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# Aging, Distraction, and the Benefits of Predictable Location

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Three experiments examined the impact on reading time for younger and older adults in the absence vs. presence of distraction (marked by font type) in either fixed predictable locations (Experiments 1 and 2) or unpredictable locations (Experiment 3). Consistent with earlier work (S. L. Connelly, L. Hasher, & R. T. Zacks, 1991), older adults were markedly disrupted, relative to young adults, when distraction was present in unpredictable locations. When the location of distraction was fixed, however, the very large disadvantage that older adults otherwise experienced (slowed by as much as 46 s) diminished substantially (to as little as 2 s). Fixed location also eliminated the relatedness effect, by which older adults are especially susceptible to distraction from meaningfully related material.

Older adults frequently report difficulty in locating an object in a cluttered field (Kosnik, Winslow, Rasinski, & Sekuler, 1988). These self-report data are consistent with findings in the extensive literature on visual search (e.g., Madden, 1983; Plude & Hoyer, 1981, 1985, 1986; Rabbitt, 1965; Scialfa & Kline, 1988; Scialfa, Kline, & Lyman, 1987), in which age differences in response time and errors tend to increase as more distractors are present in a selection environment. Even when operating in a domain of expertise such as aviation (Morrow, Leirer, & Altieri, 1992), miniature golf (Molander & Bäckman, 1994), or reading (Connelly, Hasher, & Zacks, 1991; Shaw, Rypma, & Toffle, 1992), older adults are more disrupted by distraction than are younger adults. For example, the Connelly et al. (1991) experiments required participants to read aloud a passage that was typed in one font style and presented either in the absence or the presence of one of three types of distraction that appeared in a different font style: meaningless strings of *x*s, words that were meaningfully unrelated to the text, and words that were related to the text. Older adults were considerably more slowed in the presence of each type of distraction than were younger adults, although the younger adults also showed evidence of slowed reading in the presence of distraction. Although story-related distractors were no more disruptive for young adults than were unrelated distractors, they were indeed more bothersome to older adults. These findings join a larger literature in showing an age-related increase in vulnerability to distraction across a variety of tasks (e.g., Layton, 1975; McDowd & Filion, 1992; Rabbitt, 1965).

The greater distractibility exhibited by older adults, even under circumstances in which they are experts, seems especially troublesome given that most natural environments contain many sources of distraction. Consider the problem of reading a newspaper: A front page contains several articles that are in close spatial proximity to one another. How does an older adult, whose ability to cope with text-based distraction appears to be impaired (Connelly et al., 1991; Shaw et al., 1992), read a single article efficiently? Or, by extension, listen to the news on the radio while preparing dinner from a cookbook? Or have a conversation amidst others? Or traverse a busy intersection? It seemed important then to consider the possibility that the environment, which not only contains multiple sources of distraction, also affords some cues that can serve to reduce older adults' susceptibility to the disruptive effects of distraction.

The attention literature offers two sets of tasks in which the results converge to suggest one such environmental factor: the spatial predictability of distraction. In visual search studies in which participants are cued for the probable location of an upcoming target, older adults are as able as younger adults to select the target efficiently in spite of the presence of distractors (Hartley, Kieley, & Slabach, 1990; Madden, 1983; Madden & Plude, 1993; Nissen & Corkin, 1985; Plude & Doussard-Roosevelt, 1989; Plude & Hoyer, 1986; Wright & Elias, 1979).

A second relevant observation can be made on the basis of findings in the negative priming literature. The negative priming effect is seen in a selection task in which participants respond to the location of a target in the presence of a distractor (e.g., Tipper & McLaren, 1990). Relative to trials in which the target occurs in a new location, participants are slower to respond on critical trials in which the current target occupies the location that the immediately previous distractor had occupied. The main explanation for this slowing is that, under some circumstances, selection processes include inhibition that is applied to distractors (including their location; see May, Kane, & Hasher, 1995). Two inhibition systems may exist, one applied to the location of distractors and one applied to their identity

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(Connelly & Hasher, 1993). Although older adults often fail to show inhibition to the identity of distractors, they clearly show location inhibition effects that are equivalent to those shown by younger adults (cf. Stoltzfus, Hasher, Zacks, Ulivi, & Goldstein, 1993, with Connelly & Hasher, 1993). Researchers have obtained persistent location inhibition by both younger and older adults even in a circumstance in which the location of items is largely irrelevant to the task, suggesting that location is a fundamental principle for the ordering of information (see Connelly & Hasher, 1993, Experiment 3).

On the basis of these two lines of work within the selective attention literature, we thought it plausible that aspects of location may serve as a powerful, naturally occurring cue for older adults to capitalize on to resist the otherwise disrupting effects of ongoing distraction. To assess this possibility, we used the Connelly et al. (1991) reading aloud task and provided older and younger adults with target text that was interrupted with distraction in either predictable and fixed locations (Experiments 1 and 2) or in random locations (Experiment 3). We compared reading times and comprehension for passages read with or without distraction. The three studies confirm earlier findings that spatially unpredictable distraction has a markedly disruptive effect on reading, an effect that is particularly severe for older adults (Connelly et al., 1991; Shaw et al., 1992). The results also confirm the central hypothesis that spatially fixed and predictable distraction can substantially reduce the negative impact of such materials on older adults.

## Experiment 1

In the Connelly et al. (1991) studies, distracting material, if present, was randomly interspersed amidst the target text, interrupting it every few words. In this experiment, we used the same materials but placed the distracting materials on every other line of a page. Thus, with respect to the target text, distraction occurred in a fixed location. Note that actually fixing the location of distraction, rather than simply making location somewhat predictable, seemed critical because other results (Shaw et al., 1992) have suggested that predictability alone is insufficient to eliminate the effect of distraction on older adults. In the Shaw et al. (1992) study, distractors were interspersed, predictably occurring as every other word of an otherwise continuous text.

If older adults can use spatially fixed location information to successfully ignore distraction (e.g., Hartley et al., 1990; Plude & Doussard-Roosevelt, 1989; Plude & Hoyer, 1986), then the age-related slowdown in reading speed seen in earlier studies (Connelly et al., 1991; Shaw et al., 1992) should be greatly attenuated. To create the strongest test of this hypothesis, we used the most disruptive distractor condition from Connelly et al. (1991), the one in which distractors were meaningfully related to the target text. We then compared reading time and comprehension in the presence versus absence of distraction.

### Method

*Participants.* Thirty-two younger ($M$ age = 18.2 years, range = 17–22) and 32 older ($M$ age = 68.8 years, range = 62–75) adults participated in this study. Younger participants were students enrolled in an introductory psychology course who received course credit for their participation. Older participants were contacted through a participant registry maintained by the Duke University Center for the Study of Aging and Human Development. Older volunteers were paid $5 and reimbursed for parking expenses. In this study older participants were more highly educated (mean years of education = 15.4, $SD$ = 2.4) than were younger adults (mean years of education = 12.5, $SD$ = 0.8), $t(62) = 6.38$. However, younger and older adults did not differ in verbal ability, as assessed by the Wechsler Adult Intelligence Scale—Revised Vocabulary subtest ($M$ scores = 53.0 and 52.3, respectively; Wechsler, 1981), $t < 1$.

*Design.* Younger and older participants read aloud and then answered multiple-choice comprehension questions about stories that were presented in two different conditions. In the control condition, no distracting material appeared between lines of target text. In the experimental condition, text-related words appeared as distractors between every other line of target text. The resulting design was a 2 (age) × 2 (condition) mixed factorial, with distraction condition tested within-subjects.

*Materials.* Twelve critical stories plus one practice story were taken from Connelly et al. (1991). Each story was approximately 125 words. Story text was printed in roman (upright) font type (Apple Laserwriter 13-pt. Bookman). In the experimental condition, four different distracting words or short phrases were presented in the italicized version of a different font (13-pt. New Century Schoolbook; see Figure 1), and these words formed the content of every other line of a page. (In the original Connelly et al. work, target text appeared in italics and distraction in roman type.) Each distractor word or phrase was meaningfully related to the story and appeared approximately 15 times with the provision that no word or phrase ever repeat itself successively. Distraction, when present, appeared on every other line of a page. The lines containing distraction began with a string of four *x*s in the experimental condition and remained blank in the control condition, thus maintaining an equal distance between each line of target text. This format was modeled after that used in earlier work on reading in the presence of distraction (Willows & MacKinnon, 1973). Each participant read six consecutive stories in each condition, with the order of conditions counterbalanced across participants. Across participants, each story served equally often in control and experimental conditions. A set of four multiple-choice questions was also taken from Connelly et al. Each question contained six choices: the correct answer, a distractor word or phrase taken from the distractor condition (the foil answer), and four other plausible answers.

*Procedure.* Participants were tested individually and began by reading and answering questions about 1 practice and then 12 test stories. All participants were told before testing that they would be reading a series of stories aloud for comprehension and that a set of four questions would follow each story. Participants were instructed to read clearly and

The Volunteer

Bertha McKee was working as a volunteer at the information
*xxxx gallery college in a carton gallery college Van Dyck*
booth at the museum. She brushed off the snow which had fallen
*xxxx in a carton gallery college Van Dyck gallery Van Dyck*
on her as she came from her high school. She took her seat in
*xxxx gallery in a carton Van Dyck college in a carton gallery*
the round booth and waited for the evening's art viewers to
*xxxx Van Dyck in a carton gallery college Van Dyck college*
arrive. She liked her job because it allowed her to see all of
*xxxx in a carton college Van Dyck in a carton gallery Van Dyck*
the different types of art that moved through the displays.
*xxxx college gallery college gallery college in a carton*
Bertha picked up a box full of new pamphlets that told of
*xxxx Van Dyck gallery college in a carton college gallery*
upcoming displays. When she looked through one of them she
*xxxx gallery in a carton college Van Dyck college gallery*
became very excited. One of her favorite painters, Van Gogh, was
*xxxx Van Dyck in a carton college Van Dyck in a carton gallery*
being highlighted in an exhibition soon. She couldn't wait.
*xxxx in a carton Van Dyck college in a carton gallery*

*Figure 1.* Example display (related distractor condition) for Experiment 1.

Table 1
*Mean Reading Times and Standard Deviations (in Seconds) Per Condition for Younger and Older Adults in Experiments 1–3*

| Age group | Reading condition | | | |
|---|---|---|---|---|
| | Control | xs[a] | Unrelated[a] | Related |
| | Experiment 1 | | | |
| Younger | | | | |
| *M* | 37.6 | | | 38.2 |
| *SD* | 3.6 | | | 4.1 |
| Older | | | | |
| *M* | 47.3 | | | 49.5 |
| *SD* | 5.4 | | | 5.8 |
| | Experiment 2 | | | |
| Younger | | | | |
| *M* | 34.2 | 35.6 | 35.7 | 36.6 |
| *SD* | 3.9 | 4.6 | 4.2 | 4.9 |
| Older | | | | |
| *M* | 44.7 | 47.8 | 48.6 | 50.5 |
| *SD* | 5.9 | 7.5 | 7.3 | 7.7 |
| | Experiment 3 | | | |
| Younger | | | | |
| *M* | 34.9 | 36.8 | 49.7 | 51.4 |
| *SD* | 6.2 | 6.1 | 14.2 | 18.0 |
| Older | | | | |
| *M* | 46.9 | 52.0 | 84.2 | 93.6 |
| *SD* | 6.4 | 8.8 | 29.3 | 37.9 |

[a] Conditions not in Experiment 1.

accurately, as their reading would be tape recorded. The instructions also emphasized reading at a pace that would ensure comprehension. They were also asked not to use their fingers as a place marker during reading. The experimenter presented each story on a single sheet of paper that was placed face down in front of the participant. The participant then was cued to turn over the page and start reading with the title at the top of each page. When finished, the participant turned the page over and was immediately presented with a sheet containing four multiple-choice questions to be answered at a comfortable pace. If uncertain about the correct answer, participants were encouraged to circle their best guess. Before presentation of the 1st story in the experimental condition, participants were instructed to ignore any distracting material printed in italicized type.

### *Results and Discussion*

*Reading time.* Here, and throughout this series of studies, we set the alpha level at .05. We examined mean reading times for experimental and control stories (see Table 1) using a 2 (age) × 2 (condition) analysis of variance (ANOVA). Overall, older participants read more slowly than their younger counterparts, $F(1, 62) = 79.90$, $MSE = 44.13$. Reading was on average 1.4 s slower when distraction was present than when it was not, $F(1, 62) = 29.42$, $MSE = 2.18$. The Age × Condition interaction was significant, $F(1, 62) = 8.94$, with the disruptive effect of distraction being reliable for both older and younger adults, $F(1, 31) = 23.98$, $MSE = 3.21$, and $F(1, 31) = 5.65$, $MSE = 1.14$, respectively. However, the disruption effect was larger for older adults, whose reading time, when distracted, was slowed by 2.2 s, than for younger adults, whose reading time was slowed by 0.6 s.

*Comprehension accuracy.* The mean number of correct answers per story (out of a possible four) is shown in Table 2. Overall, younger adults answered more questions correctly than older adults, $F(1, 62) = 4.01$, $MSE = 0.19$. Also, participants answered more questions correctly in the control than in the experimental condition, $F(1, 62) = 14.67$, $MSE = 0.09$. However, age and condition did not interact, $F(1, 62) = 1.77$. Both older and younger adults showed small increases in errors after reading a story with distraction relative to reading a story without distraction.

Further analysis of the subset of comprehension errors that were foil errors (in which the participant selected an item shown as a text-related distractor) provided an additional measure of participants' susceptibility to distraction when compared with the baseline control condition. Mean number of foil answers per story in each condition are presented in Table 2. There were more such errors following experimental than control stories, $F(1, 62) = 20.54$, $MSE = 0.04$. No other effects were significant ($F$s < 1.0). Older participants, although more slowed by distraction in their reading times than younger participants, were no more likely than younger participants to use the distracting information to answer a comprehension question.

The circumstances in which this experiment was conducted (including the sources of participants, materials, and unconstrained times of testing participants[1]) differed from those of Experiment 1 of Connelly et al. (1991) only in the location of the distractors and when the experiment was conducted (actually, a few months apart). As a result, the disruption induced by each spatial arrangement of distractors can be tentatively compared across these two studies. First, a comparison of reading times for control stories indicates that they did not differ across the two studies for younger adults ($F < 1$) although they did tend to differ for older adults who were slightly faster in our study (mean reading time = 47.3 s) than in Connelly et al. (1991; $M = 50.2$ s), $F(1, 54) = 3.18$, $MSE = 35.46$, $p = .08$. The disruption effects (distractor minus control reading time) seen in our experiment, 2.2 s for older adults and 0.6 s for younger adults, are far smaller than the comparable disruption effects reported by Connelly et al. (1991), with 75.4 s and 26.8 s for older and younger adults, respectively. Similarly, the disruptive effects of distraction on comprehension were considerably smaller in our study than they were in Connelly et al.

Thus, the placement of meaningful text-related distraction in predictable, fixed locations amidst the target text drastically reduced distraction effects reported earlier for both age groups. Reductions in reading time were especially pronounced for older adults. However, placing distraction in fixed locations did not eliminate the effects of distraction entirely, and, as mea-

[1] As in the Connelly et al. (1991) experiments, no control was exercised over the time at which participants were tested. It is now known that some control should be exercised because peak energy periods of younger and older adults do not coincide, and, at least under some circumstances, a mismatch between optimal energy times and time of testing can have marked implications for age differences in performance (May & Hasher, 1995; May, Hasher, & Stoltzfus, 1993).

Table 2
*Mean Number Correct and Mean Proportion of Foil Errors and Standard Deviations Per Condition for Younger and Older Adults in Experiments 1–3*

| Age group | Reading condition | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Control | | xs[a] | | Unrelated[a] | | Related | |
| | Correct | Foil | Correct | Foil | Correct | Foil | Correct | Foil |
| | | | | Experiment 1 | | | | |
| Younger | | | | | | | | |
| *M* | 3.51 | 0.22 | | | | | 3.24 | 0.44 |
| *SD* | 0.36 | 0.20 | | | | | 0.36 | 0.24 |
| Older | | | | | | | | |
| *M* | 3.29 | 0.32 | | | | | 3.16 | 0.43 |
| *SD* | 0.37 | 0.25 | | | | | 0.40 | 0.25 |
| | | | | Experiment 2 | | | | |
| Younger | | | | | | | | |
| *M* | 3.41 | 0.22 | 3.33 | 0.27 | 3.31 | 0.28 | 3.14 | 0.46 |
| *SD* | 0.46 | 0.30 | 0.50 | 0.31 | 0.42 | 0.27 | 0.61 | 0.40 |
| Older | | | | | | | | |
| *M* | 3.30 | 0.29 | 3.27 | 0.38 | 3.12 | 0.35 | 3.12 | 0.49 |
| *SD* | 0.45 | 0.34 | 0.53 | 0.38 | 0.47 | 0.31 | 0.56 | 0.46 |
| | | | | Experiment 3 | | | | |
| Younger | | | | | | | | |
| *M* | 3.41 | 0.30 | 3.63 | 0.23 | 3.45 | 0.30 | 3.14 | 0.62 |
| *SD* | 0.49 | 0.40 | 0.32 | 0.26 | 0.41 | 0.25 | 0.39 | 0.36 |
| Older | | | | | | | | |
| *M* | 3.38 | 0.23 | 3.00 | 0.54 | 3.38 | 0.29 | 2.79 | 1.02 |
| *SD* | 0.50 | 0.36 | 0.38 | 0.36 | 0.63 | 0.44 | 0.51 | 0.48 |

[a] Conditions not in Experiment 1.

sured by reading times, older adults remained slightly more vulnerable to distraction than younger adults.

## Experiment 2

Our initial assumption was that older adults would focus efficiently on target information if the location of distraction were fixed and predictable. By contrast with earlier work in which the location of distraction was unpredictable (Connelly et al., 1991; Shaw et al., 1992), that hypothesis was supported in Experiment 1, where very small disruption effects were seen for older adults. However, in the earlier studies that demonstrated pronounced age-related vulnerability to meaningful distraction, participants encountered distraction approximately every 4 words of target text (see Connelly et al., 1991). By contrast, in Experiment 1, participants read an entire line of approximately 10 to 12 words before being exposed to a single distractor. Thus, it was possible that the reduction in distraction effects in Experiment 1 relative to those seen in earlier studies was due not to spatial predictability but rather to benefits stemming from the increased predictability afforded by longer uninterrupted sequences of continuous discourse (see Glanzer & Nolan, 1986). Furthermore, in the earlier Connelly et al. (1991) studies, distraction occurred on the same text line as did the target text, whereas in Experiment 1 distraction occurred on different lines from target text. Thus, in Experiment 2 we used a spatial array in which target text was interrupted more frequently than in Experiment 1. In addition, distraction occurred on the same line as the target text. As in Experiment 1, however, the location of target and distractor text was fixed and predictable.

To strengthen the test of the usefulness of spatial cuing for older adults, we modified the materials used in Experiment 1 in three ways. First, distracting material occurred after approximately every four words of target text, as it did in the original Connelly et al. (1991) work. Second, because enhanced perceptual discriminability between targets and distractors can eliminate age differences (Shaw, 1991; but see also Shaw et al., 1992), we made the distraction particularly difficult to ignore by using the same font (with the target material in italics) for both types of text.[2] (In Experiment 1, two different fonts were used.) Third, we added two other types of distraction (strings of *x*s and text-unrelated words) used by Connelly et al. (Experiment 2) to assess whether the age-related benefits of spatial cuing in this context would be limited to material previously shown to be less distracting (for older adults at least) than the meaningfully related distraction used in Experiment 1.

[2] To ensure that target text and distracting material in Experiment 2 were indeed less discriminable than in Experiment 1, we gave 12 participants a target–distractor word pair representing the fonts used in each of the experiments. We asked students to choose which pair of target and distractor words was more discriminable. All participants selected the pair from Experiment 1.

This experiment posed a very difficult challenge to the hypothesis that spatial predictability is a sparing factor for the handling of distraction. Relative to Experiment 1, the target text was more frequently interrupted and more similar in appearance to distracting text.

## Method

*Participants.* Participants included 32 younger (*M* age = 19.1 years, range = 18–22) and 32 older (*M* age = 68.7 years, range = 62–75) adults who were selected in the same way as in Experiment 1. A comparison of participant groups revealed that older adults had more formal education than did younger adults (*M*s = 15.9 and 12.8 years, respectively), $t(62) = 7.03$. In addition, older adults attained higher vocabulary scores than younger adults (*M*s = 34.4 and 24.4, respectively), $t(62) = 5.25$, on the Extended Range Vocabulary Test, version 3 (ERVT; Educational Testing Service, 1976), which is a difficult multiple-choice test used because of its greater sensitivity than other tests at higher ranges of verbal ability.

*Design.* Reading aloud time and comprehension were again compared in younger and older adults across three distractor conditions and a control condition. In addition to the text-related distractor condition used in Experiment 1, the two new conditions included words that were unrelated to the text and strings of *x*s. The design was a 2 (age) × 4 (condition) mixed factorial.

*Materials and procedure.* The materials and procedures from Experiment 1 were reused here, with the following exceptions: Two distractor conditions were added. Text-unrelated distractors were words or short phrases matched to text-related distractors for length and frequency (Kuçera & Francis, 1967) but that had no meaningful connection to the topics in the text. Meaningless distractors were created by replacing the letters in a distractor word or phrase with *x*s. In addition, all materials were presented in the same font (Jetware Laserjet 16 pt. Helvetica), with target text presented in italicized type and distracting material in roman type. Presentation of the 12 test stories across four conditions yielded 3 stories per condition. The order each condition was presented in was counterbalanced across participants. In addition, each story was presented in each of the four conditions equally often across participants.

The display was arranged by dividing a landscape-formatted page (an $8\frac{1}{2} \times 11$ in. page held sideways) into five columns, with distracting material always occupying the second and fourth blocks and target text occupying the first, third, and fifth blocks (see Figure 2). For the control condition, the second and fourth blocks of space were left empty. Text was read across a single line, ensuring that distraction was encountered approximately after every fourth word of target text.

A modification in testing procedure was adopted because recent research has shown substantial effects of synchrony between the time at which testing occurs and individuals' optimal time of day on the performance of both younger and older adults (May & Hasher, 1995; May, Hasher, & Stoltzfus, 1993). Furthermore, May et al. reported norms suggesting that optimal times are at their peak for most older adults in the morning and for many younger adults late in the day. The following general procedure was adopted for testing participants: (a) All older adults were tested prior to 1 p.m., and (b) no younger adults were tested prior to noon. Because testing rooms had no natural light and were sound screened, ambient light and noise were controlled across time of day. In Experiment 1, however, participants were tested at unconstrained times between 9 a.m. and 6 p.m.

## Results and Discussion

*Reading time.* Reading times (see Table 1) were subjected to a 2 × 4 mixed-design ANOVA. Older adults generally read more slowly than younger adults, $F(1, 62) = 101.97$, $MSE = 95.87$, and, overall, reading times differed across the four conditions, $F(3, 186) = 12.15$, $MSE = 15.19$. The interaction between age and condition approached but did not attain significance, $F(3, 186) = 2.26$, $MSE = 15.19$, $p = .083$. When collapsed across age, Newman-Keuls comparisons across the four conditions revealed that each distraction condition differed from the no-distraction control, but the distraction conditions did not differ from each other.

Because the Age × Condition interaction had been significant in earlier work in which distractor location was unpredictable (Connelly et al., 1991, Experiment 2) and because the present interaction is a trend, we also conducted separate planned comparisons on the basis of findings from Connelly et al., which had indicated that as distraction became more similar to the target text it became more disruptive, particularly to older adults. Therefore, the following comparisons were made: control reading times with x-condition reading times, *x*-condition times with unrelated-word times, and the unrelated-word times with related-word times. No conclusions were altered by this liberal test: Young adults were slowed by the presence of *x*s as distractors, $F(1, 31) = 5.48$, $MSE = 10.49$. However, unrelated words did not slow reading beyond that seen for *x*s ($F < 1$), nor did related words slow reading beyond that seen for unrelated words, $F(1, 31) = 1.45$, $MSE = 16.83$. Older adults showed precisely this same pattern: A reliable disruption was introduced by the *x* distraction, $F(1, 31) = 16.52$, $MSE = 18.84$, with no additional slowdown created by either unrelated words ($F < 1$) or by the change from unrelated to related words, $F(1, 31) = 2.90$, $MSE = 38.69$.

In summary, even when analyzed very liberally (although the presence of any distraction slowed younger and older adults' reading times somewhat), variations in the nature of that distraction (i.e., *x*s, unrelated, and related words) did not differentially disrupt reading times for older adults. By contrast, Connelly et al. (1991) found that meaningfulness (that is, words as opposed to *x*s serving as distraction) mattered to both older and younger adults (although it was more disruptive to older adults than to younger adults) and that beyond the meaningfulness effect, there was an additional disruption introduced by meaningfully related distraction. In the previous experiment, both older and younger adults were able to successfully overcome meaningful distraction, treating it in the same way as meaningless strings of *x*s when distraction was placed in spatially predictable and fixed locations within target text. Furthermore, older adults were able under these circumstances to overcome related distraction, treating it in the same way as unrelated distraction.

*Comprehension accuracy.* The mean number of correct answers per story condition is presented in Table 2. Overall (and in contrast with Experiment 1), younger and older participants did not differ in comprehension, $F(1, 62) = 1.57$, $MSE = 0.38$. There were comprehension differences among the four conditions, $F(3, 186) = 3.02$, $MSE = 0.22$. These differences were comparable for older and younger adults ($F < 1$). Using Newman-Keuls comparisons, the only reliable pairwise difference was between the control and text-related distractor condition. Foil errors were compared for the text-related and control conditions. More foil errors occurred in the text-related than con-

*The Volunteer*

| | | | | | |
|---|---|---|---|---|---|
| *Bertha McKee was* | in a carton cold | *working as a* | gallery Van Dyck | *volunteer at the* |
| *information booth* | Van Dyck college | *at the museum.* | in a carton cold | *She brushed off the* |
| *snow which had* | cold Van Dyck | *fallen on her as* | college gallery | *she came from her* |
| *high school. She* | gallery college | *took her seat in* | cold in a carton | *the round booth* |
| *and waited for* | Van Dyck cold | *the evening's art* | gallery college | *viewers to arrive.* |
| *She liked her job* | cold gallery cold | *because it allowed* | Van Dyck gallery | *her to see all of the* |
| *different types* | gallery Van Dyck | *of art that moved* | college in a carton | *through the displays.* |
| *Bertha picked up* | in a carton college | *a box full of new* | Van Dyck cold | *pamphlets that* |
| *told of upcoming* | cold gallery cold | *displays. When* | college gallery | *she looked through* |
| *one of them* | in a carton gallery | *she became very* | cold Van Dyck | *excited. One of her* |
| *favorite painters,* | Van Dyck college | *Van Gogh, was* | gallery in a carton | *being highlighted* |
| *in an exhibition* | college in a carton | *soon. She couldn't* | Van Dyck gallery | *wait.* |

*Figure 2.* Example display (related distractor condition) for Experiment 2.

trol conditions, $F(1, 62) = 12.70$, $MSE = 0.12$, as was found in Experiment 1. No other effects were reliable ($Fs < 1$).

Note that the reading speed for the control condition in Experiment 2 was faster than that seen for the comparable condition in Experiment 1, $F(1, 108) = 3.10$, $MSE = 23.39$, $p = .08$. This increase in speed was approximately the same magnitude for younger and older participants because the Age × Experiment interaction was not significant, $F(1, 108) = 1.82$. In addition to differences between the two studies in the participants, two other factors might have contributed to this effect: changes in the display format and changes in the times of testing. With respect to changes in display format, the display in Experiment 2 contained fewer lines of text than the display in Experiment 1, thereby requiring fewer shifts or return sweeps from the end of one line to the beginning of the next. This is consistent with eye-movement studies showing that first fixations on a line are longer than others (e.g., Rayner, 1977). With respect to testing at optimal versus nonoptimal times of day, there is unpublished evidence from our laboratory that basic response times are sometimes faster at optimal times rather than at nonoptimal times.

These results make it clear that when spatial information is available to cue the fixed location of distraction, older adults use this information to ignore distraction as efficiently as younger adults. They are able to do this even when the distraction is related to the text. These findings are particularly compelling because, in the case of this experiment, distraction was both encountered frequently and bore a strong physical resemblance to the target. Predictable location does appear to offer a pronounced sparing effect for older adults.

## Experiment 3

Experiment 2 confirmed that older adults were not differentially slowed by meaningful distraction when it occupied fixed, predictable locations within a line of target text. Not only was the meaningfulness effect eliminated but even text-related distraction had no special disruptive impact on older adults' reading times and comprehension. However, it seemed necessary to ensure that the predictable placement of distraction, not some other property of the format used, was critical to eliminating age effects. Therefore, in Experiment 3 we replicated earlier findings of age-related distractor effects (Connelly et al., 1991; Shaw et al., 1992) by modifying the format from Experiment 2 in the following way: The columnar style remained intact but distracting material was no longer fixed to every other column; it could appear in any column along a line of target text. Thus, the location of distraction was no longer fixed and predictable. As in Experiment 2, we tested participants at normatively optimal times—younger adults in the afternoon and older adults in the morning. We expected that the reintroduction of unpredictably located distraction would reinstate the substantial age-related distractor effects observed by Connelly et al.

### Method

*Participants.* Sixteen younger ($M$ age = 20.6 years, range = 18–24) and 16 older ($M$ age = 69.6 years, range = 63–75) adults participated in this reading aloud task. They were selected the same way as in Experiments 1 and 2. Older adults had completed more formal education than had younger adults ($Ms$ = 16.7 and 14.1 years, respectively), $t(30) = 3.68$. In addition, older adults attained slightly higher vocabulary scores on the ERVT, version 3, than younger adults ($Ms$ = 34.8 and 28.8, respectively), $t(30) = 2.02$, $p = .052$.

*Design, materials, and procedure.* The only change from Experiment 2 was in the location of distraction. It could now appear anywhere across the page, with the constraint that, on average, it interrupted target text every four words or so (see Figure 3). Neither target nor distracting material appeared in more than two successive columns. In the control condition, the spaces occupied by distraction were otherwise left empty. All older adults were tested prior to 1 p.m., and all younger adults were tested after noon.

### Results

*Reading time.* Mean reading times are presented in Table 1. Once again, older adults were generally slower than younger

*The Volunteer*

*Bertha McKee was working as a* cold Van Dyck *volunteer at the* gallery Van Dyck *information booth* college in a carton *at the museum.* gallery in a carton *She brushed off the* Van Dyck college *snow which had fallen on her as* cold Van Dyck *she came from her high school. She* college gallery *took her seat in the round booth* gallery college *and waited for the evening's art* college in a carton *viewers to arrive.* Van Dyck gallery *She liked her job* in a carton college *because it allowed* gallery Van Dyck *her to see all of the* in a carton cold *different types of art that moved* Van Dyck cold *through the displays. Bertha picked up* cold gallery cold *a box full of new pamphlets that* in a carton cold *told of upcoming displays. When* college gallery *she looked through one of them* Van Dyck cold *she became very* cold gallery cold *excited. One of her* gallery college *favorite painters,* Van Dyck college *Van Gogh, was* Van Dyck gallery *being highlighted* in a carton gallery *in an exhibition soon. She couldn't* cold in a carton *wait.*

*Figure 3.* Example display (related distractor condition) for Experiment 3.

adults, $F(1, 30) = 22.58$, $MSE = 953.31$. There were reliable differences among conditions, $F(3, 90) = 43.42$, $MSE = 185.22$. The condition effect was modified by an interaction with age, $F(3, 90) = 9.31$, $MSE = 185.22$, that replicated the findings of Connelly et al. (1991, Experiment 2) very closely.

We explored the interaction by using planned comparisons done separately on younger and older adults' data, again comparing each pairwise difference in order from control to *x* strings, from *x* strings to unrelated words, and from unrelated to related words. Younger adults were reliably slowed in the presence of meaningless distraction, $F(1, 15) = 7.05$, $MSE = 7.98$. They were additionally slowed by unrelated meaningful distraction, $F(1, 15) = 24.62$, $MSE = 107.72$, but were no more disrupted by text-related than text-unrelated word distraction ($F < 1$). With 1 exception, older adults exhibited a pattern of disruption similar to that shown by younger adults: Text-related distraction reliably slowed reading times for older adults relative to text-unrelated words, $F(1, 15) = 4.43$, $MSE = 321.73$. As was the case for young adults, reading with *x* strings slowed older adults' times relative to control times, $F(1, 15) = 11.06$, $MSE = 37.98$, and unrelated words slowed reading more than *x* strings, $F(1, 15) = 28.73$, $MSE = 574.65$. In replication of the Connelly et al. (1991) findings, each pairwise disruption effect shown by older adults was larger than that for younger adults.

*Comprehension accuracy.* The mean number of correct answers in each story condition is presented in Table 2. Younger adults answered more questions correctly than older adults, $F(1, 30) = 9.49$, $MSE = 0.25$, and the presence of distraction reduced comprehension accuracy in all participants, $F(3, 90) = 6.66$, $MSE = 0.20$. In addition, there was an interaction between age and condition, $F(3, 90) = 2.99$, $MSE = 0.20$. We used the same planned comparisons as for reading time for younger and older adults separately. For younger adults, we observed a trend between the *x*-distractor condition and the control condition, $F(1, 15) = 3.52$, $MSE = 0.22$, $p = .08$. The presence of unrelated words did not disrupt comprehension beyond that seen for *x* distraction, $F(1, 15) = 1.45$, $MSE = 0.35$. In addition, text-related distraction significantly reduced comprehension accuracy relative to the text-unrelated distractor condition, $F(1, 15) = 4.78$, $MSE = 0.31$. Older adults' comprehension accuracy was significantly reduced in the *x*-distractor condition relative to the control condition, $F(1, 15) = 4.38$, $MSE = 0.52$. Their comprehension accuracy was only marginally reduced in the unrelated-word condition relative to the *x* distractors, $F(1, 15) = 3.29$, $MSE = 0.68$, $p = .09$, and it was additionally reduced in the text-related versus -unrelated conditions, $F(1, 15) = 9.02$, $MSE = 0.60$.

Analyses of the proportion of foil errors (see Table 2) for the control and text-related distractor conditions (in which the foils were presented) revealed a marginal trend for age, $F(1, 30) = 3.20$, $MSE = 0.14$, $p = .084$. The effect of condition was significant, $F(1, 30) = 26.20$, $MSE = 0.19$, with more foil responses being selected after reading the text-related distractor than after reading control stories. An Age × Condition interaction was also observed such that older adults committed more foil errors than younger adults, $F(1, 30) = 4.91$, $MSE = 0.19$. This interaction did not attain significance in Connelly et al.'s (1991, Experiment 2) analyses of distractibility. This age-related effect on comprehension further strengthens the importance of finding no such age-related susceptibility to text-related foils in the previous two experiments.

## Discussion

Note that the age differences reported in Experiment 3 are in sharp contrast to those reported in Experiment 2, even though participants in both studies were tested at their normatively optimal time (May et al., 1993). Thus, sparing from distraction effects introduced by fixed locations functions when people are tested at both optimal times of day (cf. Experiment 2 with Experiment 3) and at uncontrolled times of day (cf. our Experiment 1 with Connelly et al., 1991, Experiment 1). Synchrony between optimal time of day and the time of testing has been

shown to have a substantial impact on the performance of older adults (May & Hasher, 1995; May, Hasher, & Bhatt, 1994; May et al., 1993). Our findings suggest that spatial predictability is an important sparing factor, overriding both the presence of physical distraction (especially meaningful distraction for skilled readers) and the otherwise apparently substantial effects of performing at dysynchronous times.

The patterns of reading time, comprehension questions, and foil-response data point to an age-related increase in disruption when distraction was present, a disruption that was relatively heightened for older adults when that distraction was related to the text. In summary, Experiment 3 replicated earlier findings of age-related differences in distractibility when the location of such distraction was unpredictable within the target text (Connelly et al., 1991; Shaw et al., 1992). Of special note here and in the earlier work is the differential susceptibility older adults have to distraction that is meaningfully related to the target text.

There are two possible sources of the heightened disruption by meaningfully related distractors for older but not younger adults seen here and in Connelly et al. (1991, Experiment 2). The first possible source is that heightened disruption is the by-product of older adults' greater breadth of activation of ideas during reading (e.g., Stoltzfus, 1992; Zacks, Hasher, & Griffin, 1994). Some of the self-generated ideas may match the extraneous information that served as distracting material in these studies. The observed slowing would then be the product of an older reader pausing to consider alternative interpretations (Hamm & Hasher, 1992). Younger adults who activate meaning more narrowly in a given context (Stoltzfus, 1992; Zacks et al., 1994) have fewer accidental matches with the distracting material; hence, for them, unrelated and related words are equivalent, both when the location of distraction is fixed and when it is not. Alternatively, the differential slowing to meaningfully related distraction shown by older adults may be triggered initially by the distraction's physical presence, which then stimulates greater attentiveness, again as older adults struggle with multiple meanings. In either case, the finding of greater distraction by meaningfully related material, over and above the distraction afforded by simply meaningful material, is consistent with a general model of the role of inhibition in the processing of information (Hasher, 1994; Hasher & Zacks, 1988; Zacks, 1995).

## General Discussion

Differential age-related slowing in reading target text interspersed with meaningful distraction (Experiment 3) can be greatly attenuated when such distraction occupies fixed spatial locations within the text (Experiments 1 and 2). In fact, in Experiment 2, older adults were able to use spatial cues to overcome what has been shown elsewhere (Connelly et al., 1991) to be their unique susceptibility to disruption by text-related distraction. Together, these findings suggest that spatial information cuing the location of relevant material provides a powerful aid to older adults whose performance would otherwise be greatly disrupted by semantically meaningful distraction. Thus, the answer to the initial question posed here, how do older adults read the front page of a newspaper in the face of massive candidates for distraction (i.e., the other articles), seems clear: with not much more difficulty than younger adults, because each article is in a fixed, predictable, and delineated location.

Other evidence suggests that the sparing afforded by location functions best when locations are fixed, rather than simply predictable. Shaw et al. (1992) reported a similar study in which participants read in the face of distraction that occurred, predictably, as every other word on each line of text. As words are of different lengths, distraction was predictable, although it was not in a fixed location. Even though younger and older participants were told explicitly to read only every other word, participants were greatly slowed by meaningful distraction, and this effect was particularly strong for older adults. The size of the disruption effect was still robust in older adults even when perceptual discriminability between targets and distractors was great (i.e., uppercase vs. lowercase print). Thus, the cued sparing of disruption by distraction occurs because the cues indicate fixed, not simply predictable, locations.

Older adults' reduced susceptibility to spatially cued distraction is consistent with findings in visual search (Folk & Hoyer, 1992; Hartley et al., 1990; Madden, 1983; Nissen & Corkin, 1985; Plude & Doussard-Roosevelt, 1989; Plude & Hoyer, 1986; Wright & Elias, 1979) and in negative priming studies (Connelly & Hasher, 1993). The search studies demonstrate that older adults are as able as younger adults to use spatial cues presented at very brief cue–target display intervals to efficiently focus on a target. The negative priming findings show that the locations of distractors are as effectively suppressed by older as by younger adults. Furthermore, location negative priming has been found in young children at a level not different from that seen for young adults (Tipper & McLaren, 1990). Therefore, the ability to suppress distraction according to its location appears to develop early in life and remain stable throughout the aging process. Connelly and Hasher (1993) have speculated that the sparing afforded by location suppression, although not by identity suppression, may be tied to the existence of two separate underlying neural pathways, one serving location and one serving identity, with the former retaining its inhibitory component across the life span (Tipper & McLaren, 1990) and the latter developing sometime in childhood (Tipper, Bourque, Anderson, & Brehaut, 1989) and diminishing with older age (e.g., McDowd & Oseas-Kreger, 1991; Stoltzfus et al., 1993; see also Plude, Enns, & Brodeur, in press).

Such a pattern of spared processing of location information may have important implications for spatial memory. For example, when spatial cues are provided as cues to remember the location of objects, older adults benefit as much or more than younger adults (Cherry & Park, 1993; Park, Cherry, Smith, & Lafronza, 1990; Sharps, 1991; Sharps & Gollin, 1987; Zelinski & Light, 1988). However, the presence of spatial cues does not appear to have the same beneficial impact on memory for an object's identity (Park et al., 1990; Zelinski & Light, 1988; but see Sharps & Gollin, 1988).

The present data, taken together with other findings in the selective attention and negative priming literatures, suggest that fixed and predictable spatial location provides a sparing factor to older adults who are otherwise more impacted by the presence of distraction in the environment. May et al. (1995) suggested that the spared ability to suppress irrelevant locations reduces the range of distraction that older adults otherwise are

unable to ignore, largely because of their diminished ability to inhibit the identity of marginally relevant and irrelevant information, both in the environment and in thought.

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