased age difference on the noncued trials probably reflects an age-related slowing in the rate at which information can be extracted from a visual display (Walsh & Prasse, 1980).

The Response Type × Noise Item interaction, $F(2, 36) = 7.73$, $MS_e = 1{,}629.7$, represents changes in the effects of the highly familiar stimuli across the *yes* and *no* trials (see Figure 2). The paired comparisons that define the distraction associated with the Days 1–4 stimuli (Taylor, 1977) were thus performed on the *yes* and *no* trials separately. For the *no* trials, neither the prior target versus new item comparison nor the prior nontarget versus new item comparison was significant. On the *yes* trials, however, search RT was increased in the presence of both the familiar targets and the familiar nontargets. The prior target versus new item comparison was significant, $F(1, 18) = 5.01$, $MS_e = 2{,}420.5$, as was the prior nontarget versus new item comparison, $F(1, 18) = 14.75$, $MS_e = 869.7$. The amount of distraction provided by these highly familiar stimuli was equivalent for the two age groups, however, as all interactions that involved both age and noise item type were nonsignificant ($p > .10$ in each case). The mean increase in RT associated with the highly familiar stimuli on the *yes* trials was 35 msec for the older subjects and 15 msec for the young subjects. On the cued-*yes* trials (when the familiar items only appeared in target-irrelevant locations), the distraction effect was 27 msec for the older subjects and 15 msec for the young.

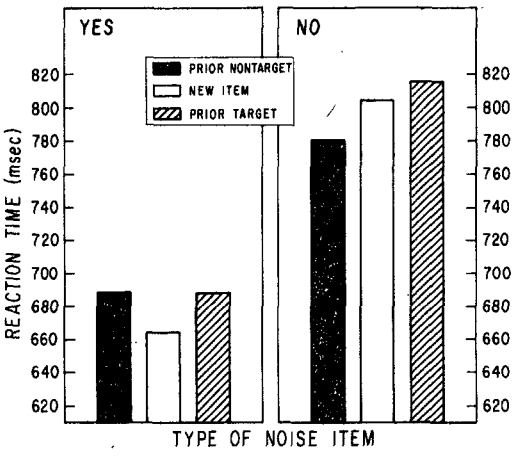

Figure 2. Mean reaction time on Day 5 for each type of noise item (prior target, new item, prior nontarget). (The two response types [*yes, no*] are plotted separately. Each bar is based on a maximum of 840 observations.)

Table 2
Mean Reaction Time (RT) and Mean Percentage Error by Age and Cue on Day 5

	Trial type	
Age group	Noncued	Cued
Old		
RT	892	752
Misses	8.30	3.22
False alarms	.47	.84
Young		
RT	697	621
Misses	5.44	3.81
False alarms	1.66	.72

Errors. A univariate ANOVA performed on the mean percentage error for Day 5 yielded significant main effects of response type, $F(1, 18) = 70.42$, $MS_e = 15.5$, and cue, $F(1,$

18) = 19.37, MS_e = 10.3. These effects represent, respectively, a higher miss rate (5.19%) than false alarm rate (.92%) and a higher error rate on the noncued trials (3.97%) than on the cued trials (2.14%). Also significant were the Response Type × Cue, $F(1, 18)$ = 18.23, MS_e = 7.8, and Age × Response Type × Cue, $F(1, 18)$ = 10.89, MS_e = 7.8, interactions. These interactions occurred because the miss rates were in accord with the cue and Age × Cue effects obtained for RT, whereas the false alarm rates were quite low and did not exhibit a consistent pattern (see Table 2).

The Response Type × Noise Item interaction, $F(2, 36)$ = 7.44, MS_e = 12.3, was also significant. As seen in Table 3, the error pattern corresponds closely to the RT data in that the highly familiar targets and nontargets led to increased error rates on the *yes* trials (misses), but not on the *no* trials (false alarms).[2]

Table 3
Mean Percentage Error for Each Noise Item Type on Day 5

Error type	Noise item type		
	Prior nontarget	New item	Prior target
Misses	6.60	3.74	5.26
False alarms	.24	1.43	.95

Discussion

Improvement in performing the search task over Days 1–4 was evident in the diminished effect of memory-set size on RT over practice; as in previous studies (e.g., Salthouse & Somberg, 1982), the rate of this improvement was at least as rapid for the older subjects as for the young subjects. According to the perceptual noise hypothesis of Rabbitt (1965, 1968) and Layton (1975), the distracting effects of the highly familiar (Days 1–4) stimuli in a subsequent search task should have been relatively greater for the older subjects. The results of the Day-5 search task did not support this hypothesis, however. The RT effects on Day 5 must represent attentional disruption to some extent, not simply response competition, since RT on the *yes* trials increased in the presence of the prior targets; the highly practiced response and the current response were compatible. Yet the degree of this attentional disruption was equivalent for the two age groups. The present results resemble those of Wright and Elias (1979), who found (using a relatively low level of practice) that the presence of noise items in target-irrelevant display locations led to equivalent RT increases, as compared with a no-noise condition for young and older subjects. The present experiment demonstrated that the distraction-related consequences of extensively practiced stimuli were the same for young and older adults.

Both of the age groups in the present experiment exhibited significantly lower RTs on the cued trials of Day 5 than on the noncued trials, and the magnitude of this effect was even larger for the older subjects. Since the cued trials specifically required subjects to ignore irrelevant information, the pattern of cuing effects obtained is also incompatible with the perceptual noise hypothesis. The present experiment is the first demonstration that older subjects can successfully use a spatial cue to reduce search RT. Although a similar cuing effect can be inferred from a between-experiments comparison (for the "contrasting information" condition) of the

[2] Shiffrin and Schneider (1977, Experiment 4d) also found that the presence of highly familiar stimuli disrupted search on the *yes* trials but not on the *no* trials. These authors employed a multiple-display search task in which accuracy was the dependent variable of interest; RT was not measured. All displays contained two target-relevant and two target-irrelevant locations. Items that had previously been targets in a consistent mapping search task were used as noise stimuli. The baseline error rate (i.e., when familiar items were not present in the displays) was 16% misses and 4% false alarms. The presence of a single prior target in an irrelevant display location increased the miss rate to 38% but did not affect the false alarm rate. Shiffrin and Schneider did not speculate as to why the distracting effects of the familiar stimuli were restricted to the *yes* trials. One potentially important factor may be the variability associated with each response type. In the present experiment, the RT error variance associated with the noise item effect on Day 5 was higher on the *no* trials (2,359.0) than on the *yes* trials (1,862.9). This increase in variance would make it more difficult for reliable RT differences to emerge on the *no* trials than on the *yes* trials. The reasons for this difference in variability, however, also need to be clarified.

Farkas and Hoyer (1980) data, the spatial cue in their study also informed subjects of the exact display position at which the target would appear. The paradigm used by Wright and Elias (1979) did not include more than one target-relevant position. The presence of a spatial cue regarding target location, like the presence of a familiar stimulus dimension for grouping memory-set items (Madden, 1982; Thomas, Waugh, & Fozard, 1978) and practice with consistently mapped stimuli (Madden & Nebes, 1980; Plude & Hoyer, 1981; Salthouse & Somberg, 1982), is an opportunity for improving search performance that both young and older adults can successfully exploit.

Despite the similarity of the two age groups in using the spatial cue, the older subjects were more vulnerable to the attentional demands of the Day-5 search task. Age differences in both RT and miss rate were larger when all four display items required inspection (noncued trials) than when only two items required inspection (cued trials). Similar interactions between age and processing load have been obtained in the majority of the search experiments that have included older subjects (Cerella et al., 1980). This pattern of results, however, is more accurately described as an age-related deficit in attending to relevant information than as a deficit in ignoring irrelevant information. In fact, Rabbitt's (1965) own results would not necessarily lead to the adoption of the perceptual noise hypothesis, since in his experiment there was no specific dimension that partitioned relevant and irrelevant items (see Hoyer & Plude's, 1980, distinction between *selective search* and *selective filtering* tasks). The only search-paradigm data that do support the perceptual noise hypothesis appeared in the Farkas and Hoyer (1980) card-sorting experiments. These authors found that the sorting time of older subjects was slowed more than that of the young by the presence of irrelevant display information that was physically similar to the target; this age difference persisted even when the irrelevant items were restricted to those display positions that could not potentially contain the target item. The stimuli used by Farkas and Hoyer were quite small (6 × 2.5 mm), however, and their results may thus reflect acuity differences as well as attentional differences.

Finally, it is important to note that the attentional disruption present on the *yes* trials of Day 5 was significant for both prior-target and prior-nontarget noise items. This result would not be expected on the basis of the Shiffrin and Schneider (1977) theory, which proposes that the distracting effects of familiar stimuli arise from the automatic responses that these items come to elicit after extensive consistent mapping practice. In theory, subjects should not develop such automatic responses for the nontarget items, since there are nontargets present in the stimulus display of a visual-search task regardless of whether the correct response is *yes* or *no*. The Shiffrin and Schneider experiments provide considerable evidence that automatic target detection is one consequence of experience with consistent mapping. The present results suggest that the acquisition of information regarding the set of nontarget items also occurs (cf. Prinz, 1977; Rabbitt et al., 1979). It need not be assumed, however, that automatic detection is responsible for the distraction effects observed in the present experiment; familiarity could be the critical variable. The use of new-item control trials on Day 5 did ensure that the distraction effects were the result of stimulus identity, not just stimulus presence. Yet these effects might have also appeared if on Days 1–4 subjects had been given 2,000 trials of practice in which the total stimulus population remained constant but varied stimulus–response mapping was employed. There appear to be different forms of attentional disruption during visual search (e.g., Flowers, Polansky, & Kerl, 1981). The role of automatic detection in these different forms is an open and important question.

References

Anders, T. R., Fozard, J. L., & Lillyquist, T. D. Effects of age upon retrieval from short-term memory. *Developmental Psychology,* 1972, *6,* 214–217.

Cerella, J., Poon, L. W., & Williams, D. M. Age and the complexity hypothesis. In L. W. Poon (Ed.), *Aging in the 1980s: Psychological issues.* Washington, D.C.: American Psychological Association, 1980.

Chase, W. G. Elementary information processes. In W. K. Estes (Ed.), *Handbook of learning and cognitive*

processes (Vol. 5): *Human information processing.* Hillsdale, N.J.: Erlbaum, 1978.

Farkas, M. S., & Hoyer, W. J. Processing consequences of perceptual grouping in selective attention. *Journal of Gerontology,* 1980, *35,* 207–216.

Flowers, J. H., Polansky, M. L., & Kerl, S. Familiarity, redundancy, and the spatial control of visual attention. *Journal of Experimental Psychology: Human Perception and Performance,* 1981, *7,* 157–166.

Fozard, J. L. Speed of mental performance and aging: Costs of age and benefits of wisdom. In F. J. Pirozzolo & G. J. Maletta (Eds.), *Behavioral assessment and psychopharmacology* (Vol. 2). New York: Praeger, 1981.

Hoyer, W. J., & Plude, D. J. Attentional and perceptual processes in the study of cognitive aging. In L. W. Poon (Ed.), *Aging in the 1980s: Psychological issues.* Washington, D.C.: American Psychological Association, 1980.

Layton, B. Perceptual noise and aging. *Psychological Bulletin,* 1975, *82,* 875–883.

Madden, D. J. Age differences and similarities in the improvement of controlled search. *Experimental Aging Research,* 1982, *8,* 91–98.

Madden, D. J., & Nebes, R. D. Aging and the development of automaticity in visual search. *Developmental Psychology,* 1980, *16,* 377–384.

Plude, D. J., & Hoyer, W. J. Adult age differences in visual search as a function of stimulus mapping and processing load. *Journal of Gerontology,* 1981, *36,* 598–604.

Prinz, W. Memory control of visual search. In S. Dornič (Ed.), *Attention and performance VI.* Hillsdale, N.J.: Erlbaum, 1977.

Rabbitt, P. Age and time for choice between stimuli and between responses. *Journal of Gerontology,* 1964, *19,* 307–312.

Rabbitt, P. An age-decrement in the ability to ignore irrelevant information. *Journal of Gerontology,* 1965, *20,* 233–238.

Rabbitt, P. Age and use of structure in transmitted information. In G. A. Talland (Ed.), *Human aging and behavior.* New York: Academic Press, 1968.

Rabbitt, P., Cumming, G., & Vyas, S. Improvement, learning and retention of skill at visual search. *Quarterly Journal of Experimental Psychology,* 1979, *31,* 441–459.

Salthouse, T. A., & Somberg, B. L. Skilled performance: The effects of adult age and experience on elementary processes. *Journal of Experimental Psychology: General,* 1982, *111,* 176–207.

Schneider, W., & Shiffrin, R. M. Controlled and automatic human information processing: I. Detection, search, and attention. *Psychological Review,* 1977, *84,* 1–66.

Shiffrin, R. M., & Schneider, W. Controlled and automatic human information processing: II. Perceptual learning, automatic attending, and a general theory. *Psychological Review,* 1977, *84,* 127–190.

Taylor, D. A. Time course of context effects. *Journal of Experimental Psychology: General,* 1977, *106,* 404–426.

Thomas, J. C., Waugh, N. C., & Fozard, J. L. Age and familiarity in memory scanning. *Journal of Gerontology,* 1978, *33,* 528–533.

Walsh, D. A., & Prasse, M. J. Iconic memory and attentional processes in the aged. In L. W. Poon, J. L. Fozard, L. S. Cermak, D. Arenberg, & L. W. Thompson (Eds.), *New directions in memory and aging: Proceedings of the George A. Talland Memorial Conference.* Hillsdale, N.J.: Erlbaum, 1980.

Wright, L. L., & Elias, J. W. Age differences in the effects of perceptual noise. *Journal of Gerontology,* 1979, *34,* 704–708.

Received January 13, 1982
Revision received March 26, 1982 ■