BRAIN AND LANGUAGE **40**, 181–201 (1991)

Semantic Priming Effects, Lexical Repetition Effects, and Contextual Disambiguation Effects in Healthy Aged Individuals and Individuals with Senile Dementia of the Alzheimer Type

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An experiment is reported that addresses semantic priming effects, lexical repetition effects, and the influence of context on meaning selection for ambiguous words in 32 healthy aged individuals and 32 individuals with Senile Dementia of the Alzheimer Type (SDAT). On each of 232 trials, subjects pronounced each of three words. The four major conditions were concordant (*music-organ-piano*), discordant (*kidney-organ-piano*), neutral (*ceiling-organ-piano*), and unrelated (*kidney-ceiling-piano*). In order to address lexical repetition effects, target words were repeated across Blocks 1 and 2 but not in Block 3. Analyses of naming latencies indicated that semantic priming effects and lexical repetition effects were slightly larger in SDAT individuals than in healthy aged individuals. More importantly, healthy aged individuals produced normal selective access of the contextually biased meaning whereas SDAT individuals produced evidence consistent with nonselective meaning access. These results are discussed within both an attentional and a connectionist account of homograph disambiguation.

This work was supported by Grants R01 AGO6257 and AG07406 from the National Institute on Aging. The authors thank Wendy Overkamp and Katherine Verdolini-Marston for their contributions in running the study, and also Michael Posner and Jennifer Sanson in the planning stages of the study. Thanks are also extended to the clinicians of the Washington University Alzheimer's Disease Research Center for their diagnostic assistance. We also thank Richard Ferraro for his comments on an earlier draft of this paper. All correspondences regarding this paper should be sent to David A. Balota, Department of Psychology, Washington University, St. Louis, MO 63130, or via e-mail at C39814DB@WUVMD.

0093-934X/91 $3.00

Individuals with Senile Dementia of the Alzheimer Type (SDAT) exhibit deficits on a wide variety of cognitive tasks. In addition to a marked episodic memory deficit, they show deficits in language processing. For example, rather global deficits have been reported in verbal expression (Smith, Chenery, & Murdoch, 1989), auditory comprehension (Murdoch, Chenery, Wilks, & Boyle, 1987), and word associations (Gewirth, Shindler, & Hier, 1984; Santo Pietro & Goldfarb, 1985). More specific deficits have been reported in word finding (Kempler, Curtiss, & Jackson, 1987), verbal fluency (Ober, Dronkers, Koss, Delis, & Friedland, 1986; Martin & Fedio, 1983), object naming (Kirshner, Webb, & Kelly, 1984), picture naming (LaBarge, Balota, Storandt, & Edwards, 1990), and ranking semantic attributes of concepts (Grober, Buschke, Kawas, & Fuld, 1985). Based on these findings, it has been argued that SDAT individuals exhibit a deficit in semantic/lexical processing (see Nebes, 1989, for a review).

The goal of the present study is to investigate three different aspects of semantic/lexical processing in one paradigm to develop a better understanding of the mechanisms that underlie the cognitive breakdown in SDAT individuals. These aspects are the semantic priming effect, the lexical repetition effect, and the extent to which semantic context controls the selection of meaning for ambiguous letter strings. The emphasis on these components of lexical processing was chosen because each has been central to recent developments concerning the architecture of the cognitive system. We will now turn to a brief discussion of the relevant literature that deals with these aspects of lexical processing in SDAT individuals.

THE SEMANTIC PRIMING EFFECT

First, consider the semantic priming effect. This effect refers to the finding that subjects are faster and more accurate to recognize (e.g., make a lexical decision or name a word aloud) a target word (*cat*) when it follows a related word (*dog*) than when it follows an unrelated word (*pen*). The semantic priming effect has been at the center of considerable work in word recognition research and has been one of the hallmark indicators of spreading activation within a semantic memory network (e.g., Anderson, 1983).

A number of studies already in the literature indicate that SDAT individuals produce similar or larger semantic priming effects compared to healthy young and old adults (Chertkow, Bub, & Seidenberg, 1989; Hartman, 1989; Margolin, 1987; Nebes, Brady, & Huff, 1989; Nebes, Boller, & Holland, 1986; Nebes, Martin, & Horn, 1984). The finding of larger priming effects in SDAT individuals may be expected if one considers the possibility that SDAT individuals have a global deficit in simple word recognition (see Pirozzolo, Nolan, Kuskowski, Mortimer, & Maletta, 1988). Specifically, the reason that SDAT individuals produce larger priming effects may be that the context facilitates a degraded word recognition system. Similar findings can be found with healthy individuals when word recognition processes are slowed via degradation or simple word difficulty (i.e., length and word frequency), and in children who have yet to develop highly skilled word recognition performance. Thus, across a wide variety of variables, whenever the word recognition process is slowed, there is an increased influence of context (see Balota & Rayner, 1990; Stanovich, 1980, for reviews). The increased influence of semantic context in SDAT individuals may simply be another example of such an impact.

However, there are some studies that have failed to produce a semantic priming effect in SDAT individuals (Albert & Milberg, 1989; Margolin, 1987; Ober & Shenaut, 1988). For example, in the Ober and Shenaut study, SDAT patients failed to show semantic priming effects in a lexical decision task when coordinate category members (e.g., *dog–cat*) were used as prime-target pairs. Margolin failed to find semantic priming in SDAT individuals in a lexical decision task when the prime items were pictures. Finally, Albert and Milberg (1989) found a subgroup of SDAT patients who actually produced "negative priming effects" in a lexical decision task (i.e., the unrelated condition was actually faster than the related condition).

Nebes (1989) has argued that the different patterns of priming effects in SDAT individuals may be due to differences across studies in the prime-target stimulus onset asynchronies (SOAs). For example, in the Ober and Shenaut study nearly 2 sec elapsed between the onset of the prime and the onset of the target, whereas, in a later study with a shorter prime-target interval (250 msec), Ober and Shenaut (1989) reported similar priming effects in healthy aged and SDAT individuals. Thus, differences in prime-target SOA may be the critical factor.

It should also be noted that the studies that have failed to produce semantic priming effects in SDAT individuals have all relied on the lexical decision task as the dependent measure. Clearly, this cannot be the only mitigating factor, because some studies have produced large priming effects in the lexical decision performance of SDAT individuals (e.g., Nebes et al., 1984). However, there is now considerable evidence that the lexical decision task is especially sensitive to strategic factors (e.g., Balota & Chumbley, 1985; Balota & Lorch, 1986; Chumbley & Balota, 1984; West & Stanovich, 1982). Moreover, list composition factors (such as the percentage of related prime-target trials and nonword trials) modulate the influence of these strategic factors (see, Neely, 1990 for a review). If within a given experiment strategies develop because of previous exposure to particular types of prime-target trials, it is possible that SDAT individuals may be less likely to develop such strategies. Such list context strategies apparently demand a type of running memory for the proportions of related trials and nonword trials, and hence would demand a memory system that is deficient in SDAT individuals. Moreover, it is possible that such strategies may play a stronger role when there is a longer delay between the prime and target, consistent with the Nebes argument.

In the present study, an attempt was made to avoid the above difficulties with the lexical decision task, by using a simple naming response as the dependent measure. Also, as described below, a prime-target delay manipulation was included to directly address the argument that prime-target delay is the crucial factor in modulating the presence of semantic priming effects across studies with SDAT individuals.

LEXICAL REPETITION EFFECTS

The second issue addressed in the present study is whether lexical processing in SDAT individuals will be facilitated by an exposure to the same stimulus word approximately 15 min earlier. Specifically, will the prior exposure of an item produce activation that lasts for an extended period of time? Repetition priming effects have recently played a central role in the memory literature because of their relationship to implicit/procedural memory (see Schacter, 1987, for a review). This type of memory can be contrasted to the memory that is tapped by traditional recall and recognition tasks that presumably reflect a different memory system referred to as explicit/declarative memory. One of the interesting findings in the literature contrasting these two memory "systems" is that amnesics produce large deficits on declarative memory tasks but relatively little, if any, deficit on procedural memory tasks (see Squire, 1986, for a review). Thus, it is important to address whether SDAT individuals, who have relatively global cognitive deficits, produce normal repetition priming effects.

Again, there is already available literature regarding repetition-type priming in SDAT individuals. For example, Moscovitch, Winocur, and McLachlan (1986) have provided evidence that SDAT individuals benefitted as much as healthy older adults from the repetition of stimuli in a mirror reading task. Knopman and Nissen (1987) reported that *overall* SDAT individuals benefitted on subsequent trials from the prior exposure of a repeated motor sequence of responses. However, Knopman and Nissen also reported that some of their SDAT individuals did not show any influence of the repeated motor sequences. Furthermore, Strauss, Weingartner, and Thompson (1985) found that SDAT individuals did not benefit from the number of earlier repetitions of a given word either in recall performance or in frequency monitoring performance. Thus, the extant literature has been inconsistent regarding the impact of repetition on later task performance.

The influence of an earlier repetition on target performance will be addressed by repeating the target words in the first and second blocks of trials, while in the third block of trials a new set of target words will be presented. If the memory system that underlies simple lexical repetition effects remains intact in SDAT individuals, then one should expect that response latency to the target words would be faster in the second block of trials than in the first block. Furthermore, response latency to the new set of targets in the third block of trials should be slower than in the second block and more similar to the first block of trials. This latter aspect of the repetition effect is quite crucial to rule out a simple practice effect account of performance.

THE INFLUENCE OF SEMANTIC CONTEXT ON MEANING SELECTION

Finally, the present study will also address the extent to which semantic context influences the selection of meaning for ambiguous letter strings. For example, given the homograph *organ,* does the context word *kidney* serve to bias the interpretation of the word *organ* (referring to a *bodily organ*), thereby making the other meaning of the word *organ* (referring to *musical instrument*) less accessible? If the context constrains the interpretation of *organ* as a *bodily organ,* then response latency to *kidney-organ-piano* should be similar to the unrelated condition *kidney-ceiling-piano.* Swinney (1979) has interpreted the disambiguation of homographs within an attentional framework in which context serves to modulate the selection of attention. However, Cottrell and Small (1983) have argued that such results can also be modeled within a connectionist framework without appealing to an *extra* attentional mechanism. In either case, it is quite important to determine whether context resolves lexical ambiguity in SDAT individuals or whether multiple meanings remain active independent of context. Ambiguity resolution has been one of the hallmark issues underlying developments in the area of language processing (Rayner and Pollatsek, 1989).

There is already some evidence that SDAT individuals have difficulty using semantic context to bias the correct interpretation of a pronoun (LeDoux, Blum, & Hirst, 1983) and to disambiguate homophones (Cushman & Caine, 1987; Kempler et al., 1987). For example, Cushman and Caine (1987) auditorily presented lists of words for subjects to write. The last word in each list was a homophone (e.g., *him* or *hymn*) and the other words in the list provided a semantic context which biased the interpretation of the homophone (e.g., *church, music,* . . .). They found that SDAT individuals were less likely to write down the biased spelling of the homophone than healthy older adults. The present study will further address the impact of context on ambiguity resolution in a speeded naming task, in which context either directs or misdirects the selection of the relevant meaning of an ambiguous letter string.

The present study was based, in part, on a study reported by Schvaneveldt, Meyer, and Becker (1976). The four major prime-target conditions are displayed in Table 1. In the *concordant* condition, the first word

TABLE 1
PRIME CONDITIONS

Prime Condition	First Prime	Second Prime	Target
Concordant	Music	Organ	Piano
Discordant	Kidney	Organ	Piano
Neutral	Ceiling	Organ	Piano
Unrelated	Kidney	Ceiling	Piano

biased the meaning of the second homographic word such that it was consistent with the meaning of the third target word. In the *discordant* condition, the first word biased the meaning of the second homographic word such that it was inconsistent with the meaning of the third target word. In the *neutral* condition, the first word was unrelated to the second homographic word that was related to the third target word. Finally, in the *unrelated* condition, both the prime words were unrelated to the third target word. In a sequential lexical decision task, Schvaneveldt et al. found facilitation in response latency to the third word for the concordant condition compared to the remaining three conditions. More importantly, they also found that the discordant and unrelated conditions produced relatively equal response latencies with both being slower than the neutral condition. This general pattern of data has been replicated and extended to a number of different experimental paradigms (see Seidenberg, Tannenhaus, Leiman, & Bienkowski, 1982; Swinney, 1979). As noted above, the argument is that the first word (e.g., *kidney*) biases the selected meaning of the second homographic word (e.g., *organ* as a *body part*). Because in the discordant condition, the meaning of the homographic word (e.g., *organ* as a *body part*) is unrelated to the meaning of the third word (e.g., *piano*), response latency to the third word is similar to an unrelated condition (e.g., *kidney-ceiling-piano*). If SDAT individuals do not use context to bias the interpretation of homographic words, then one might find that the discordant condition is actually faster than the unrelated condition, and is more similar to the concordant condition.

The time available for the biasing context to influence the interpretation of the ambiguous word was also manipulated. Specifically, the delay between the pronunciation of the second word and the onset of the third word was either 250 or 1250 msec. Based on the Seidenberg et al. results, one should find that healthy adults can use context to disambiguate homographs very quickly, at the 250-msec delay. Thus, the discordant condition should be slower than the concordant condition and more similar to the unrelated condition at the short *and* long delays. However, because of a general slowdown in the processing system, the SDAT individuals may not resolve the ambiguity until the longer delay. Hence, it is possible that SDAT individuals will only show ambiguity resolution at the long delay.

SUMMARY

The present study will provide evidence regarding three aspects of lexical processing in a single paradigm; (1) semantic priming, (2) lexical repetition effects, and (3) the extent to which context modulates the selection of meaning for ambiguous stimuli. On each trial subjects pronounced each word in a three-word sequence.[1] The semantic priming effects were assessed through response latency to the second word in each sequentially presented triad (e.g., the word *organ* in the sequence *piano-organ-heart*). As shown in Table 1, both the concordant and the discordant conditions have related primes before the second word, whereas both the neutral and the unrelated conditions have unrelated primes before the second word. As described above, lexical repetition effects were assessed through response latency changes to the target words across the three blocks of trials. Finally, the influence of context in meaning selection was assessed through response latency to the third word in each triad as a function of prime-target condition (i.e., concordant, discordant, neutral, unrelated).

METHOD

Design. There are two aspects to the design of the present study. First, in order to tap simple semantic priming effects, response latency to the *second* word was the dependent variable in a 2 (Healthy Old vs SDAT individuals) × 2 (related vs unrelated primes) mixed-factor design. Second, in order to tap lexical repetition effects and meaning selection effects, response latency to the *third* word was the dependent variable in a 2 (Healthy Old vs SDAT individuals) × 3 (Block of trials) × 2 (250 msec vs 1250 msec Delay between the pronunciation of the second word and the onset of the third word) × 4 (Concordant, Discordant, Neutral, Unrelated Prime Conditions) mixed-factor design. Health was the only between-subjects factor.

Subjects. Thirty-two individuals who were diagnosed as having SDAT were recruited from the *Washington University Alzheimer's Disease Research Center* and the *Memory and Aging Project.* Their mean age was 73.6 years (SD = 8.6) and their mean education was 12.6 years (SD = 2.7).

All of these participants were originally screened by physicians for depression, severe

[1] We originally attempted to conduct each trial such that subjects would only read the prime words silently to themselves and then pronounce the target word aloud. However, after pilot work, we found that SDAT individuals had difficulty suppressing their naming response to the prime items. Hence, we had subjects name each word as it was presented. In this way, subjects were processing the primes at their own pace. The problem of course with this procedure is that SDAT individuals were overall slower than healthy aged individuals. Interestingly, however, there was only a 150-msec average slowdown in naming rates. Also, because of the inclusion of a delay interval manipulation between the second and the third words, one can directly address the speed of presentation issue in the present results. As discussed in the results section, presentation speed cannot account for the present results.

hypertension, reversible dementias, and other disorders or medications that could potentially produce mental impairment. The inclusionary and exclusionary criteria for SDAT are consistent with the *NINCDS-ADRDA* criteria (McKhann, Drachman, Folstein, Katzman, Price, & Stadlan, 1984). The severity of the dementia was staged according to the *Washington University Clinical Dementia Rating* (*CDR*) scale where CDR 0.5, 1, 2, and 3 represent questionable, mild, moderate, and severe dementia, respectively (Berg, 1988; Hughes, Berg, Danziger, Coben, & Martin, 1982). Eleven individuals had a CDR of 0.5, 18 individuals had a CDR of 1, and 3 individuals had a CDR of 2.

The CDR is based on a 90-min interview that assesses the person's cognitive abilities in the areas of memory, orientation, judgement and problem solving, community affairs, home and hobbies, and personal care. Part of the interview is with the subject and part is with the collateral source. The interviews were originally conducted by one of eight board-certified physicians (four neurologists and four psychiatrists). The physician's interviews were taped and then reviewed by a second physician for an index of reliability. Both reliability of the CDR and validation of the inclusionary and exclusionary criteria (based upon autopsy confirmation) by this research team have been excellent and well-documented (e.g., Berg, Smith, Morris, et al., 1990; Burke, Miller, Rubin, et al., 1988; Morris, McKeel, Fulling, Torack, & Berg, 1988; Morris, McKeel, & Price, et al. 1988). To date (9/11/90), 62 of 64 individuals diagnosed as having SDAT who have come to autopsy have had Alzheimer's Disease confirmed.[2]

In addition to the 32 SDAT individuals, an additional 32 healthy older adults were recruited from the Washington University local community. The healthy control subjects had a mean age of 70.8 years (SD = 3.7), and a mean education of 13.4 years (SD = 2.4). Neither the healthy control subjects' age nor education level significantly differed from the SDAT individuals. Finally, the healthy control subjects rated their health on average as Good (5 indicated Fair, 13 Good, and 14 Excellent) and their activity level as Moderate (18 as moderate and 14 as very active). All older adults provided their own transporation to the experimental session.

Apparatus. An *Apple IIe* microcomputer interfaced with a *Mountain Hardware* Clock Card was used for stimulus display and msec resolution. A *Gerbrands* (Model *G1341T*) electronic voice operated relay was also interfaced to the computer to measure voice onset times.

Materials. The critical stimuli consisted of 64 sets of seven words that were based on the stimuli used by Balota (1983). For each set, there was a homographic word (e.g., *organ*), two words related to one meaning of the homograph (e.g., *music* and *piano*), two words related to a different meaning of the homograph (e.g., *kidney* and *heart*) and two unrelated words (e.g., *ceiling* and *world*). One of the related words was designated as the target word for a given set of triads. The four conditions created from each set are displayed in Table 1. Within each group of four subjects, the target word was rotated across the four prime conditions. Across each group of four subjects the delay interval between the pronunciation

[2] For further documentation regarding cognitive breakdowns across CDR levels see Storandt and Hill (1989). For the present purposes it is noteworthy that there is a substantial breakdown in a wide range of psychometric tests across each CDR level, even at the questionable level. Preliminary analyses as a function of CDR level indicated that subjects at different levels were indistinguishable with respect to semantic priming, repetition priming, and meaning selection. However, because of the rather small groups per condition and the fact that items were not completely counterbalanced within a group, this is a relatively weak test. Hence the emphasis in the present study is on healthy older adults versus SDAT individuals, independent of CDR level.

of the second word and third target word was counterbalanced across the 250- and 1250-msec delay intervals.

As described earlier, subjects received the same set of prime target pairs in the first and second blocks of trials. The third block of trials involved switching the conditions for a given group of seven words between the concordant and the discordant conditions and between the neutral and the unrelated conditions. For example, if the subject received the concordant triad *music-organ-piano* for the first two blocks of trials, then in the third block, the subject would receive the discordant triad *music-organ-heart.* Likewise, if the subject received the discordant triad *kidney-organ-piano* for the first two blocks of trials, then in the third block the subject would receive the concordant triad *kidney-organ-heart.* If the subject received the neutral triad *ceiling-organ-piano* for the first two blocks of trials then in the third block of trials the subject would receive the unrelated triad *music-world-heart.* If the subject received the unrelated triad *kidney-ceiling-piano* in the first two blocks of trials, then in the third block of trials subjects would receive the neutral triad *world-organ-heart.* Because the targets changed across the first two blocks and the third block of trials, the target conditions which occurred for the first two blocks of trials for the first group of eight subjects were switched to the target conditions for the third block of trials for the next eight subjects and vice versa. Finally, the delay between the second and the third word was kept constant across the first two and the third blocks for a given set of triads. It is important to note here that the counterbalancing of stimuli across subjects ensured that each item occurred equally in each condition across subjects.

In addition to the 64 critical target groups of seven words, there were 36 additional triads constructed. Twenty-eight of these triads served as practice trials, whereas the remaining eight triads served as buffer items which were presented on the first four trials of a given test block. The same four buffer triads served in Blocks 1 and 2, and a different four buffer triads served in Block 3. These buffer and practice triads included no discordant biasings of meanings, but rather, included conditions in which (1) the first two words were related to the third, (2) the first word was related and second word was unrelated to the third, (3) the first word was unrelated and the second word was related to the third, and (4) both words were unrelated to the third. Within the practice trials and within a group of buffer items for a given block, each of the four conditions was equally represented.

Procedure. The following sequence occurred on each trial: (a) a row of three asterisks separated by blank spaces presented in the center of the screen for 275 msec; (b) a blank screen for 275 msec; (c) the first word in the center of the screen until the subject completed their pronunciation, at which time the word was erased and a 500-msec delay occurred; (d) the second word appeared immediately below the line where the first word appeared until the subject completed their pronunciation, at which time the word was erased; (e) either a 250- or a 1250-msec delay was presented; (f) the third word was presented on the line immediately below where the second word appeared; (g) after the subject completed their pronunciation of the third word, the word was erased. Following this sequence on each trial the procedure was slightly different for the healthy older adults and the SDAT individuals. For the healthy older adults the following message occurred on the screen: "IF YOU CORRECTLY PRONOUNCED THE WORDS, PRESS THE '0' BUTTON, OTHERWISE PRESS THE '1' BUTTON." This was followed by a keypress and a blank screen for a 2-sec intertrial interval. In order to simplify the procedure for the SDAT individuals, the experimenter sat with them during the experiment and monitored each trial by pressing either the '1' or the '0' button indicating whether a correct or incorrect pronunciation triggered the system.

Subjects received a total of 232 trials; 28 practice trials, and three blocks of 68 trials; as noted, the first four trials in each test block were buffer trials. Subjects also received four planned practice breaks. One break occurred after the 14th practice trial and the remaining

TABLE 2
MEAN OF THE MEDIAN RESPONSE LATENCIES (msec) AS A FUNCTION OF GROUP AND PRIME-TYPE

	Prime Condition		
	Related	Unrelated	Priming Effect[a]
Healthy Old	545	556	11
SDAT	675	698	23

[a] Priming Effect = Unrelated − Related.

breaks occurred before each test block. In addition, subjects were allowed to take breaks whenever they felt such breaks were necessary.

RESULTS

In analyzing the data, we first calculated the mean response latency and *SD* for a given subject. Any observation that was either 3 *SD*s above or below the subject's mean was treated as an outlier. From the remaining correct observations, a median response latency was calculated for a given subject/cell. We conducted separate overall Analyses of Variance (*ANOVA*s) on the median response latencies to the second word and the median response latencies to the third word.

Although the primary analyses will be on the response latency data it should be noted that healthy older individuals produced 98.9% correct responses (also excluding outliers) while SDAT individuals produced only 91.7% correct responses. Analyses on the percentage correct data yielded only a main effect of group with no interactions. Of course, one must be cautious in interpreting these data, because errors would be recorded if the subject made a mispronunciation on any of the three words in a given triad, or also if an extraneous sound such as a movement or cough was made while the stimulus was being presented. Because of the difficulty in interpreting accuracy data in naming performance, response latency will be the primary variable of interest in the present results.

Second Word Performance

Semantic priming effects. In order to assess semantic priming effects, we conducted an *ANOVA* on the median response latencies to the second word. In this analysis, we collapsed across the concordant and discordant conditions (yielding a semantically related prime condition), and across the neutral and unrelated conditions (yielding a semantically unrelated prime condition). Because the delay factor occurred after production of the second word this variable was not included in this analysis.

The means of the median response latencies to the second word as a function of Group and Prime type are displayed in Table 2. There are

TABLE 3
Mean of the Median Response Latencies (msec) as a Function of Group and Block

	Block 1	Block 2	Block 3	B1-B2	B2-B3
Healthy old	575	548	560	27	−12
SDAT	721	687	710	34	−23

two points to note from Table 2. First, as expected, the healthy older adults produced faster response latencies than the SDAT individuals. Second, the priming effect, if anything, is slightly larger for the SDAT individuals than for the healthy older adults.

These observations were supported by a 2 (Group) × 3 (Block) × 2 (Related vs Unrelated Prime) mixed-factor *ANOVA*. There were significant main effects of Group, $F(1, 62) = 18.82$, $MS_e = 1781128$; Block, $F(2, 124) = 14.26$, $MS_e = 37643$; and Prime $F(1, 62) = 32.18$, $MS_e = 28420$. There was also a significant Group × Block interaction, $F(2, 124) = 3.32$, $MS_e = 8765$, indicating that for the healthy older adults Block 1 (562 msec) was slightly slower than Block 2 (542 msec) and Block 3 (547 msec), whereas, for the SDAT individuals, response latency for Block 1 (714 msec) was considerably slower than for Block 2 (680 msec) and Block 3 (666 msec). This overall pattern simply suggests that SDAT individuals benefitted slightly more from repetition than healthy adults. (We will return to this issue below.) More importantly, there was a significant Group × Prime-type interaction, $F(1, 62) = 4.70$, $MS_e = 4151$. As shown in Table 2, this interaction indicates that SDAT individuals produced larger semantic priming effects than the healthy older adults.

Third Word Performance

We shall now turn to the primary analysis of the median onset latencies for the third word in each triad. The overall *ANOVA* was a 2 (Group) × 3 (Block) × 2 (Delay) × 4 (Prime-type) mixed-factor ANOVA. We will first discuss the lexical repetition effects and then will discuss the influence of context on meaning selection.

Lexical repetition effects. In order to assess repetition effects, we were primarily interested in the change in response latency across Blocks of trials. As previously mentioned, the targets were repeated across Blocks 1 and 2 and switched in Block 3. Table 3 displays the mean of the median onset latencies as a function of Group and Block. There are two major points to note in Table 3. First, overall response latency was slower for the SDAT individuals than the healthy older adults. Second, response latency for both groups was faster in Block 2 than in Block 1 and response latency in Block 3 was slower than in Block 2 and more similar to Block 1.

TABLE 4
MEAN OF THE MEDIAN RESPONSE LATENCIES (msec) AS A FUNCTION OF GROUP, DELAY, AND PRIME

	Concordant	Discordant	Neutral	Unrelated
Healthy Old				
Short delay	557	570	564	571
Long delay	547	564	551	561
Means	552	567	558	566
SDAT				
Short delay	702	709	695	735
Long delay	689	700	698	714
Means	696	705	697	725

These observations were supported by the overall *ANOVA*. There was a highly significant main effect of group, $F(1, 62) = 22.89$, $MS_e = 351066$, and Block $F(2, 124) = 12.54$, $MS_e = 9755$. Separate planned comparisons indicated that the facilitation from Block 1 to Block 2 was significant for both groups, and the inhibition from Block 2 to Block 3 was significant for both groups (all $ps < .05$). Finally, the Group × Block interaction did not approach significance, $F(2, 124) = .38$, $MS_e = 9755$. Hence, there was a reliable influence of repetition of stimuli and it had a relatively equal impact for both healthy aged individuals and SDAT individuals. Moreover, the increase in response latencies from Block 2 to Block 3 indicates that the lexical repetition effect cannot simply be attributed to a nonspecific practice effect.

Context and meaning selection. Table 4 displays the mean of the median onset latencies as a function of Group, Delay, and Prime Condition. There are four major points to note. First, there appears to be an overall effect of Prime Condition with the concordant and neutral conditions being faster and more similar than the discordant and unrelated conditions. Second, the concordant and neutral conditions are similar and fastest for both the healthy aged individuals and the SDAT subjects. Third, and most importantly, the discordant and unrelated conditions are virtually equivalent for the healthy aged individuals, whereas, for the SDAT individuals, the discordant condition is considerably faster than the unrelated condition. Fourth, the delay factor appears to have little influence on this pattern.

The above observations were supported by the overall *ANOVA*. The analysis yielded a significant main effect of Prime Condition, $F(3, 186) = 15.98$, $MS_e = 12260$, and most importantly, a Group by Prime Condition interaction, $F(3, 186) = 3.77$, $MS_e = 2307$. Before turning to a more detailed analysis of the Group by Prime type interaction, there are two further points to note regarding the results of the overall *ANOVA*. First, although the main effect of delay approached significance, $F(1, 62)$

$= 3.35$, $MS_e = 10843$, $p = .07$, this variable did not participate in any significant interactions with the remaining variables (all *p*s $> .25$). The important Group by Delay by Prime interaction did not approach significance, $F(3, 186) = 1.09$, $MS_e = 3078$. Second, although, as noted in the previous section, Block produced a significant main effect, this variable did not participate in any significant interactions with any of the remaining variables (all *p*s $> .25$). We can now turn to the interaction between Group and Prime-type without being concerned with interactions between other variables within the design.

First, consider the healthy aged individuals. Planned contrasts on the median response latencies yielded the predicted pattern of data for the healthy aged individuals. That is, the discordant condition was significantly slower (15 msec) than the concordant condition, and significantly slower (10 msec) than the neutral condition (both *p*s $< .01$). Moreover, the discordant condition was remarkably similar (1 msec difference) to the unrelated condition. Thus, for the healthy aged individuals, the first word served to select the meaning of the ambiguous homograph such that it slowed performance compared to the neutral and concordant conditions, and produced equivalent performance with the unrelated condition.

Turning to the SDAT individuals, although the discordant condition was 9 msec slower than the concordant condition and 8 msec slower than the neutral condition, neither of these differences reached significance, $p = .10$ and .07, respectively. Moreover, even a test of the main effect of prime condition across these three conditions did not yield a significant effect of prime condition, $F(2, 31) = 1.99$, $MS_e = 1739$. Finally, and most importantly, the unrelated condition was significantly slower (20 msec) than the discordant condition ($p < .01$). Thus, unlike the healthy aged individuals, for the SDAT individuals, the first word did not totally constrain meaning selection for the homographic word, and hence, the discordant condition produced substantially faster response latencies than the unrelated condition.

DISCUSSION

The purpose of this study was to assess the impact of SDAT on (1) semantic priming effects, (2) lexical repetition effects, and (3) the influence of context on meaning selection. The results of the present study are straightforward with respect to each of these issues.

Semantic Priming Effects

The results clearly indicated that SDAT individuals produced normal semantic priming effects. Both SDAT and healthy older individuals produced faster response latencies to pronounce the second word when it was preceded by a related word than an unrelated word. As previously mentioned, there is some debate as to whether SDAT individuals produce normal semantic priming effects. The question of interest is whether the semantic network is disrupted by the disease. If the network is damaged, then one may not expect normal semantic priming effects in SDAT. This "disrupted semantic network" could then account for some of the more general semantic deficits seen in SDAT such as difficulty in object naming, verbal fluency, etc.

As noted in the introduction, there have been several reports of priming effects in SDAT individuals (Chertkow et al., 1989; Hartman, 1989; Margolin, 1987; Nebes et al., 1989, 1986). However, there are some studies in which SDAT individuals have failed to produce priming effects (Albert & Milberg, 1989; Ober & Shenaut, 1988; Margolin, 1987). It has been suggested that the failure to find priming effects in some of these studies (e.g., Ober & Shenaut, 1988) may be due to relatively long SOAs which evoke more attentional processes (Nebes, 1989). However, in the present study SDAT individuals pronounced the prime words and the interval between the completion of the pronunciation of the second word and the presentation of the third word was a full 1250 msec at the long delay condition. Yet, the SDAT individuals produced significant priming effects in the concordant (25 msec), neutral (16 msec) and discordant (14 msec) conditions relative to the unrelated condition at this long delay condition (all $ps < .05$). Thus, in a pronunciation task SDAT individuals do show priming at relatively long SOAs. This suggests that it is not simple delay that is the crucial factor that eliminated the priming effect in the Ober and Shenaut study. Because SDAT individuals show priming at short SOAs in a lexical decision task (Margolin, 1987; Nebes et al., 1989), it seems more likely to conclude that the failure to produce priming in the Ober and Shenaut study was due to the combination of a long SOA and the use of a lexical decision task. Possibly, there is an increased reliance on checking for an associative relationship to bias the *word* response at long SOAs in the lexical decision task (see Neely & Keefe, 1989, for similar arguments). If SDAT individuals do not develop such a checking strategy, then it is possible that this eliminated the priming effects. At the short SOAs, the priming effect in SDAT individuals may be more a reflection of spreading activation. It should also be noted here that the lexical decision task was used in the Albert and Milberg (1989) study in which a subgroup of SDAT individuals did not show a priming effect. Clearly, further research needs to be conducted regarding the impact of *strategies* on observed priming effects in the lexical decision task (see Neely, 1990), especially if this task is to be used as a reflection of spreading activation or semantic network organization in populations with rather global cognitive breakdowns.

Finally, the results of the present study indicated that SDAT individuals actually produced *larger* semantic priming effects than the healthy older adults. This same finding has been reported in other studies (Chertkow et al., 1989; Margolin, 1987; Nebes et al., 1986, 1989). As previously mentioned, the increased priming effect in SDAT may reflect an overall deficit in simple word recognition in these individuals. If SDAT individuals have more difficulty (e.g., are slower) in lexical access, then they would be expected to benefit more than healthy older adults from a related context. The related context would serve to compensate for a loss in simple word recognition and thus facilitate recognition relative to an unrelated condition. Interestingly, Chertkow et al. (1989) found that SDAT individuals produced larger priming effects for items which showed "semantic degradation" as measured by prior semantic knowledge questions compared to those items which showed "intact" semantic knowledge. They suggest that this exaggerated priming reflects a semantic memory degradation and semantic context serves to disproportionately increase the accessibility of semantically degraded items. Likewise it is possible that semantic information actually contributes to the lexical access processes involved in word recognition (Balota, 1990; Balota, Ferraro, & Connor, 1991).

Lexical Repetition Effects

Although it is clear that SDAT individuals produce large deficits in explicit/declarative memory tasks (e.g., recall and recognition tasks), the present results support the notion that there is relatively little deficit in implicit/procedural memory tasks, at least as reflected by simple lexical repetition effects. That is, SDAT individuals produced repetition effects similar to those of the healthy older adults. Pronunciation latencies in Block 2 were faster than those in Block 1 for SDAT individuals. Furthermore, these results were not simply due to nonspecific practice effects because response latencies in Block 3 in which the items were switched were reliably slower than those in Block 2 and more similar to those in Block 1 for both groups of subjects. Thus, these results indicate that in SDAT, the prior exposure of the items produced a level of activation that lasts for an extended period of time, which is consistent with the arguments made by Moscovitch et al. (1986).

It is not entirely clear why some of the SDAT individuals in the Knopman and Nissen (1987) study failed to show implicit learning. It may be the case that the major difference is between learning a new response (i.e., motor sequence) versus activating a preexisting structure. In both the present study and the Moscovich et al. (1986) study subjects were required to reactivate preexisting memory structures.

On the other hand, Strauss et al. (1985) reported that SDAT subjects were unable to monitor the frequency of occurrence of repeated words and thus produced a deficit in what might be referred to as a type of procedural/automatic processing task. Obviously, words have a preexisting representation, so one might ask how we can reconcile their results.

A close inspection of their data indicates that the SDAT subjects do show a slight increase in frequency judgements as a function of repetitions. This effect may not have reached statistical significance due to the relatively small sample size (i.e., $n = 9$). At this level, it is worth noting that the present study had considerable power to detect such lexical repetition effects. That is, across the 32 subjects within each group, there was a total of 2048 observations for each block of trials.

In sum, we would argue that SDAT individuals will exhibit normal repetition effects when preexisting memory structures are activated via repetition, and the dependent variable is relatively simple for a given level of dementia. Of course, like all the arguments in the present paper, one must be cautious not to generalize beyond relatively mild levels of SDAT.

The Influence of Context on Meaning Selection

A major purpose of the present study was to examine the extent to which context modulates the selection of meaning for an ambiguous lexical item. The results indicate that semantic context does not influence the selection of meaning in SDAT, as it does in healthy older adults. For healthy adults, the discordant condition was slower than the concordant condition and equivalent to the unrelated condition. It appears that the healthy older adults used the context to strongly constrain the interpretation of the homographic word. However, for the SDAT individuals, the discordant condition was more similar to the concordant and neutral conditions, and significantly faster than the unrelated condition. Hence, it appears that the SDAT individuals did not use context to bias the interpretation of the homographic word. Therefore, the ambiguous homographic word primed the target word (compared to the unrelated prime condition), independent of its preceding context. Finally, the delay did not interact with prime condition and group. Thus, even at the long delay, context did not constrain the interpretation of ambiguous strings in the SDAT individuals.

Before discussing potential underlying mechanisms, we should address two important aspects of the present group by prime-type interaction. First, one might suggest that there was not enough power in the present study to detect a difference among the concordant, discordant, and neutral conditions in the SDAT group. However, this explanation does not seem reasonable since the present design yielded 1536 observations across the four prime conditions. Therefore, the present design had considerable power to detect a reliable difference.

A second argument might be that the difference in the observed pattern of data may be due to the fact that the SDAT individuals are simply slower to recognize the words, and therefore slower to disambiguate the homographs. This explanation cannot account for the present data for two major reasons. First, the present study was self-paced. That is, all subjects both recognized and pronounced each word before the next word appeared. Thus, it would be difficult to argue that subjects did not recognize the prime items when there is behavioral data indicating that they sufficiently recognized the primes to correctly pronounce them aloud. Furthermore, because the task was self-paced, the SDAT individuals actually had slightly more time to process the primes. Thus, if anything, the slightly longer delays between the second and the third word for the SDAT individuals should have allowed the context more time to disambiguate the homographs.

A second and important argument against a simple deficit in processing the primes is that the response latencies to the second word indicated that the SDAT individuals actually produced larger semantic priming effects than the healthy older adults. Moreover, compared to the unrelated prime condition, response latency to the third word produced larger priming effects in SDAT individuals than in healthy older adults. Thus, it is not the case that the SDAT individuals were not sufficiently processing the primes but rather they were processing the primes in a qualitatively different manner.

We shall now turn to a brief discussion concerning potential underlying mechanisms that may account for the nonselective access of meaning produced in SDAT individuals. These results could be interpreted within an attentional framework as suggested by Swinney (1979). Possibly, context does not serve to direct attention to the biased meaning in SDAT individuals. That is, given *music-organ,* the context word *music* does not direct attention to a particular meaning of the word *organ.* Both meanings of *organ* are accessible because SDAT individuals have difficulty localizing attention within the memory network. On the other hand, in healthy aged individuals, the context *music* quickly constrains the interpretation of *organ* and the meaning of *organ* as a *body part* is not accessible. Thus, there has to be a redirection of attention within the network, similar to an unrelated condition (see Balota, 1983; Neely, 1977, for further discussion of such an attentional mechanism).

Many cognitive tasks demand such attentional processing and therefore one should not be surprised by the global deterioration in cognitive task performance observed in SDAT. Such a deficit could account for SDAT deficits in tasks such as object naming and verbal fluency which involve search and attentional direction in the memory network. Thus, the nonselective access pattern found in the SDAT individuals may simply reflect a more global attentional breakdown in these individuals.

These findings may also be interpreted within a connectionist framework such as the one proposed by Cottrell and Small (1983) to model word sense disambiguation. Within this framework, meaning selection simply occurs because of inhibitory pathways between multiple meanings of the same lexical item. Hence, when the meaning of *organ* referring to *musical* *instrument* becomes activated it inhibits the meaning of *organ* referring to *bodily organ.* The potentially interesting aspect of this framework is that there is no need to appeal to a qualitatively different mechanism (i.e., the direction of attention) to account for these results. The non-selective processing of ambiguous strings in SDAT individuals simply reflects a general failure of the inhibitory system. This of course, could be due to a loss of inhibitory pathways or a change in the activation system itself.

Of course, the attentional and connectionist frameworks are not mutually exclusive. It may be the case that the engagement of attention to the biased interpretation inhibits the alternative interpretation. It is the coordination of this engagement and inhibition that would produce a type of edge sharpening for stimuli that have multiple interpretations. Moreover, one might argue that the buildup of activation at a particular memory representation quite nicely maps onto notions regarding attentional engagement. At the very least, further research is necessary to distinguish between an attentional and a connectionist account of the present results.

CONCLUSIONS

The present study provides evidence that the semantic priming and lexical repetition effects remain stable in early stages of SDAT. There was clear evidence that primes indeed activate related areas in the memory structure. More importantly, however, the primes do not appear to select appropriate meanings, thereby inhibiting inappropriate meanings. Instead, multiple meanings remain activated in the SDAT network. Of course, an important next step in this research would be to determine whether such selection deficits are a general characteristic of the SDAT processing system and therefore extend into other domains of the cognitive system.

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