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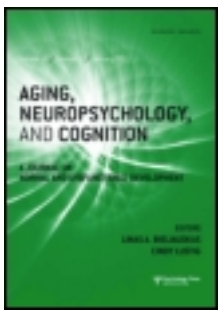

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Inhibition of Visual and Conceptual Information During Reading in Healthy Aging and Alzheimer's Disease*

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ABSTRACT

The present experiment examined the effect of distraction on reading ability and comprehension in healthy aging and early stage dementia of the Alzheimer type (DAT). A modified version of the reading task used by Connelly, Hasher, and Zacks (1991, Experiment 2) was employed. Healthy young, healthy old (60–79 years, and 80 years and over), very mild DAT, and mild DAT participants read passages aloud and then answered comprehension questions. There were four experimental conditions in which distracting information was embedded in the text: (*control)*, orthographic *(xxxxx)*, lexical *(unrelated)*, and semantic *(related)*. The results indicated that there was greater susceptibility to increasing levels of distraction with age and increasing dementia severity. Moreover, there was a substantial slowdown in reading time in mild DAT when text was used as distracting information, especially conceptually related text. Furthermore, mild DAT participants were more likely to make false alarms in comprehension performance (i.e., choose as an answer the incorrect response which contained the related distracting information). Thus, in early stage DAT, there appears to be increased difficulty inhibiting partially activated information, especially when it is related to the relevant information being processed.

Dementia of the Alzheimer's type (DAT) is characterized by a deterioration of cognitive performance across a wide variety of tasks. Despite this generalized cognitive breakdown, there are aspects of cognitive processes that appear to be spared, at least in the early stages of the disease. For example, there is evidence from semantic priming (e.g., Balota & Duchek, 1988, 1989, 1991; Shenaut & Ober, 1996) and some implicit memory tasks (e.g., Balota & Ferraro, 1996; Faust, Balota, & Spieler, 1996; Gabrieli et al., 1994; LaVoie & Light, 1994; Moscovitch, Winocur, & McLachlan, 1986) that the automatic activation of relevant processing pathways is relatively unimpaired in both healthy older adults and in early stage DAT. However, there is evidence that performance declines in healthy aging and DAT when tasks demand attentional control systems (e.g., Balota, Black, & Cheney, 1992; Ferraro, Balota, & Connor, 1993; Gabrieli et al., in press; Moscovitch, 1994). More specifically, there appears to be a breakdown in the control or inhibition of partially activated but inappropriate processing pathways.

First turning to healthy aging, the notion of a deficit in inhibitory control has been used to account for the cognitive deficits observed in healthy older adults. This work has been motivated largely by Hasher and Zacks' (1988) model of inhibitory processing, which states that one consequence of deficient inhibitory control is that older adults are more distracted by irrelevant information. According to the model, this deficit in inhibitory control allows more ''non-

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goal path ideas'' to enter working memory and remain activated, thereby making the processing of task-relevant information more difficult. Indeed, there have been a number of studies that have demonstrated an age-related decline in inhibitory control. For example, there is evidence that older adults show reduced negative priming effects under some circumstances (e.g., Hasher, Stolzfus, Zacks, & Rympa, 1991; McDowd & Oseas-Kreger, 1990; Tipper, 1991; however, see Sullivan & Faust, 1993; Sullivan, Faust, & Balota, 1995). Also, older adults exhibit increased Stroop interference effects (e.g., Spieler, Balota, & Faust, 1996), increased interference effects in a picture-word paradigm (Duchek, Balota, Faust, & Ferraro, 1995), and increased difficulty inhibiting an overt response in a stop-signal paradigm (Kramer, Humphrey, Larish, Logan, & Strayer, 1994).

The notion of an inhibitory control deficit also has been extended to the DAT population. A number of recent studies have indicated that there is a disproportionate breakdown in inhibitory control in the early stages of DAT relative to healthy aging, greater than expected by overall differences in speed or accuracy. For example, there is evidence that individuals with DAT do not show negative priming effects with both picture and word stimuli, suggesting that there is little inhibition of the to-be-ignored information on the previous trial (Sullivan et al., 1995). Spieler et al. (1996) found that individuals with DAT exhibited a greater breakdown in inhibitory control relative to healthy older adults in a Stroop paradigm, as evidenced by an increase in intrusion errors during color naming (i.e., incorrectly naming the word). In a speeded naming task, Balota and Ferraro (1993) found that individuals with DAT were more likely to make pronunciation errors for irregular words (e.g., pronouncing PINT as if it rhymes with HINT), suggesting that within a dual route model they had more difficulty suppressing the sublexical route. On the other hand, when the task placed emphasis on the sublexical route (i.e., a rhyme task), individuals with DAT had difficulty suppressing the influence of the lexical route (Balota & Ferraro, 1996). Thus, there appears to be evidence of a deficit in the inhibitory control of inappropriate processing pathways in early DAT across a variety of cognitive tasks (also see Simone & Baylis, 1997).

It is interesting to note that the original Hasher and Zacks (1988) model discussed the age-related inhibitory deficit specifically in terms of memory retrieval and language comprehension. It was argued that a reduced ability to inhibit partially activated information should lead to increased difficulty in language processing. Clearly, other models of language comprehension also have emphasized the role of an inhibitory mechanism which serves to suppress extraneous information and maintain the activation of relevant information in working memory during comprehension processes (e.g., Gernsbacher, 1990). In terms of DAT, there is certainly evidence of deficits in written and spoken language comprehension (e.g., Appell, Kertesz, & Fisman, 1982; Cummings, Houlihan, & Hill, 1986; Murdoch, Chenery, Wilks, & Boyle, 1987) which have been correlated with deficits in working memory tasks (Small, Kemper, & Lyons, 1997). More specifically, an inhibitory deficit has been used as an explanatory construct for impaired performance in language processing tasks. For example, we have reported that individuals with DAT are more likely to have an alternative interpretation of a homograph available (e.g., *ORGAN* meaning *body part*) in the presence of a single-word disambiguating context (e.g., *MUSIC*) (Balota & Duchek, 1991). Likewise, individuals with DAT are less efficient than healthy older adults in suppressing the alternative meaning of an ambiguous word in the presence of a biasing sentence context (Faust, Balota, Duchek, Gernsbacher, & Smith, 1997). Based on both of these studies, one could argue that the inability to suppress partially activated, inappropriate information may be an important contributor to the language-related deficits in DAT.

The goal of the present study was to further explore inhibitory deficits in healthy aging and early stage DAT in a more complex language processing task, namely on-line reading and comprehension performance. The present study represents a modified version of the reading task used by Connelly, Hasher and Zacks (1991, Ex-

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periment 2). In this task, participants are required to read text passages aloud and then answer comprehension questions. In order to address the impact of distracting information on reading ability and comprehension, various information is embedded in the text. As shown in the Appendix, there are four experimental conditions with increasing levels of interference. Across these conditions, distracting information is (a) not presented (*control*), (b) orthographic (*xxxxx*), (c) lexical (*unrelated*), or (d) semantic (*related*). It is important to note that the present task was made easier than the Connelly et al. task by making the distracting information more physically distinct to insure that the DAT participants could accurately perform the task. Of course, it is possible that this methodological change also made it easier for participants to ignore the distracting information in the present study. Connelly et al. found that healthy older adults' reading times were slowed when any type of distracting information was embedded in the text, but particularly when the distracting information was semantically related to the target information. Furthermore, there was a slight tendency for older adults, relative to younger adults, to exhibit poorer comprehension performance in the related condition. Thus, Connelly et al. argued that older adults' reading and comprehension performance is more susceptible to the effects of distracting information.

There are two primary issues addressed in the present study. First, we are interested in the impact of DAT on reading ability and comprehension in the presence of distracting information. This is an excellent task to examine the influence of increasing levels of distraction (i.e., low-level visual/orthographic, lexical, and semantic) on reading comprehension. It is expected that reading time and comprehension will be more disrupted by distracting information in early stage DAT relative to healthy aging, especially as the level of distraction increases to be conceptually related to the relevant information. In addition, the inclusion of two levels of dementia severity (i.e., very mild and mild DAT) allows one to trace the impact of increasing levels of distraction on reading as the disease progresses. Second, we are interested in further exploring inhibitory processes during reading in healthy aging by comparing young adults with young-old (60-79 years) and old-old (80 years and over) adults. There is relatively little literature on inhibitory control processes in this latter group of older adults. Furthermore, the comparison of the nondemented oldest-old group with younger demented participants (Clinical Dementia Ratings or CDRs of 0.5 and 1, respectively) is important for addressing the issue of whether there are qualitative differences between normal aging and DAT.

METHODS

Participants

A total of 88 participants were recruited from the Washington University Alzheimer Disease Research Center's (ADRC). All participants were originally screened for depression, hypertension, reversible dementias, and other disorders that could potentially produce cognitive impairment. The inclusionary and exclusionary criteria for DAT are consistent with the National Institute of Neurological and Communicative Disorders and Stroke and the Alzheimer's Disease and Related Disorders Association (NINCDS-ADRDA) criteria (McKhann et al., 1984). The severity of dementia was staged according to the Washington University CDR scale (Berg, 1988; Hughes, Berg, Danziger, Coben, & Martin, 1982; Morris, 1993). According to this scale, CDRs 0, 0.5, 1, 2, and 3 represent no dementia, very mild dementia, mild dementia, moderate dementia, and severe dementia, respectively. The CDR is based on a 90-min interview with both the participant and a collateral source. This interview assesses the participant's cognitive abilities in the areas of memory, orientation, judgment and problem solving, community affairs, home and hobbies, and personal care. Both the reliability of the CDR and the validation of the diagnosis (based upon autopsy) by the research team have been excellent (93% diagnostic accuracy) and well documented (e.g., Berg et al., 1998).

Of the 88 participants recruited from the Washington University ADRC, 28 were healthy older controls (CDR = 0) under age 80 years (M = 71.7, range 60–79; M education = 14.6 years); 18 were healthy older controls (CDR = 0) age 80 or over (M = 86.0, range 80–92; M education = 14.9); 25 were diagnosed with very mild DAT (CDR = 0.5; M = 73.4, range 60–96; M education = 13.6); and

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17 were diagnosed with mild DAT (CDR = 1; *M* = 74.7, range 62–92; *M* education = 12.5). The education level did not differ among these groups, $F(3, 83) = 1.87$, $p = .14$.

In addition, 20 young college-aged participants (*M* = 20.3 years) were recruited for this study. All young participants had 13–14 years of education. These participants were paid $5 per hour for their participation.

Materials

Stories (eight test and one practice) used in this study were modeled after the materials used by Connelly et al. (1991). Each story was approximately 125 words in length and was printed on a single standard sheet of paper. Each story was rotated across all four experimental conditions: *control, related text distraction, unrelated text distraction, and xxxxx distraction.* In addition, the ordering of these conditions was rotated across participants. As shown in the Appendix, in all four conditions the story text was presented in uppercase, bold font. In the control condition, there was no distracting information embedded within the text. In the related text distraction condition, distracting information was embedded within the text and presented in lowercase italics. This distracting information was comprised of 4 different words that were related to the story. These words were interspersed throughout the story either as single words or a two-word phrase. Each word occurred 15 times within the text and was positioned after every 2 to 5 words of text. In the unrelated distraction condition, the related distracting information, as described above, was simply replaced by 4 words of equal length and frequency that were unrelated to the text. In the xxxxx distraction condition, the related distracting information was replaced by a string of xxxxxs of equal length. The practice story was always presented in the control condition.

The comprehension test consisted of four multiple choice questions for each story printed on a single sheet of paper. There were six alternatives for each question: the correct answer, an incorrect answer which contained the related distracting information (i.e., a foil), and four other plausible, yet incorrect answers that were not part of the distracting information. For example, for the story displayed in the Appendix, the following six alternatives were presented for the question *Paul was cooking ??? and sausage*: (a) *onions*; (b) *pepperoni;* (c) *spaghetti;* (d) *sauerkraut*; (e) *mushrooms*; and (f) *liver.*

Procedure

All participants were tested individually in a quiet testing room. Prior to testing, each participant was given a sheet of paper containing 30 unrelated words, 15 in bold uppercase and 15 in lowercase italics. Participants were instructed to simply read the bold uppercase words only. This pretest was given to insure that participants were capable of understanding the instructions for the subsequent reading task. All participants were able to perform this pretest.

During testing, the experimenter placed each story sheet in front of the participant and instructed the participant to read the story aloud into the tape recorder. Participants were instructed only to read the story as presented in the bold uppercase lettering. Immediately after reading a story, the experimenter replaced the story sheet with the comprehension test for that story. Participants were instructed to circle the correct answer for each question and work at their own pace. Upon completion of the comprehension test, the next story sheet was given to the participant to read aloud, followed by the corresponding comprehension test.

RESULTS

Reading Time

The time taken to read each passage was obtained for each participant.[1] Figure 1 displays

[1] Similar to Connelly et al. (1991), an attempt was made to analyze errors made while participants were reading the passages. Reading errors included intrusions of the distracting text, saying the wrong word, or omitting a word. Given that misreadings were relatively rare in the young group and in the other participant groups, errors were analyzed for a subset of the older participant groups only (young-old $n = 11$; old-old $n = 9$; very mild DAT $n = 10$; mild DAT $n = 12$). There were no group or condition differences for either saying the wrong word or omitting a word while reading the passages. There was a significant group difference for intrusions of distracting text while reading, which indicated that the mild DAT group made more intrusions than the healthy young-old, healthy old-old, or very mild DAT groups, $F(3, 38) = 3.22$, $p = .033$. However, intrusions did not differ as a function of distraction condition (i.e., related vs. unrelated). This analysis proved to be relatively uninformative, presumably due to the low reading error rates (an average of 1.6 errors per participant in the mild DAT group; see Connelly et al. for a similar conclusion). Of course, the goal of the present study was to insure that all groups could perform the task without a high error rate.

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the mean reading times as a function of group and experimental condition. The results of a 5 (Group) × 4 (Condition) mixed-factor ANOVA indicated that there was a main effect of group, $F(4, 103) = 14.07$, $p < .0001$, and condition, $F(3, 309) = 65.52$, $p < .0001$. In general, reading time slowed across age and increasing dementia severity and reading time slowed with increasing distraction. More interesting, there was a highly significant Group × Condition interaction, $F(12, 309) = 7.44$, $p < .0001$. As can be seen in Figure 1, distracting text, especially related text, slowed reading times for the mild DAT group more than any other participant group. To insure that the Group × Condition interaction was not simply due to group-related differences in overall processing speed, we conducted a 5 (Group) × 4 (Condition) mixed-factor ANOVA on proportional reading times in which each participant's mean reading time per condition was taken as a proportion of that participant's overall reading time across all four conditions. The results of this analysis again yielded a significant Group × Condition interaction, $F(12, 309) = 3.91$, $p < .0001$, indicating that the differential slowing of reading time as a function of group and condition was not merely the result of group differences in processing speed. It is important to note that the Group × Condition interaction also was significant when each participant's mean reading time for the control condition was used as a baseline in a similar analysis, $F(12, 309) = 5.06$, $p < .0001$.

To further examine the Group × Condition interaction, separate ANOVAs on reading times (i.e., raw scores) were conducted for each group as a function of condition. For younger adults, reading times were significantly slower in the xxxxx condition relative to the control condition, $F(1, 19) = 78.68$, $p = .006$; however, there were no significant differences in reading time among the xxxxx, unrelated, and related conditions, all ps $< .25$. For the young-old CDR 0 and old-old CDR 0 groups, there was also a signifi-

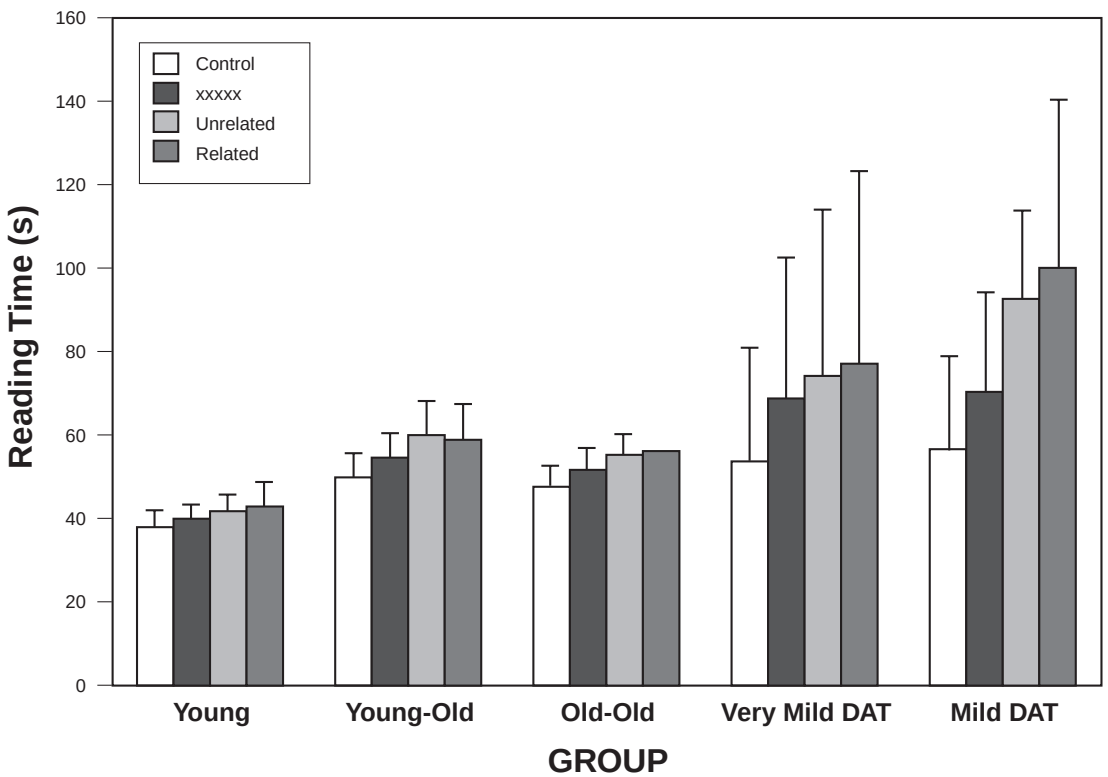

Fig. 1. Reading time (s) as a function of distractor condition and group.

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cant difference in reading times between the control versus xxxxx conditions, $F(1, 27) = 39.06$, $p < .0001$; $F(1, 17) = 20.33$, $p = .0003$, respectively, and the xxxxx versus unrelated conditions, $F(1, 27) = 8.00$, $p < .009$; $F(1, 17) = 6.21$, $p < .03$, respectively. However, there was no difference in reading times between the unrelated versus related conditions, $F(1, 27) = .65$, $p = .43$; $F(1, 17) = .24$, $p = .63$. Likewise, for the CDR 0.5 group, there was a significant difference in reading times between the control versus xxxxx conditions, $F(1, 24) = 18.52$, $p = .0002$, and xxxxx versus unrelated conditions, $F(1, 24) = 8.66$, $p = .007$. However, there was no significant difference between the unrelated versus related conditions, $F(1, 24) = .58$, $p = .46$. Finally, for the CDR 1 group, there was also a significant difference in reading times for the control versus xxxxx conditions, $F(1, 16) = 27.31$, $p = .0001$ and xxxxx versus unrelated conditions, $F(1, 16) = 22.78$, $p = .0002$. More important, there was a marginally significant difference in reading times for the unrelated versus related conditions, $F(1,16) = 2.99$, $p = .10$.

Given that the participant groups were differentially affected by increasing levels of distraction, it is important to determine whether this interference in reading time changed across the passage. One might expect that the effect of distraction, especially at the conceptual level (i.e., related condition), may increase across time. In order to examine the buildup of the effect of distraction on reading time, we computed the reading times (i.e., raw scores) for the first half versus second half of each passage for each participant across conditions. The mean reading times as a function of group, first versus second half, and experimental condition are presented in Figure 2. The results of a 5 (Group) × 2 (First vs. Second Half) × 4 (Condition) mixed-factor ANOVA indicated that there was a significant main effect of group, $F(1, 103) = 14.83$, $p < .0001$, and condition, $F(3, 309) = 70.29$, $p < .0001$. There was also a main effect of first versus second half, $F(1, 103) = 18.53$, $p < .0001$, which indicated that overall reading times were slightly slower in the second half versus first half of the passage. The ANOVA also yielded a significant Group × Condition interaction, $F(12, 309) = 7.83$, $p < .0001$, and Condition × Half interaction, $F(3, 309) = 5.05$, $p = .002$. Most important, there was a significant three-way interaction among group, condition, and half, $F(12, 309) = 2.21$, $p < .02$. Post hoc analyses indicated that reading times were equally slowed in the second half across all conditions for the young, young-old CDR 0, old-old CDR 0, and CDR 0.5 groups (all ps > .18 for the Half × Condition interaction). However, for the CDR 1 group, there was a significant Half × Condition interaction, $F(3, 48) = 3.20$, $p = .03$, which indicated that reading times slowed more in the second half for the related condition, $F(1, 16) = 5.25$, $p < .04$, compared with the remaining conditions.

Comprehension Performance

Percentage correct

The mean number correct (out of four) as a function of group and condition is presented in Table 1. A 5 (Group) × 4 (Condition) mixed-factor ANOVA on the mean number correct yielded a significant main effect of group, $F(4, 103) = 20.33$, $p < .0001$, and a marginally significant main effect of condition, $F(3, 309) = 2.23$, $p < .09$. Post hoc analyses of the group effect indicated that there was no difference between the young versus young-old CDR 0 groups ($p = .97$) and a marginally significant difference between the young-old CDR 0 versus old-old CDR 0 groups ($p = .057$). Furthermore, the old-old CDR 0, CDR 0.5, and CDR 1 groups significantly differed from each other (all ps < .05), indicating poorer comprehension performance with increasing age and dementia severity. There was no significant Group × Condition interaction, $F(12, 309) = .81$, $p = .64$.

Percentage related false alarms

To further examine the effect of distraction on comprehension performance, a 5 (Group) × 2 (Condition) mixed-factor ANOVA was performed on false alarms to the related distractor. These occurred when participants chose as an answer the incorrect response which contained the related distracting information. Since a true false alarm could only occur in the related con-

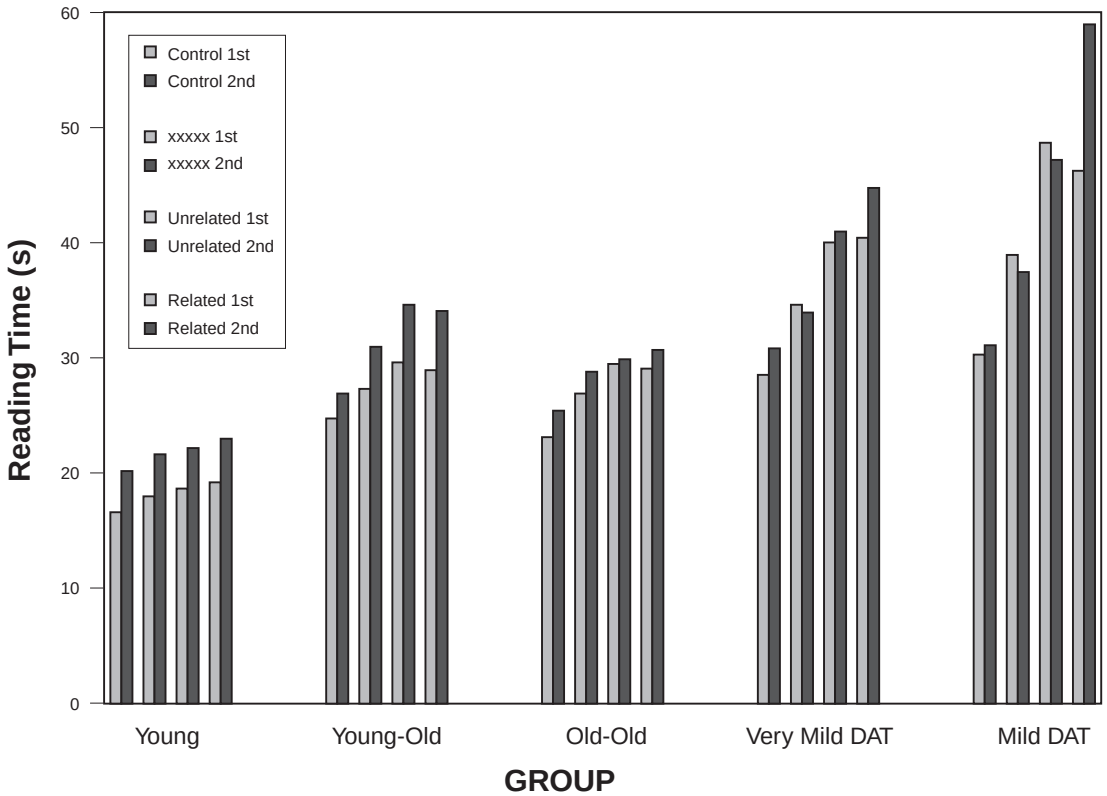

Fig. 2. Reading time (s) as a function of first versus second half, distractor condition, and group.

dition, the analysis compared false alarms in the control versus related conditions. Table 2 displays the mean percentage errors as a function of group and condition. The results of the ANOVA yielded a main effect of group, $F(4, 103) = 4.10$, $p = .004$, and condition, $F(1, 103) = 10.35$, $p < .002$. Overall, there was an increase in false alarms to related distractors with increasing age and dementia severity and more false alarms in the related than control condition. The interaction between group and condition approached significance, $F(4, 103) = 2.03$, $p = .095$. Post hoc analyses indicated that the old-old CDR 0 and CDR 1 groups made significantly more false alarms in the related condition, $F(1, 17) = 7.29$, $p < .02$; $F(1, 16) = 4.70$, $p < .05$,

Table 1. Mean Number Correct (4) as a Function of Group and Distractor Condition.

	Distractor condition			
Group	Control	xxxxx	Unrelated	Related
Young	3.75	3.65	3.35	3.55
Young-old	3.68	3.57	3.61	3.43
Old-old	3.61	3.06	3.28	3.00
Very mild DAT	2.72	2.84	2.92	2.84
Mild DAT	2.41	2.12	2.41	1.88

Note. DAT = dementia of the Alzheimer's type.

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respectively. There was no difference in false alarms for the related versus control conditions for the young, young-old CDR 0, and CDR 0.5 groups, all *p*s > .21. It is also interesting to note that there were significantly more false alarms in the control condition for the CDR 0.5 and CDR 1 groups relative to the other groups, $F(4, 103) = 2.79$, $p = .03$, suggesting that the DAT groups may be utilizing a different strategy for answering the comprehension questions (e.g., using general knowledge rather than context specific information).

DISCUSSION

The purpose of the present study was to examine the effect of orthographic, lexical, and conceptual distraction on reading ability and comprehension in healthy aging and early stage DAT. The results of the study are quite straightforward. There was greater susceptibility to increasing levels of distraction with age and increasing dementia severity. This interference was clearly reflected in reading time as well as aspects of comprehension performance.

In terms of reading time, there was a stepwise progression of slower reading times across groups and levels of distraction. Overall, both the healthy young-old and old-old participants had slower reading times than the young participants. Similarly, the very mild DAT and especially mild DAT participants overall had slower reading times than both groups of healthy older participants.

Most interesting, however, was the differential impact of distraction on reading times across groups. The young participants were slightly slowed by all levels of distraction relative to the control condition, but there was no difference across the different levels of distraction (orthographic, lexical, or semantic). The healthy young-old and old-old groups' reading times also were slowed by any distraction relative to the control condition. However, reading times were further slowed by text (both lexical, unrelated and semantic, related) relative to meaningless, orthographic distraction (i.e., xxxxx), yet the conceptual relatedness of the distracting text did not affect reading times. The very mild DAT group showed the same pattern of data across distracting conditions, albeit somewhat larger, even though overall reading times were slower for the very mild DAT group. Although there appears to be a slight trend toward an increase in reading time between the related versus unrelated conditions for the very mild DAT group, this difference was not reliable. Thus, there was no difference in the impact of lexical versus semantic distraction for the very mild DAT group.

On the other hand, for the mild DAT group the reading time was reliably slower when the distracting information was conceptually related to the text versus unrelated to the text. It is interesting to note that there is relatively little difference in reading times for the very mild and mild DAT groups in the control and xxxxx conditions. However, there is a substantial slowdown in reading time in the mild DAT group when text (lexical or semantic) is used as distracting information, especially when the text is concep-

Table 2. Mean Percentage False Alarms as a Function of Group and Distractor Condition.

	Distractor condition	
Group	Control	Related
Young	2.5	7.5
Young-old	2.8	6.0
Old-old	2.8	15.0*
Very mild DAT	10.0	8.0
Mild DAT	8.0	22.0*

Note. DAT = dementia of the Alzheimer's type.
* $p < .05$.

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tually related to the story content. Moreover, the proportional analysis indicated that this disproportionate slowdown in the mild DAT group was not just due to overall differences in processing speed. Thus in early stage DAT there is greater difficulty inhibiting partially activated but inappropriate information, especially when it is conceptually related to the relevant information that is being processed.

It is noteworthy that the present results comparing young versus healthy young-old participants do not fully replicate the results of the Connelly et al. (1991) study. Connelly et al. also found that healthy older adults' reading times were slowed when any type of distracting information was embedded in the text, but they were further slowed when the distracting information was semantically related compared to unrelated to the relevant text. In the present study we did not find an increase in reading time between the related versus unrelated conditions for the healthy young-old group.

Given that Connelly et al. (1991) did not do a proportional analysis on reading times, it is possible that the age differences in their study were due to overall differences in processing speed. However, this discrepancy in results is most likely due to the two studies' procedural differences which are related to the physical similarity between the relevant text and the distracting information. In the Connelly et al. study the relevant text was presented in lowercase italics with distracting information in standard lowercase font. In the present study, the relevant text was presented in uppercase bold font with distracting information presented in lowercase italics. We chose to make the distracting information physically distinct in order to increase the likelihood that the demented participants could perform the task at a relatively high accuracy level. One would assume that the selection of relevant text involved in the present study would be easier than in the Connelly et al. study.

In support of this notion, Carlson, Hasher, Connelly, and Zacks (1995) found that older adults' reading time was not slowed when the distracting information was spatially blocked and predictable within the passage to make the selection of relevant text easier. Furthermore, it appears that the reading times in the control conditions for the healthy older adults are very similar in both studies (approximately 50 s). However, the reading times more than doubled in the related and unrelated conditions in the Connelly et al. (1991) study, but only increase approximately 10 s in the present study. Thus, it appears that healthy older adults were not as susceptible to the effect of related distracting text in the present study because the selection of relevant text was easier.

In order to examine the buildup of the effect of distraction on reading ability in the present study, the reading times for the first half versus second half of each passage were compared. Overall, there was an increase in reading time in the second half of the passages across all groups. Apparently, there is an accumulating burden of reading passages with distraction and this slows reading performance. However, this increase in reading time was consistent across all levels of distraction for all participant groups except the mild DAT group. In the mild DAT group there was a disproportionate increase in reading time in the second half of the passage in the related condition relative to all other conditions. Thus in mild DAT the ability to suppress the conceptually related material decreased across time as the participant extracted the semantic information from the text. On the other hand, the remaining groups of participants were able to select with relatively little conceptual processing of the related information.

If related distracting information slows online reading time in mild DAT and this interference builds up across time, then one might also expect comprehension processes to be impaired. Indeed, the impact of distraction also was reflected in aspects of comprehension performance in the present study. First, there was a decrease in the number correct with increasing age and increasing dementia severity. This pattern of data was consistent across distracting conditions, although there was a slight trend for poorer comprehension performance for both the healthy old-old and mild DAT group in the related compared to the control conditions. Thus, there was not strong evidence that related distraction differentially impaired comprehension

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performance when merely examining the number of correct responses.

On the other hand, the impact of distraction in comprehension was apparent when examining false alarms. Again, a false alarm occurred when a participant chose as an incorrect answer the alternative that contained the related distracting information. The mild DAT group was more likely to false alarm to the related distractor in the related compared to the control condition, indicating that the conceptually related distracting text was being processed and later confused with the relevant text.

It is also noteworthy that the healthy old-old group made significantly more false alarms in the related versus control condition. This is interesting in light of the fact that the healthy old-old group displayed relatively fast reading times compared with the young-old group, who were not differentially affected by related versus unrelated distracting text. Also, they exhibited better comprehension performance in terms of number correct than either the very mild or mild DAT groups. However, it is clear that the healthy old-old group did show some confusion in the related condition relative to the control condition. Given that the other incorrect alternatives were plausible and thus also ''related'' to the content of the target story, the healthy old-old group was susceptible to the related distraction, even though this interference was clearly not reflected in reading time. Of course, there may have been some trade-off between speed and accuracy in reading the distracting information for the healthy old-old group. Thus, aspects of the healthy old-old group's comprehension performance looked qualitatively more like that of the younger mildly demented participants than the young-old healthy participants.

It is interesting to note that Dywan and Murphy (1996), using a similar task, found that healthy older adults were more likely to false alarm to distractor words than younger adults; however, younger adults were more likely to recognize the distracting words in a subsequent memory test. Thus they argued that younger adults do initially process the distractor information, as do older adults, but younger adults can better discriminate the source of the information (i.e., target vs. distractor) during comprehension testing. It seems unlikely that the present results merely represent a source memory problem for the DAT group. Based upon reading time, it is clear that the initial selection of the relevant text was differentially affected by increasing levels of distraction in mild DAT relative to the other groups. Although younger adults may initially ''process'' the distracting information to some extent, it clearly does not produce the interference that it does in mild DAT and this interference is not affected by the type of distraction. Furthermore, Multhaup, Hasher, and Zacks (1998) recently found that when the reading task is followed by an *indirect* memory test, older adults do show activation of the distractor words. They argue that older adults show poorer recognition of distractor words because they are simply less able to consciously retrieve recent information; however, such information does remain active and can later influence performance.

In sum, the present study provides further evidence for deficient attentional control in healthy aging and early stage DAT in a more complex language processing task (Balota & Duchek, 1991; Balota & Ferraro, 1993, 1996; Faust et al., 1997; Spieler et al., 1996). According to Hasher and Zacks (1988), a deficient inhibitory mechanism allows more task-irrelevant information to enter working memory and remain activated, thereby making the comprehension and retrieval of task-relevant information more difficult. In the present task, the decreased efficiency of an inhibitory system resulted in impaired reading ability and comprehension processes, especially in early stage DAT. In particular, there is increasing difficulty in early stage DAT suppressing conceptually related, partially activated extraneous information. Furthermore, these highly related irrelevant dimensions of the task environment may serve to erroneously drive responses. For example, Spieler et al. argued that the increase in intrusion errors in a Stroop task in mild DAT reflects difficulty in distinguishing among multiple activated representations. Often a deficient inhibitory control system will force responses based on the inappropriate dimensions of the task, particularly when those

inappropriate dimensions are prepotent and highly related to the task at hand. In the present task, aspects of comprehension processes (i.e., false alarms) were driven by highly related inappropriate information. Thus, the present study could be viewed as supporting the notion of an accelerated breakdown in inhibitory processes in early stage DAT and further suggests that a deficient attentional control system may play a role in more general language processing deficits in DAT.

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APPENDIX

Experimental Conditions

Control Condition

THE PARTY

PAUL STARTED COOKING BY 7 A.M. TO PREPARE THE ITALIAN SAUSAGE FOR HIS GREAT-GRANDMOTHER'S BIRTHDAY PARTY. HE STOOD OVER A LARGE STEAMING POT OF SPAGHETTI AND WORKED FEVERISHLY TO GET THE SPICES JUST RIGHT FOR THE SAUCE....

Related Condition

THE PARTY

PAUL STARTED COOKING BY *pepperoni* **7 A.M. TO PREPARE** *juice great aunt* **THE ITALIAN** *juice* **SAUSAGE FOR HIS** *indian pepperoni* **GREAT-GRANDMOTHER'S** *great aunt* **BIRTHDAY PARTY. HE** *pepperoni juice* **STOOD OVER** *pepperoni* **A LARGE STEAMING** *great aunt* **POT OF SPAGHETTI** *juice* **AND WORKED FEVERISHLY TO** *indian pepperoni* **GET THE SPICES** *great aunt* **JUST RIGHT** *pepperoni* **FOR THE SAUCE....**

Unrelated Condition

THE PARTY

PAUL STARTED COOKING BY *parachute* **7 A.M. TO PREPARE** *jump grass arts* **THE ITALIAN** *jumps* **SAUSAGE FOR HIS** *ideas parachute* **GREAT-GRANDMOTHER'S** *grass arts* **BIRTHDAY PARTY. HE** *parachute jumps* **STOOD OVER** *parachute* **A LARGE STEAMING** *grass arts* **POT OF SPAGHETTI** *jumps* **AND WORKED FEVERISHLY TO** *ideas parachute* **GET THE SPICES** *grass arts* **JUST RIGHT** *parachute* **FOR THE SAUCE....**

XXXXX Condition

THE PARTY

PAUL STARTED COOKING BY *xxxxxxxxx* **7 A.M. TO PREPARE** *xxxxx xxxxx xxxx* **THE ITALIAN** *xxxxx* **SAUSAGE FOR HIS** *xxxxx xxxxxxxxx* **GREAT-GRANDMOTHER'S** *xxxxx xxxx* **BIRTHDAY PARTY. HE** *xxxxxxxxx xxxxx* **STOOD OVER** *xxxxxxxxx* **A LARGE STEAMING** *xxxxx xxxx* **POT OF SPAGHETTI** *xxxxx* **AND WORKED FEVERISHLY TO** *xxxxx xxxxxxxxx* **GET THE SPICES** *xxxxx xxxx* **JUST RIGHT** *xxxxxxxxx* **FOR THE SAUCE....**

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