Neuropsychology
1995, Vol. 9, No. 4, 537–555

0894-4105/95/$3.00

Identity Negative Priming in Older Adults and Individuals With Dementia of the Alzheimer Type

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This study addressed the question of whether dementia of the Alzheimer type (DAT) produces a breakdown in aspects of the inhibitory component underlying selective attention. Two measures of identity negative priming and 2 measures of distractor interference were obtained. In Experiment 1, participants were presented with overlapping picture stimuli, and in Experiment 2, participants were presented with overlapping written word stimuli. The results of both experiments produced reliable and similar size negative priming in young and old adults, but there was no evidence of negative priming in the individuals with DAT. In contrast, the naming latencies of all 3 groups showed a reliable and similar size distractor interference effect. These results suggest that although the inhibitory component underlying selective attention is impaired in individuals with DAT, the ability to differentiate a target from a distractor may be preserved under certain task conditions.

In the natural environment, we are confronted with multiple sources of information. One function of attention is to select some subset of this information for further processing. Many current theories of selective attention are based on the assumption that the "selected" or goal-relevant information is facilitated while the "ignored" or irrelevant information is actively inhibited (Dalrymple-Alford & Budayr, 1966; Neill, 1977; Tipper, 1985). In the present experiments, we investigate the inhibitory aspect of selective attention in healthy old adults and in individuals with dementia of the Alzheimer type (DAT). In pursuit of this goal, we first review the literature on inhibitory processes in healthy old adults and then turn to a review of the corresponding literature on individuals with DAT.

Inhibition in Healthy Old Adults

The literature on aging and cognitive function suggests that memory and language decline with age (for a review, see Sugar & McDowd, 1992). Hasher and Zacks (1988) reviewed the literature and theorized that one underlying cause for the cognitive decline in healthy old adults may be a decrement in the inhibitory component of selective attention that functions to suppress irrelevant information. They suggested that such a decrement would cause irrelevant information to remain abnormally active in working memory and thus interfere with processing during the encoding and retrieval of information. Indeed, old adults have been found to show a greater number of false positives to semantically related distractors in tasks of recognition memory (Rankin & Kausler, 1979), more difficulty suppressing nontarget information during reading comprehension (Connelly, Hasher, & Zacks, 1991; Hamm & Hasher, 1992; Hartman & Hasher, 1991), more intrusions (inappropriate recurrence of previous responses) in tasks of story recall (G. Cohen, 1988; Winthorpe & Rabbitt, 1988), and a decreased ability to judge frequency of occurrence of right words (relevant) that had previously appeared with wrong words (irrelevant distractors) in a task of recognition learning (Kausler & Hakami, 1982).

Further support for an age-related change in inhibitory function was provided by studies of selective attention, which used distractor interference and negative priming paradigms. In distractor interference tasks, response latency to a target is measured in the presence of either an interfering or neutral distractor stimulus. The typical finding with young adults is that an interfering stimulus will slow response latency to a target, whereas a neutral stimulus will not (Ericksen & Ericksen, 1974; Stroop, 1935). The results of several studies found old adults to be more susceptible to interfering distractors than were young adults (N. Cohen, Dustman, & Bradford, 1984; Comalli, 1962; Dulaney & Rogers, 1994; Farkas & Hoyer, 1980; Plude & Doussard-Roosevelt, 1989; Rogers & Fisk, 1988; Spieler, Balota, Faust, 1994).

Unlike distractor interference tasks, which provide a measure associated with how much an interfering stimulus slows selection of a concurrent target, negative priming tasks have been viewed as providing a more direct measure of the amount of inhibition directed toward that interfering stimulus. Negative priming tasks have been used to measure the suppression of both location (Tipper, Brehaut, & Driver, 1990) and identity

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This research was supported in part by the Alzheimer's Disease Center (ADC) in the form of National Institute on Aging (NIA) Grants P30AG08017, AG08820-04, a Coleman and Cornelia Wheeler Endowment, NIA Grants P01 AG03991 and R01 AG10193, and Washington University Alzheimer's Disease Research Center Grant P50 AG05681. We thank the clinicians at both study sites for their diagnostic assistance; Jeff Kaye, Joyce Lear, Robin Guariglia, and Rachel Brooks of the ADC at Oregon Health Sciences University for their assistance in recruiting and scheduling patients; Martha Storandt for making the psychometric data on the St. Louis subjects available; and Cindi May, Michael Kane, and Lynn Hasher.

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information (Neill, 1977; Tipper, 1985). In the present study we focus on identity negative priming. In an identity negative priming experiment, subjects are instructed to respond to a target stimulus while ignoring a concurrent distracting stimulus. On negative priming trials, the target is the stimulus that had just occurred as the to-be-ignored distractor in the previous trial. Response latency to the target is slowed in relation to a control condition in which it did not appear as a to-be-ignored distractor in the previous trial. This slowing of reaction time, termed *negative priming,* has been interpreted as evidence that the processing of the to-be-ignored stimulus was actively inhibited (see Houghton & Tipper, 1993, and Neill, Valdes, & Terry, 1995, for reviews).

The results of several studies provided converging support for an age-related decrement in inhibitory function in that old adults do not produce reliable negative priming effects, whereas young adults do (Hasher, Stoltzfus, Zacks, & Rypma, 1991; Kane, Hasher, Stoltzfus, Zacks, & Connelly, 1994; McDowd & Oseas-Kreger, 1991; Stoltzfus, Hasher, Zacks, Ulivi, & Goldstein, 1993; Tipper, 1991). However, several recent studies have reported reliable and similar size distractor interference in young and old adults (Kane, Hasher, et al., 1994; Kramer, Humphrey, Larish, & Logan, 1994; Sullivan & Faust, 1993; Stoltzfus et al., 1993) as well as reliable and similar size identity negative priming (Earles, et al., 1994; Grant & Dagenbach, 1993; Humphrey, Kramer, & Strayer, 1994; Kramer et al., in press; Kwong See, Tipper, Weaver, & Ryan, 1994; Sullivan & Faust, 1993; West, Ball, Edwards, & Cissell, 1994).[1] Although these findings call into question the notion of an age-related decrement in the inhibitory component underlying selective attention, they are not sufficient to reject Hasher and Zacks's (1988) theory. This is because, to date, none of these studies have provided a definitive answer for the discrepant results. At this point, it appears that inhibition underlying selective attention can function normally in old adults under some conditions. Whether it does depends on a number of as yet undefined age-related processing deficits that influence not only when but how it functions.

Inhibition and Alzheimer's Disease

Interestingly, a somewhat similar story can be derived from the literature on DAT and cognitive function. In fact, a review of the literature suggests that Hasher and Zacks's (1988) theory also may provide a coherent explanation for many of the memory and language impairments seen in individuals with DAT. In the following section we provide a brief review of evidence in support of an inhibitory decrement in DAT.

In the memory literature, there is evidence that individuals with DAT produce more false positives to semantically related distractors than do healthy old adults in recognition memory tasks (Branconnier, Cole, Spera, & DeWitt, 1982; Hartman, 1991; Larner, 1977; Miller, 1978). Morris and Kopelman (1986) examined the influence of distractors on short-term memory. Although the presence of distractors did not influence the performance of healthy old adults, the performance of the individuals with DAT was reduced. Individuals with DAT have also been found to produce a greater number of intrusion errors than did controls in tasks of list and story recall (Butters, Granholm, Salmon, & Grant, 1987; Ober, Dronkers, Koss, Delis, & Friedland, 1986), visual reproduction (Jacobs, Troster, Butters, Salmon, & Cermak, 1990), letter fluency (Fuld, Katzman, Davies, & Terry, 1982), and Stroop color naming (Spieler et al., 1994). In a recent study, Kern, Van Gorp, Cummings, Brown, and Osato (1992) found that individuals with DAT produced a greater number of both verbal and nonverbal confabulations (novel response unrelated to the original task information) than did controls in tasks of learning and free recall. Thus, there is ample evidence in the memory literature to suggest that DAT may impair the ability to inhibit distracting or irrelevant information during both the encoding and retrieval of information.

Although the literature is sparse, there are a few recent studies of language function that suggest that DAT individuals' semantic and lexical processing also may be compromised by an impairment in the ability to inhibit irrelevant information (Balota & Duchek, 1991; Balota & Ferraro, 1993; Faust, Balota, Duchek, Gernsbacher, Smith, 1994; Hartman, 1991). For example, Balota and Duchek (1991) reported evidence suggesting that old adults could use biasing word contexts to suppress the alternative interpretation of ambiguous words, whereas the individuals with DAT appeared to keep both interpretations of ambiguous words active. Faust et al. (1994) extended this observation and found that even within a biasing sentence context, individuals with DAT kept inappropriate interpretations of ambiguous words active under conditions in which healthy old adults suppressed those interpretations. Finally, Balota and Ferraro (1993; also see Patterson, Graham, & Hodges, 1994) provided evidence that individuals with DAT were more likely to fail to inhibit a sublexical route in naming exception words aloud, thereby leading to an increased likelihood of regularization errors (e.g., pronouncing the word *pint* such that it rhymes with *mint*).

The majority of the literature on selective attention indicates that DAT individuals' ability to select a target that occurs in the presence of one or more distractors is impaired (Fisher, Freed, & Corkin, 1990; Grady et al., 1988; Koss, Ober, Delis, & Friedland, 1984; Massman, Delis, Filoteo, Butters, Salmon, & Demadura, 1993; Sahakian et al., 1990; Spieler et al., 1994, but see Filoteo et al., 1992; Nebes & Brady, 1989). For example, several researchers have administered the Stroop interference task in which subjects are presented with color words (e.g., *green*) printed in congruent (e.g., green) or incongruent colors (e.g., red). Results have consistently shown that individuals with DAT are more susceptible to Stroop interference given incongruent stimuli than are healthy old adults. In a recent Stroop study, Spieler et al. (1994) found that individuals with DAT were more likely than healthy adults to erroneously

[1] In contrast to the literature on identity negative priming, the literature on spatial negative priming in old adults has consistently shown that old adults' ability to suppress location information is preserved (Connelly & Hasher, 1993; McDowd & Fillion, in press). On the basis of the results of their study, as well as on neurophysiological, clinical, and developmental research, Connelly and Hasher (1993) proposed that there may be two inhibitory systems and that the one subserving location information may be spared, whereas the one subserving identity information may be diminished with age.

produce the name of the written word rather than the color name on incongruent trials. These results are consistent with those of Balota and Ferraro (1993) and suggest that when presented with conflicting stimulus information, individuals with DAT have more difficulty than healthy old adults in selecting one of two available responses. This difficulty may be related to their ability to suppress the irrelevant dimensions of the stimulus.

The results of these studies raise the question of whether DAT pathologically impairs the ability to suppress distracting or irrelevant information or simply exacerbates an existing neuropathology that is associated with aging. One underlying factor, which may influence the inhibitory function underlying selective attention in both old adults and individuals with DAT, is a degeneration of the cortically projecting cholinergic neurons of the nucleus basalis of Meynert (Drachman & Leavitt, 1974; Fuld et al., 1982). Although early studies attributed decreased cholinergic function to learning and memory deficits in old adults and individuals with DAT (Bartus, Dean, & Flicker, 1987; Drachman & Leavitt, 1974), more recent studies suggest that the primary affect of the cholinergic system is on attention (Callaway, Halliday, & Naylor, 1992; Meador et al., 1993; Muir, Page, Sirinathsinghji, Robbins, & Everitt, 1993). For example, on the basis of Callaway et al.'s (1992) hypothesis that cholingergic activity narrows the focus of attention and that anticholinergics broaden it, Meador et al. (1993) investigated the effect of the anticholinergic scopolamine on two tests of visual–spatial memory in young adults. One test, the Complex Figure Test, required focused attention, whereas the other, the Spatial Array Memory Test, required distributed attention. Results showed that cholinergic blockade impaired focused attention but not distributed attention. In addition, Sahakian et al. (1993) improved the performance of individuals with mild DAT on a five-choice attentional task with the anticholinesterase tetrahydroaminoacridine. Taken together, the results of these studies suggest that old adults' and DAT individuals' ability to selectively attend may have a cholinergic basis.

Present Study

Although the data from these distractor interference tasks provide some evidence consistent with breakdowns in inhibitory control in individuals with DAT, we are unaware of any studies that have measured such inhibitory processes using the methodology of the negative priming paradigm. Therefore, in the present study, a negative priming task was administered to obtain converging evidence in support of an inhibitory breakdown in DAT. We administered the negative priming task designed by Sullivan and Faust (1993) to groups of young adults, old adults, and individuals with DAT. This task requires subjects to name one of two overlapping pictures and has proven to be sensitive to inhibitory function in healthy old adults.

Given the current uncertainty regarding the nature of inhibitory function in old adults, who serve as a control group in the present study, one could raise the question of whether an investigation of inhibitory function in individuals with DAT is premature. We believe that such an investigation is valid given the following assumption regarding inhibitory function in old adults. Under certain conditions, inhibitory processing operates normally in old adults. The conditions imposed by the negative priming task designed by Sullivan and Faust (1993) may not all be necessary, but they are sufficient to reveal this normal processing.

The task includes two measures of negative priming as well as two measures of positive priming (see Figure 1). The two measures of negative priming include one condition in which the ignored prime picture is identical to the probe target (ignored repetition) and one condition in which it is semantically related to the target (ignored semantic). To the extent that DAT impairs inhibitory function, we expect significant and similar size negative priming in the ignored repetition and ignored semantic conditions for the young and old adults and either a null effect or facilitation for individuals with DAT. The task also includes two measures of positive priming, which includes one condition in which the attended prime is identical to the probe target (attended repetition) and one condition in which it is semantically related to the probe target (attended semantic). The measures of positive priming were included to obtain measures of processing selected targets in two element displays. Previous research on positive priming indicate that individuals with DAT show similar repetition effects (Balota & Duchek, 1991; Moscovitch, Winocur, & McLachlan, 1986) and similar or larger semantic priming effects in comparison with old adults when a naming response is required (Balota & Duchek, 1991; Chertkow, Bub, & Seidenberg, 1989; for a review, see Nebes, 1989).

In addition to obtaining a measure of the inhibition associated with negative priming, we also obtained two measures of distractor interference. For the first measure, which we call *perceptual interference,* we compared the response times to a picture presented alone with response times to that same picture presented with an unrelated overlapping picture. For the second measure, which we call *semantic interference,* we compared response times to a picture presented with an unrelated distractor picture with response times to that same picture presented with a semantically related distractor picture. These provide simple measures of how well individuals with DAT process an unrelated distractor. To the extent that individuals with DAT have more difficulty suppressing distractors, we expect that they will show more interference than either the young or old healthy adults.

In summary, the same pattern of results that emerged in the research on inhibitory function and aging appears to be emerging in the literature on DAT. The literature on DAT provides considerable evidence in support of the notion that many of the memory and language deficits may be due to an impairment of the inhibitory component of selective attention. However, there are currently no studies that have provided a direct measure of how well this process is functioning. Therefore, in the present study, we address the question of whether or not DAT produces a breakdown in the inhibitory process associated with a measure of negative priming. In addition, we further explore the notion that DAT individuals may be more susceptible to distractor interference than are healthy adults.

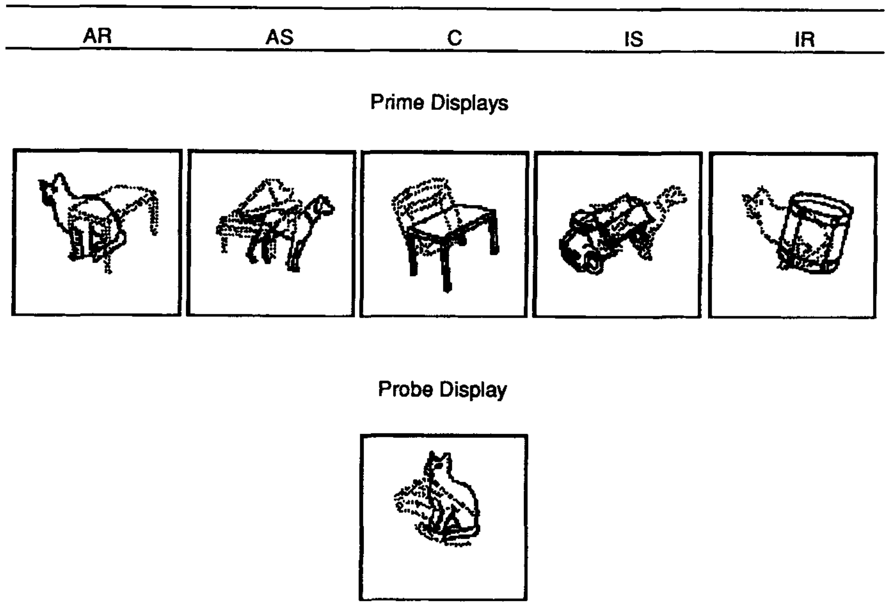

Figure 1. Idealized examples of the stimulus displays for the prime and probe conditions in Experiment 1. Selected pictures are drawn with normal lines, and to-be-ignored pictures are drawn with dotted lines. In these examples, the clarity of the pictures has been reduced by scaling and pixel editing. In the experiment, selected pictures were presented to participants in red and to-be-ignored pictures were in green. AR = attended repetition; AS = attended semantic; IS = ignored semantic; IR = ignored repetition; C = control.

Experiment 1

Method

Participants

Twenty-one young adults (mean age = 21.10 years, *SD* = 2.88), 20 old adults (mean age = 66.95 years, *SD* = 4.51), and 15 individuals with DAT (mean age = 70.80 years, *SD* = 7.16) participated in the experiment. The mean years of education were 14.43 (*SD* = 1.23) for the young adults, 16.05 (*SD* = 1.93) for the old adults, and 12.80 (*SD* = 2.96) for the individuals with DAT. The mean ages of the old adults and individuals with DAT were not statistically different from each other ($p > .05$). The individuals with DAT had significantly fewer years of education than did the young adults ($p < .01$), and both the individuals with DAT and the young adults had fewer years of education than did the old adults ($p < .01$). The young adults were students recruited from Portland State University and Linfield College. The old adults were recruited from the Portland community, and the individuals with DAT were recruited from the Alzheimer's Assessment Clinic (AAC) at Legacy Good Samaritan Hospital and Medical Center and the Alzheimer's Disease Center (ADC) at Oregon Health Sciences University.

The diagnosis of DAT was made according to the National Institute of Neurological and Communicative Disorders and Stroke and Alzheimer's Disease and Related Disorders Association (NINCDS-ADRDA) inclusionary and exclusionary criteria (McKhann et al., 1984). Both the old adults and the individuals with DAT were screened for neurologic disease, depression, and any other disorder or medication that could affect cognitive function. Both the old adults and individuals with DAT were administered the Dementia Rating Scale (DRS; Mattis, 1988) and the Wechsler Adult Intelligence Scale—Revised (WAIS-R, 1981) Vocabulary test. All old adults received a total DRS score that was greater than or equal to Mattis's recommended cutoff of 140/144. The mean DRS subtest scores (Attention, Conceptualization, Initiation/Perseveration, Memory, and Construction) and the mean age-scaled vocabulary scores (Ivnik et al., 1992) for the old adults and the individuals with DAT are shown in Table 1. Separate *F* tests were conducted to assess the effect of group on each of the DRS subtests and the vocabulary test. Results showed that individuals with DAT performed reliably worse than did the old adults on all tests ($ps < .001$) except for the Construction subtest of the DRS, on which the two groups did not differ.

Dementia severity was staged according to the Washington University Clinical Dementia Rating (CDR) scale (Berg, 1988; Hughes, Berg, Danziger, Coben, & Martin, 1982). The CDR is based on an interview that assesses cognitive ability in areas including memory, orientation, judgment and problem solving, community affairs, home and hobbies, and personal care. Both the patient and his or her primary caregiver

Table 1
Means and Standard Deviations of the Mattis Dementia Rating Scale (DRS) Subtest Scores and WAIS Vocabulary Age-Scaled Scores for Older Adults and Individuals With DAT in Experiment 1

	Group			
	Older		DAT	
Test	*M*	*SD*	*M*	*SD*
DRS				
Attention	36.5	0.51	35.20	2.43
Initiation	36.3	1.49	29.47	5.85
Construction	6.0	0	6.0	0
Conceptualization	38.2	0.77	35.27	3.22
Memory	24.6	0.82	15.30	2.66
Total	142	1.5	121	9.88
WAIS Vocabulary	14.3	3.73	10.07	3.79

Note. WAIS = Wechsler Adult Intelligence Scale; DAT = dementia of the Alzheimer type.

are interviewed separately. Patients recruited from the AAC were interviewed by Michael P. Sullivan, and individuals recruited from the ADC were interviewed by one of several board-certified neurologists, a neuropsychologist, or a nurse practitioner at the ADC. To date, the clinical diagnosis of Alzheimer's disease at the ADC has been excellent, with 18/18 cases confirmed at autopsy. Neuropathologic confirmation of the clinical diagnosis of DAT is not routinely obtained or quantified at the AAC. A score of 0 indicates no dementia; a score of 0.5 indicates "questionable" dementia or "very mild" dementia; a score of 1.0 indicates "mild" dementia; and a score of 2.0 indicates "moderate" dementia. Of the individuals with DAT, 7 had a diagnosis of very mild dementia (CDR = 0.5), and 8 had a diagnosis of mild dementia (CDR = 1.0). Note also that in a recent study conducted by Rubin, Morris, Grant, and Vendegna (1989), a subset of individuals (11/16) originally classified as having very mild dementia (CDR = 0.5) actually progressed to a more severe stage over the course of 84 months or had a clinical diagnosis confirmed at autopsy. This finding supports the view that a diagnosis of very mild DAT most likely indicates an early stage in the disease progression. All subjects had normal or corrected-to-normal vision and reported no color blindness. All subjects were paid $5 for their participation.

Stimuli

The stimuli consisted of 10 pictured objects: 9 were selected from those constructed by Snodgrass and Vanderwart (1980; foot, hand, bus, dog, cat, drum, piano, table, and chair), and 1 pictured object was an original drawing (truck). The pictured objects were digitized for computer presentation and enlarged to be approximately uniform in size. The mean visual angles of the pictures were 3.71° vertical (range = 2.86 to 5.01, SD = 0.20) and 3.76° horizontal (range = 2.86 to 4.65, SD = 0.21). The semantically related pairs were chair–table, piano–drum, bus–truck, cat–dog, and hand–foot. Selected pictures were drawn in red, and ignored pictures were drawn in green. Each of the pictures was superimposed over every other picture not in its own category, yielding 80 displays. The overlapping pictures were arranged pseudorandomly with the constraint that both could be easily recognized. The mean visual angles of the overlapped pictures were 5.11° vertical (range = 3.49 to 6.45, SD = 0.52) and 5.74° horizontal (range = 4.12 to 7.29, SD = 0.66). Except as noted below, the superimposed pictures of the displays were always in different categories. Twenty of these displays were selected to be the probe displays such that the 10 target pictures appeared twice. Of the remaining 60 displays, 50 were used for the prime conditions that contained overlapping pictures. The 10 target pictured objects also appeared with their semantically related prime and as a prime without an overlapping picture. The remaining 10 displays were used to construct 12 practice trials, which occurred twice in random order. A masking stimulus was constructed by randomly scrambling each of the 10 pictured objects and then combining the parts of each. The visual angle of the mask was 8.14° horizontal and 8.14° vertical. Each prime display, each probe display, and the mask appeared centered in a 7.6 × 7.6 cm box formed by a black border.

Design

The design consisted of the between-subjects factor of group (young adults, old adults, and DAT individuals) and the within-subjects factor of priming condition. Following is a description of the priming conditions, which are based on Tipper and Driver (1988). *Attended repetition* (AR) is when the selected prime picture and selected probe picture had the same name. *Attended semantic* (AS) is when the selected prime picture and selected probe picture had names within the same semantic category. For the *control* condition, the names of the ignored prime picture and selected probe picture were unrelated. For the *ignored semantic* (IS) condition, the ignored prime picture and selected probe picture had names within the same semantic category. In the *ignored repetition* (IR) condition, the ignored prime picture and selected probe picture had the same name.

Also, three additional conditions were included to assess the extent to which a subject's naming latency is affected by the presence of concurrent distractors. These occurred as prime stimuli to balance the design. However, these were not priming conditions. The *semantic* condition was when the selected and ignored prime pictures were semantically related to each other and both were unrelated to the pictures in the probe display. *Unrelated* condition were primes from the control condition. The selected and ignored prime pictures were semantically unrelated to each other. And for the *alone* condition, only one picture appeared as a prime, which was unrelated to the pictures in the probe display.

There were 20 trials in each condition. Each prime display appeared twice in each condition, and each probe display appeared once in each condition. Stimulus presentation was pseudorandomized for each subject with the constraint that no two conditions could repeat across two successive trials.

Apparatus

The experiment was run on a Macintosh IIx with a high-resolution Magnavox monitor. A custom software program that controlled the presentation and timing of the stimuli was written using Psyscope (J. Cohen, MacWhinney, Flatt, & Provost, 1993). Naming latencies to the primes and probes were collected with a Shure SM 57 microphone that was connected to a Carnegie Mellon University button box containing a voice-activated relay. The button box contains a crystal oscillator that produces time measurements to within ±1 ms.

Procedure

Each participant was tested individually. The subject was seated in front of the computer monitor in a dimly lit room and was first given a short color test. In addition to the red and green colors used to draw the picture stimuli, yellow and blue colors were computer generated. Each of the colors was drawn in a 2.5 × 2.5 cm filled square. The four colors were placed in the four quadrants of a 7.6 × 7.6 cm white box formed by a black border. The red and green colors always appeared diagonally to each other. The experimenter presented the colors and asked the subject to point to the green and red colors. None of the subjects failed this test. Following the color test, the experimenter presented and named the 10 pictured objects (printed in red) individually. Then the experimenter presented each of the 10 pictures again and asked the subject to name them. This was done to ensure that each subject used the same name for the pictures and to ensure that the individuals with DAT could correctly name all of the pictured objects. The pictures were presented with feedback until the subject could quickly and accurately provide the correct names.

The experimenter then presented the practice trials. For the young and old adults, the subject saw the following series of events on each trial: (a) fixation cross centered in the screen (500 ms); (b) prime display centered in the screen (250 ms); (c) pattern mask for 100 ms, which replaced the prime display; (d) onset of pronunciation to name the prime beginning a 250-ms response–stimulus interval; (e) fixation cross centered in the screen (500 ms); (f) probe display centered in the screen (250 ms); (g) pattern mask for 100 ms, which replaced the probe display; and (h) intertrial interval (500 ms). The intertrial interval began with the voice onset to name the selected probe picture. This same series of events was used with the DAT individuals except that they were first given practice with prime and probe durations of 450 ms and then with durations of 350 ms and 250 ms.

The subject was told that he would see two overlapping pictures, one drawn in red and the other drawn in green. The experimenter told the subject to always name the red picture and to ignore the green picture. The experimenter told the subject

> The green picture is there to make the task more difficult, but as far as you are concerned it is irrelevant. So the more you can ignore the green picture, the better you will be able to name the red picture, which is what I am interested in.

The participant was also told to name each red picture just as quickly and as accurately as possible but to minimize errors. The subject was not informed of the presence of the pattern mask.

After the practice trials, the 140 experimental trials were presented in two blocks of 47 trials and one block of 46 trials. After the last trial, the subject was queried about the organization and sequence of the picture displays to assess whether he or she became aware of the relationship between the ignored and selected pictures in the two negative priming conditions. None reported noticing these relationships.

Results

In analyzing the naming latency data, all trials on which the voice-activated relay was tripped too soon or failed were eliminated. For the priming conditions, these were eliminated from attempts to name either the prime or probe pictures (young: 0.01; old: 0.005; and DAT: 0.005). For the interference conditions, these were eliminated from attempts to name the prime pictures (young: 0.004; old: 0.007; and DAT: 0.002). In addition, all trials on which an error occurred were eliminated. For this and subsequent analyses, an error was defined as a failure to make a response, a dysfluency, or the production of an incorrect name. From the remaining observations, we calculated a median response latency. For the priming conditions, the median was based on the number of correct responses on both prime and probe displays for each subject/condition (young: 0.974; old: 0.952; and DAT: 0.89). For the interference conditions, the median was based on the number of correct responses to the prime displays for each subject/condition (young: 0.976; old: 0.976; and DAT: 0.91).

In analyzing the error data from the priming conditions, an error was scored if the subject named the prime correctly but misnamed the probe on a trial. For the interference conditions, an error was scored if the subject misnamed the prime. Errors comprised dysfluencies, naming the green distractor, producing the name of one of the other nine target pictures not included in the current trial, and producing a nontarget object name.

Priming Conditions

Naming latency. The mean of the median naming latencies to the selected probes for each condition are shown in Table 2. There are three points to note: First, as expected, the naming latencies of the young adults are faster than those of the old adults, who in turn are faster than the individuals with DAT. Second, the attended repetition condition appears to be consistently faster than the control condition, whereas the ignored repetition condition appears to be consistently slower than the control condition. Third, the effect of the crucial ignored repetition condition appears larger for the young and old adults than for the individuals with DAT.

The above observations were supported by a 3 × 5 mixed factor analysis of variance (ANOVA) with age as a between-subjects factor (young, old, and DAT) and priming condition as a within subjects factor (AR, AS, control, IS, and IR). The significance level was set at $p < .05$, two-tailed. Results showed a main effect of group, $F(2, 53) = 14.28$, $p < .0001$, $MSE = 30{,}863$, an effect of priming condition, $F(4, 212) = 64.72$, $p < .0001$, $MSE = 1393$, and a Group × Priming Condition interaction, $F(8, 212) = 2.17$, $p < .03$, $MSE = 1393$. Post hoc Newman–Keuls tests showed that naming latencies increased reliably across groups, from the young adults to the individuals with DAT ($ps < .01$). Pairwise comparisons were conducted to examine the difference in naming latencies between the control condition and the AR, AS, IS, and IR conditions for each group. Table 3 shows the effect sizes of each condition in comparison with the control condition for each group. Results showed reliable facilitatory priming effects for the young adults, $F(1, 20) = 50.22$, $p < .0001$, the old adults $F(1, 19) = 51.44$, $p < .0001$, and the DAT individuals, $F(1, 14) = 21.38$,

Table 2
Mean Naming Latencies (in Milliseconds) and Percentage Errors to Selected Probe Pictures in Experiment 1

	Attended						Ignored			
	Repetition		Semantic		Control		Semantic		Repetition	
Variable	*M*	*SE*	*M*	*SE*	*M*	*SE*	*M*	*SE*	*M*	*SE*
Young										
Naming latency	573	12	634	15	643	16	639	13	659	15
Error	.02	.005	.02	.006	.02	.007	.02	.008	.01	.006
Older										
Naming latency	597	14	676	18	672	17	682	21	691	20
Error	.02	.007	.04	.010	.04	.011	.03	.008	.04	.010
DAT										
Naming latency	672	22	792	27	786	32	802	35	791	28
Error	.05	.011	.07	.014	.11	.021	.12	.024	.12	.029

Note. DAT = dementia of the Alzheimer type.

Table 3
Mean Naming Latency Differences and Percentage Error Differences in Experiment 1 According to Condition

	Control minus:											
	AR		AS		IS		IR		S − U		U − A	
Variable	*M*	*SE*	*M*	*SE*	*M*	*SE*	*M*	*SE*	*M*	*SE*	*M*	*SE*
						Young						
Naming latency	71	10	9	8	4	8	−15	6	.4	6	62	8
Error	.007	.009	.007	.009	.004	.011	.008	.010	−.007	.011	.019	.010
						Old						
Naming latency	75	11	−4	10	−10	7	−19	8	−4	10	86	9
Error	.026	.012	.005	.011	.012	.014	.003	.009	.018	.018	.008	.010
						DAT						
Naming latency	114	25	−7	18	−16	17	−5	17	8	21	83	19
Error	.061	.023	.047	.019	−.005	−.017	−.010	−.028	.013	.016	.063	.023

Note. AR = attended repetition condition; AS = attended semantic condition; IS = ignored semantic condition; IR = ignored repetition condition; S − U = semantic − unrelated condition; U − A = unrelated − attended condition.

$p < .001$, in the AR condition. However, there was no facilitatory priming effect in the AS condition for any of the groups (all *p*s > .05). Reliable negative priming effects were obtained in the IR condition for the young adults, $F(1, 20) = 7.012, p < .01$, and the old adults, $F(1, 19) = 6.19, p < .02$, but not for the DAT individuals, $F(1, 14) = .09$. Power estimates for these tests, assuming a 15- to 20-ms effect in the population, were 0.74 to 0.94 for the young adults, 0.51 to 0.74 for the old adults, and 0.17 to 0.22 for the individuals with DAT (J. Cohen, 1969). The IS condition was not significantly different from zero for any of the groups (all *p*s > .05).

To further examine the Group × Priming Condition interaction for the AR condition and the critical negative priming effect, we calculated one-factor ANOVAs with group (old and DAT) as the independent variable and the control–AR and control–IR difference scores as the dependent variables. The results comparing the AR effect across groups were not reliable, $F(1, 33) = 2.54, p > .05, MSE = 5130$. The results comparing the negative priming effect also did not yield a reliable difference in negative priming between the two groups, $F(1, 33) < 1.0, p > .05, MSE = 2496$. However, when we calculated a sign test to look at the number of subjects showing the negative priming effect in each group, we obtained a reliable effect for the old adults (78%), $p < .03$, but not for the DAT individuals (57%), $p = .79$.

Error rates. The mean number of errors for the priming conditions are also shown in Table 2. There are two points to note: First, the young adults produced fewer errors than did the old adults, who in turn produced fewer errors than the individuals with DAT. Second, the data do not provide evidence for a speed–accuracy trade-off that might explain the absence of negative priming in the naming latency data of the individuals with DAT.

These observations were partially supported by a 3 × 5 mixed-factor ANOVA identical to that described for the latency analysis. This analysis yielded an effect of group $F(2, 53) = 26.89, p < .0001, MSE = .005$, an effect of priming condition, $F(4, 212) = 5.20, p < .001, MSE = .002$, and a Group × Priming Condition interaction, $F(4, 212) = 2.50, p < .01, MSE = .002$. A post hoc Newman–Keuls test showed that both young and old adults produced fewer errors than did the individuals with DAT (*p*s < .01). However, the overall error rate did not differ between the young and old adults ($p > .05$). Pairwise comparisons were conducted to examine the difference in error rate between the control condition and the remaining priming conditions for each group. Table 3 shows the effect sizes of each condition in comparison with the control condition for each group. None of the comparisons was significant for either the young or old adults (all *p*s > .05). For the DAT individuals, the results indicated that they produced significantly more errors in the control condition than in either the AR, $F(1, 14) = 7.12, p < .02$, or AS $F(1, 14) = 6.19, p < .03$, condition. None of the other comparisons for the DAT individuals reached significance (all *p*s > .05).

Interference Effects

Naming latency. The mean of the median naming latencies to the selected primes for each interference condition are shown in Table 4. There are three points to note: First, as expected, the naming latencies of the young adults are faster than the naming latencies of the old adults, who in turn are

Table 4
Mean Naming Latencies (in Milliseconds) and Percentage Errors to Selected Prime Pictures in Experiment 1

	Semantic		Unrelated		Alone	
Variable	*M*	*SE*	*M*	*SE*	*M*	*SE*
			Young			
Naming latency	644	15	644	15	582	15
Error	.03	.008	.03	.009	.01	.005
			Older			
Naming latency	671	14	675	16	588	13
Error	.04	.014	.02	.008	.01	.006
			DAT			
Naming latency	775	21	768	33	685	24
Error	.12	.024	.11	.027	.04	.010

Note. DAT = dementia of the Alzheimer type.

faster than the individuals with DAT. Second, the semantic interference condition does not appear to be different than the unrelated interference condition. Third, the unrelated interference condition is consistently slower than the alone condition. Moreover, the size of this difference appears to be similar for all three groups.

These observations were partially supported by a 3 × 3 mixed-factor ANOVA with group as a between-subjects factor (young, old, and DAT) and interference as a within-subjects factor (unrelated–control prime, semantic, and alone). The results of this analysis yielded a significant effect of group, $F(2, 53) = 13.17$, $p < .0001$, $MSE = 15{,}339$, and an effect of interference condition, $F(2, 106) = 90.02$, $p < .0001$, $MSE = 1229$, but no significant Group × Interference Condition interaction, $F(4, 106) = 1.07$, $p > .05$, $MSE = 1{,}229$. A post hoc Newman–Keuls test showed that the overall naming latencies of young and old adults did not differ ($p > .05$). However, the overall naming latencies of both young and old adults were reliably faster than the naming latencies of the DAT individuals (all $ps < .0001$). To examine the interference effect, we calculated pairwise comparisons on the two interference measures. The perceptual interference measure was obtained by subtracting the alone condition median naming latencies from the control prime (unrelated) condition median naming latencies for each subject. The semantic interference measure was obtained by subtracting the control prime (unrelated) condition median naming latencies from the semantic condition median naming latencies for each subject. Table 3 shows the effect sizes for these comparisons for each group. The results of this analysis across all subjects showed only a reliable perceptual interference effect. All subjects were slower to name the selected prime in the presence of an unrelated distractor than when the prime occurred alone, $F(1, 55) = 22.57$, $p < .0001$. However, there was no effect of semantic interference, $F(1, 55) < 1.0$.

Error rates. The mean number of errors for the interference conditions are also shown in Table 4. There are three points to note: First, both the young and old adults produced fewer errors than did the individuals with DAT. Second, the semantic interference condition does not appear to be different from the unrelated interference condition. Third, more errors were produced in the unrelated interference condition than in the alone condition. Moreover, this effect appears larger for the individuals with DAT than for the young and old adults.

These observations were supported by a 3 × 3 mixed-factor ANOVA identical to that described for the latency analysis. This analysis yielded a main effect of age, $F(2, 53) = 14.20$, $p < .001$, $MSE = .005$, an effect of interference condition, $F(2, 106) = 9.00$, $p < .001$, $MSE = .005$, and a Group × Interference Condition interaction, $F(4, 106) = 3.14$, $p < .05$, $MSE = .005$. A post hoc Newman–Keuls test showed that both young and old adults produced fewer errors than did the individuals with DAT ($p < .001$). However, the overall error rate did not differ between the young and old adults ($p > .05$). To examine the interaction, we calculated pairwise comparisons on the interference measures obtained from each group. Table 3 shows the effect sizes for these comparisons for each group. Results showed only a reliable perceptual interference effect for the individuals with DAT. Specifically, the individuals with DAT produced more errors in the unrelated condition than in the alone condition, $F(1, 14) = 5.48$, $p = .016$. All other comparisons of the interference effects for each group were not significantly different (all $ps > .05$).

In addition to the above analyses, we also calculated the number of times subjects produced a green distractor during attempts to name prime targets when the distractors were unrelated to the targets (unrelated condition) and when they were semantically related to the targets (semantic condition). The mean number of intrusion errors are shown in Table 5. As can be seen, the DAT individuals produced more intrusion errors than either the young or old adults, but only when the distractor was semantically related to the target. This observation was supported by separate one-factor ANOVAs with group (young, old, and DAT) as the independent variable and with the mean number of intrusion errors for the unrelated condition and semantic condition as dependent variables. The results comparing the number of intrusions in the unrelated condition across groups was not reliable, $F(2, 53) < 1.0$. However, the results comparing the number of intrusions in the semantic condition showed a reliable difference between the groups, $F(2, 53) = 14.45$, $p < .0001$. A post hoc Newman–Keuls test showed that the individuals with DAT produced reliably more intrusion errors than either the young or old adults ($p < .05$). However, there was no difference between the young and old adults.

Discussion

These data replicate those of Sullivan and Faust (1993) and provide some support for the notion that DAT produces a breakdown in the inhibitory component underlying selective attention. The error rates were relatively low in the priming conditions, and there was no evidence for a speed–accuracy trade-off. In the Sullivan and Faust (1993) study, no age-related difference in overall naming latency was obtained, which raised the question of whether or not the finding of negative priming in old adults was due to the sampling of an unusual or high-functioning group. In the present study, however, an age-related difference in overall naming latencies was obtained. Nevertheless, both the young and old adults

Table 5
Mean Number of Intrusion Errors Produced in Unrelated and Semantic Conditions in Experiments 1 and 2

Group	Unrelated *M*	Unrelated *SD*	Semantic *M*	Semantic *SD*
Experiment 1				
Young	.005	.015	.012	.022
Old	.002	.013	.005	.015
DAT	.003	.013	.063	.058
Experiment 2				
Young	.023	.041	.008	.019
Old	.049	.060	.033	.038
DAT	.056	.064	.065	.067

Note. DAT = dementia of the Alzheimer type.

produced significant and similar size negative priming in the IR condition.

In contrast to the findings of Tipper (1985) and consistent with those of Sullivan and Faust (1993), this task again failed to produce negative priming in the IS condition. The critical difference between these studies appears to be whether a response is made to the prime. However, the reason for this failure is not clear, because there have been few studies that have systematically investigated the nature of semantic negative priming.

Although the comparison of the IR negative priming effect between the old adults and DAT individuals was not reliable, the evaluation of the magnitude of negative priming for each group showed a reliable effect for the old adults but not the individuals with DAT.[2] This contrasting pattern of results can be attributed to low power associated with a large variability in the DAT individuals' naming latencies and to a small n. At minimum, the results of the sign test, which showed reliable negative for the old adults but not for the individuals with DAT, argue against the notion that the absence of negative priming in the parametric test for the DAT individuals was due to a small number of subjects who were showing a large effect in the wrong direction.

The naming latency results from the perceptual interference measure suggest that the DAT individuals' ability to select targets in the presence of unrelated distractors is unimpaired (Filoteo et al., 1992; Nebes & Brady, 1989). In contrast, the overall error data showed that the DAT individuals were slightly more susceptible to the presence of an unrelated distractor than were the young and old adults. However, these results may be reflecting a floor effect. That is, the young and old adults showed some evidence of a similar pattern, but it may not have reached significance because they were performing at such a high level of accuracy. Unlike the perceptual interference effect, the presence of a semantically related distractor did not influence the naming latencies or overall error rates for any of the groups (Sullivan & Faust, 1993).

In contrast, the analysis of the number of intrusion errors showed that the individuals with DAT produced more than either the young or old adults but only when the distractor was semantically related to the target. These results are consistent with previous studies (e.g., Spieler et al., 1994) and suggest that DAT individuals may have more difficulty than old adults in suppressing irrelevant information that shares many of the same properties with the target.

With regard to positive priming, all three groups showed reliable and similar size effects, but only in the AR condition. These results are consistent with those in previous studies showing preserved repetition priming in individuals with DAT (Balota & Duchek, 1991; Moscovitch et al., 1986).

Experiment 2

The results of Experiment 1 provide further evidence that both old adults and individuals with DAT are as susceptible, at least in response latencies, to the presence of an unrelated distractor as young adults. However, unlike both young and old adults, DAT individuals' ability to inhibit distracting information, as measured by the negative priming task, appears to be impaired. Experiment 2 was designed to obtain converging support for these observations with written word stimuli.

This experiment is important for the following reasons: First, we wanted to examine whether the Sullivan and Faust (1993) procedure would produce significant negative priming in young as well as old adults with word stimuli. A review of recent studies suggests that negative priming in old adults is more difficult to obtain with written words than with pictures. For example, Kane, Hasher, et al. (1994) obtained significant negative priming with word stimuli in young adults but not with old adults. Moreover, Earles et al. (1994), although obtaining significant negative priming in a large sample of old adults (n = 123), reported that the magnitude of the effect declined across age groups (young, middle-aged, and old) with written word stimuli but not picture stimuli. All of these studies used nonoverlapping stimuli, which may not engage the suppression mechanism to the same extent as overlapping stimuli (DeSchepper & Treisman, 1991, but see May, Kane, & Hasher, in press, for an alternative explanation). Therefore, we examined whether the use of overlapping word stimuli would produce reliable negative priming in old adults and whether or not the magnitude of negative priming would be equivalent to that obtained from Experiment 1 with picture stimuli. Second, assuming that both the young and old adults produce reliable negative priming, and on the basis of the results from Experiment 1, we expected that the DAT individuals would show less negative priming than either the young or old adults. Moreover, because of the conflict between the nonsignificant interaction in the overall ANOVA and the reliability of the planned comparisons, and because the power of detecting a negative priming effect in the individuals with DAT was small, we (a) tripled the sample size of the DAT individuals and (b) used word rather than picture stimuli to reduce the variance of the naming latencies. Finally, in addition to the measures of negative priming, we also investigated whether or not the measures of distractor interference would again produce similar-size naming latency effects in all three groups.

Method

Participants

Twenty-six young adults (mean age = 20.46 years, SD = 7.45), 41 old adults (mean age = 77.22 years, SD = 1.49), and 44 individuals with DAT (mean age = 73.86 years, SD = 1.12) participated in the experiment. The mean years of education were 14.71 (SD = 3.66) for the old adults and 12.98 years (SD = 3.60) for the individuals with DAT. The mean ages of the old adults and of individuals with DAT were not statistically different from each other ($p > .05$). The individuals with DAT had significantly fewer years of education than the old adults ($p < .05$). The young adults were recruited from Washington University and paid $10.00 for their participation. The old adults and

[2] The correlation between IR negative priming and years of education for the old adults and individuals with DAT was not significantly different from zero either for Experiment 1, $r = .03$, $F(1, 33) < 1.0$, or for Experiment 2, $r = -.13$, $F(1, 83) = 1.38$, $p > .05$. Therefore, the absence of negative priming in the individuals with DAT cannot be attributed to their fewer years of education.

individuals with DAT were volunteers recruited from the Washington University Alzheimer's Disease Research Center (ADRC).

Screening of subjects and diagnosis of DAT were made according to the same criteria described in Experiment 1. One of several board-certified physicians at the ADRC (four neurologists and four psychiatrists) conducted the CDR interviews. The interviews were videotaped and subsequently reviewed by a second physician for reliability. The clinical diagnosis of DAT by the ADRC has been excellent, with 89/92 (97%) cases confirmed at autopsy (Berg et al., 1990). Of the individuals with DAT, 15 had a diagnosis of very mild dementia (CDR = 0.5), and 29 had a diagnosis of mild dementia (CDR = 1.0). The old adults and individuals with DAT were administered a battery of psychometric tests designed to assess memory (Wechsler Memory Scale [WMS]—Associate Recall: Wechsler & Stone, 1973), language (Boston Naming Test: Kaplan, Goodglass, & Weintraub, 1983; Word Fluency Test), attention (Trail Making Test—Form A; Wechsler Adult Intelligence Scale [WAIS]—Digit Symbol: Wechsler, 1955), and intelligence (WAIS—Information and Block Design). Data were not available for 4 old adults and 2 individuals with DAT with a CDR of 0.5. Two individuals with DAT with a CDR of 1.0 did not provide data for the WAIS Digit Symbol test, and 2 individuals with DAT with a CDR of 1.0 did not provide data for the WMS Associate Recall test. As shown in Table 6, individuals with DAT performed reliably worse than the old adults on all tests ($ps < .0001$).

Stimuli

The stimuli consisted of the written names of the 10 pictured objects used in Experiment 1. The words were displayed with uppercase letters in Turbo Pascal Smallfont. The horizontal visual angle of each letter was 0.31° and the vertical angle of each letter was 0.61°. The horizontal visual angle of each word ranged from 1.15° to 1.99°. Selected words were drawn in red, and ignored words were drawn in green with Turbo Pascal's 16-color EGA palette. Each of the words was superimposed over every other word not in its own category, yielding 80 displays. These displays were assigned to the priming conditions and to practice in the same manner as in Experiment 1. The overlapping word displays were arranged according to the following constraints. First, one word of a pair was either shifted up and left from center while the other word was shifted down and right, or one word of a pair was shifted up and right while the other was shifted down and left. The words were shifted 0.15° in the vertical plane and 0.31° to 0.69° in the horizontal plane. Second, for all trials in which a selected prime word appeared in a given position (e.g., upper right), the selected probe word in the following display was switched horizontally (e.g., upper left) 50% of the time and vertically (lower right) 50% of the time. Thus, there was no way to predict the position of a selected probe word on the basis of the position of the previously selected prime word. A masking stimulus consisted of a set of black pound signs. The visual angle of the mask was 3.24° horizontal and 0.96° vertical. Each prime display, probe display, and mask appeared centered in an 8 × 6 cm rectangle formed by a black border, which was permanently displayed.

Table 6
Means of Psychometric Tests for Old Adults and Individuals With DAT in Experiment 2

Test	Old adults *M*	Old adults *SD*	DAT *M*	DAT *SD*
WMS				
Associate Recall	14.42	3.74	7.46	3.23
Boston Naming Test	55.51	5.21	41.14	12.39
Fluency (S + P)	32.57	10.81	17.64	8.13
Trail Making—Form A	46.62	14.51	67.98	29.84
WAIS				
Digit Symbol	43.08	11.59	26.70	13.68
Information	21.22	4.24	12.62	6.13
Block Design	32.32	9.33	20.02	9.30

Note. DAT = dementia of Alzheimer type; WMS = Wechsler Memory Scale; WAIS = Wechsler Adult Intelligence Scale.

Design

The design was identical to that in Experiment 1. In addition, the order of trials was randomly determined for each subject according to the following two constraints. First, the words in a probe display on trial n could not appear in the prime display on trial $n + 1$. Second, conditions could not repeat across two successive trials.

Apparatus

The experiment was run on an IBM AT compatible computer with a color monitor. A custom software program controlled the presentation and timing of the stimuli. Naming latencies were collected with a microphone that was connected to a voice-activated relay. Naming latencies were measured to within ±0.5 ms.

Procedure

Each subject was tested individually. The sequence of events in each experimental trial was the same as in Experiment 1, except that a response time-out of 5,000 ms occurred following the probe displays. In addition, the practice procedure differed in the following way. The experimenter first presented the subject with 12 practice trials that did not contain a pattern mask. The prime and probe displays of these trials also remained visible until a response was made. Then, the experimenter presented the same 12 trials with the experimental procedure. These 12 trials were repeated as necessary until the subject understood the task and could name the words accurately. Following the practice session, the experimental trials were presented in two blocks of 47 trials and one block of 46 trials. Two filler trials occurred at the beginning of each block. Instructions to the subjects were the same as in Experiment 1.

Results

In analyzing the naming latency data, all trials on which the voice-activated relay was tripped prior to stimulus presentation or within 100 ms after stimulus presentation were eliminated. From the remaining observations, a criterion value for outliers representing naming latencies greater than 3 standard deviations from the overall mean for each subject was calculated. This value was used to delete outliers in the priming and interference conditions. For the priming conditions, median naming latencies for those trials that were correct on both prime and probe displays for each subject/condition (young: 0.947; old: 0.853; and DAT: 0.721) were calculated after first removing all trials in which the naming latency to the probe display was an outlier (young: 0.016; old: 0.50; and DAT: 0.112). For the priming conditions, median naming latencies for the proportion correct on the prime displays for each subject/condition (young: 0.970; old: 0.931; and DAT: 0.861) were calculated after first removing all trials in which the naming latency to the prime display was an outlier (young: 0.016; old: 0.030; and DAT: 0.084).

Errors in the priming and interference conditions were scored in the same manner as in Experiment 1. Errors comprised dysfluencies, naming the green distractor, producing the name of one of the other nine target pictures not included in the current trial, and producing a nontarget object name.

Priming Conditions

Naming latency. The mean of the median naming latencies to the selected probes for each condition are shown in Table 7. There are three points to note: First, as expected, the naming latencies of the young adults are faster than those of the old adults, who in turn are faster than the DAT individuals. Second, in contrast to Experiment 1, the AR condition appears to be consistently slower than the control condition. Third, whereas the IR condition appears to be consistently slower than the control condition for the young and old adults, it is slightly faster than the control condition for the DAT individuals. Thus, as in Experiment 1, there appears to be no evidence for negative priming in the individuals with DAT.

These observations were supported by a 3 × 5 mixed-factor ANOVA with group as a between-subjects factor (young, old, and DAT) and with priming condition as a within-subjects factor (AR, AS, control, IS, and IR). This analysis yielded an effect of group, $F(2, 108) = 18.06, p < .0001$, $MSE = 29{,}525$, an effect of priming condition, $F(4, 432) = 5.40, p < .0001$, $MSE = = 721$, and a Group × Priming Condition interaction, $F(8, 432) = 1.94, p < .05$, $MSE = 721$. Post hoc Newman-Keuls tests showed that naming latencies increased reliably across groups, from the young adults to the DAT individuals (all *p*s < .01). To examine the interaction, we conducted pairwise comparisons to examine the difference in naming latencies between the control condition and the remaining priming conditions for each group. Table 8 shows the effects sizes of each condition in comparison with the control condition for each group. The results showed reliable inhibitory priming effects for the young adults, $F(1, 25) = 6.0, p = .022$, the old adults, $F(1, 40) = 6.69$, $p = .013$, and the DAT individuals, $F(1, 43) = 8.37, p = .006$, in the AR condition. However, there was no priming effect in the AS condition for any of the groups (all *p*s > .05). Reliable negative priming effects for the IR condition were obtained for the young adults, $F(1, 25) = 7.99, p = .009$, and the old adults, $F(1, 40) = 12.17$, $p = .001$, but not for the DAT individuals, $F(1, 43) = 0.32, p = .572$. Power estimates for these tests, assuming a 15- to 20-ms effect in the population, were .97 to .99 for the young adults, .95 to .99 for the old adults, and .60 to .82 for the individuals with DAT. The difference between the control and IS conditions was not significantly different from zero for any of the groups (all *p*s > .05).

To further examine the Group × Priming Condition interaction for the AR condition and the critical negative priming effect, we calculated one-factor ANOVAs with group (Old and DAT) as the independent variable and the control–AR and control–IR difference scores as the independent variables. The results comparing the AR effect across groups was not reliable, $F(1, 83) = 1.64, p > .05$, $MSE = 1{,}664$. However, the results comparing the negative priming effect yielded a reliable difference between the two groups, $F(1, 83) = 4.98, p < .03$, $MSE = 1{,}419$. In addition, the results of sign tests to look at the number of subjects showing the negative priming effect in each group revealed a reliable effect for the old adults (75%; $p < .01$) but not for the DAT individuals (47%; $p = .76$).

Error rates. The mean number of errors for the priming conditions are also shown in Table 7. There are two points to note: First, the young adults produced fewer errors than the old adults, who in turn produced fewer errors than did the individuals with DAT. Second, the data do not provide evidence for a speed–accuracy trade-off that might explain the slower naming latencies in the AR condition and the absence of negative priming in the naming latencies of the DAT individuals.

These observations were supported by a 3 × 5 mixed-factor ANOVA identical to that described for the latency analysis. Results showed an effect of group, $F(2, 108) = 12.35, p < .0001$, $MSE = .014$, an effect of priming condition, $F(4, 432) =$

Table 7
Mean Naming Latency (in Milliseconds) and Percentage Errors to Selected Probe Words in Experiment 2

	Attended						Ignored			
	Repetition		Semantic		Control		Semantic		Repetition	
Variable	*M*	*SE*	*M*	*SE*	*M*	*SE*	*M*	*SE*	*M*	*SE*
Young										
Naming latency	539	10	524	9	525	10	533	10	537	9
Error	.03	.012	.02	.008	.01	.005	.01	.007	.01	.005
Older										
Naming latency	604	8	596	8	593	9	598	9	607	8
Error	.06	.013	.03	.008	.03	.007	.04	.01	.06	.013
DAT										
Naming latency	662	18	642	15	640	16	648	19	636	15
Error	.09	.012	.08	.013	.07	.012	.09	.016	.08	.014

Note. DAT = dementia of the Alzheimer type.

Table 8
Mean Naming Latency Differences and Error Differences in Experiment 2 According to Condition

	Control minus:											
	AR		AS		IS		IR		S − U		U − A	
Variable	*M*	*SE*	*M*	*SE*	*M*	*SE*	*M*	*SE*	*M*	*SE*	*M*	*SE*
					Young							
Naming latency	−14	6	2	3	−7	4	−11	4	−4	4	49	5
Error	−.018	−.010	−.005	−.006	.004	−.006	.001	.004	−.019	−.008	.031	.011
					Old							
Naming latency	−11	4	−3	4	−5	4	−14	4	8	5	51	4
Error	−.033	−.012	−.003	−.009	−.007	−.008	−.026	−.010	−.022	−.011	.070	.012
					DAT							
Naming latency	−22	7	−2	5	−8	7	4	7	6	9	54	6
Error	−.017	−.013	−.009	−.013	−.023	.015	−.011	−.013	.022	.012	.068	.012

Note. AR = attended repetition condition; AS = attended semantic condition; IS = ignored semantic condition; IR = ignored repetition condition; U − A = unrelated minus alone condition; S − U = semantic − unrelated condition.

2.48, $p < .05$, $MSE = .003$, but no Group × Priming Condition interaction, $F(8, 432) < 1.0$, $p > .05$, $MSE = .003$. Post hoc Newman–Keuls tests showed that the error rate increased reliably across groups, from the young adults to the DAT individuals ($ps < .01$). Pairwise comparisons of the priming conditions across all subjects showed that, overall, subjects produced fewer errors in the control condition than in either the AR condition, $F(1, 110) = 10.56$, $p = .002$, or in the IR condition, $F(1, 110) = 4.44$, $p = .037$. Pairwise comparisons for the control condition minus AS condition and for the control condition minus IS condition were not significantly different from zero (all $ps > .05$). Table 8 shows the effect sizes of each condition in comparison with the control condition for each group.

Interference Effects

Naming latency. The mean of the median naming latencies to the selected primes for each interference condition are shown in Table 9. There are three points to note: First, as expected, the naming latencies of the young adults are faster than the naming latencies of the old adults, who in turn are faster than the individuals with DAT. Second, the semantic interference condition does not appear to be different from the unrelated interference condition. Third, as in Experiment 1, the unrelated interference condition is consistently slower than the alone condition. Moreover, the size of this difference appears to be similar for all three groups.

These results were supported by a 3 × 3 ANOVA with group as a between-subjects factor (young, old, and DAT) and interference condition as a within-subjects factor (unrelated–control prime, semantic, and alone). This analysis yielded a significant effect of group, $F(2, 108) = 23.20$, $p < .0001$, $MSE = 15{,}763$, and an effect of interference condition, $F(2, 216) = 136.25$, $p < .0001$, $MSE = 727$, but no significant Group × Interference Condition interaction, $F(4, 216) < 1.0$, $p > .05$, $MSE = 727$. Post hoc Newman–Keuls tests showed that naming latency increased reliably across groups, from the young adults to the individuals with DAT ($ps < .05$). Results of the pairwise comparisons showed a reliable perceptual interference effect. All subjects were slower to name the selected prime in the presence of an unrelated distractor than when the prime occurred alone, $F(1, 110) = 281.57$, $p < .0001$. However, there was no semantic interference effect $F(1, 110) = 1.11$, $p > .05$. Table 8 shows the effect sizes of each condition in comparison with the control condition for each group.

Error rates. The mean number of errors for the interference conditions are also shown in Table 9. There are three points to note: First, the young adults produced fewer errors than did the old adults, who in turn produced fewer errors than did the individuals with DAT. Second, more errors were produced in the unrelated interference condition than in the alone condition. Third, both the young and old adults produced more errors in the unrelated condition than in the semantic interference condition, whereas the individuals with DAT produced fewer errors in the unrelated condition than in the semantic condition. Since the young adults produced no errors in the alone condition, two separate analyses were conducted, both of which provide support for the above observations.

For the first analysis, the mean number of errors for the

Table 9
Mean Naming Latencies (in Milliseconds) and Percentage Errors to Selected Prime Words in Experiment 2

	Semantic		Unrelated		Alone	
Variable	*M*	*SE*	*M*	*SE*	*M*	*SE*
			Young			
Naming latency	507	8	511	9	461	8
Error	.01	.005	.03	.011	.00	.000
			Old			
Naming latency	592	9	585	9	533	8
Error	.05	.01	.07	.011	.002	.002
			DAT			
Naming latency	638	17	631	15	577	15
Error	.10	.014	.08	.012	.01	.003

Note. DAT = dementia of the Alzheimer type.

unrelated and alone conditions were entered into a 2 × 2 mixed-factor ANOVA with group as a between-subjects factor (old and DAT) and with interference condition as a within-subjects factor (unrelated–control prime and alone). The results of this analysis yielded no effect of group, $F(1, 83) < 1.0$, $MSE = .003$, but an effect of interference condition, $F(1, 83) = 67.75, p < .0001$, $MSE = .003$; it also yielded no Group × Interference Condition interaction, $F(1, 83) < 1.0, p > .05$, $MSE = .003$. All three groups produced fewer errors in the alone condition than in the unrelated condition. Table 8 shows the effect sizes of each condition in comparison with the control condition for each group.

For the second analysis, the mean number of errors for the semantic and unrelated conditions were entered into a 3 × 2 mixed-factor ANOVA with group as a between-subjects factor (young, old, and DAT) and interference condition as a within-subjects factor (semantic and unrelated–control). The results of this analysis yielded an effect of group, $F(2, 108) = 9.77$, $p < .0001$, $MSE = .008$, no effect of interference condition, $F(1, 108) < 1.0$, $MSE = .002$, and a Group × Interference Condition interaction, $F(2, 108) = 5.47, p < .01$, $MSE = .002$. Post hoc Newman–Keuls tests showed that the error rate increased reliably across groups, from the young adults to the DAT individuals (all $ps < .01$). To examine the interaction, we calculated pairwise comparisons of the interference effect for each group. Table 8 shows the effect sizes of each condition in comparison with the control condition for each group. Results showed that the individuals with DAT produced more errors in the semantic condition than in the unrelated condition. However, this comparison did not reach significance, $F(1, 43) = 3.59$, $p = .07$. In contrast, both the young adults, $F(1, 25) = 5.81, p < .05$, and the old adults, $F(1, 40) = 4.21$, $p < .05$, produced fewer errors in the semantic condition than in the unrelated condition.

In addition, as in Experiment 1, we analyzed the number of intrusion errors in the semantic and unrelated conditions. The mean number of intrusion errors are shown in Table 5. The results comparing the number of intrusions in the unrelated condition across groups were not reliable, $F(2, 108) = 2.61, p > .05$. However, the results comparing the number of intrusions in the semantic condition showed a reliable difference between the groups, $F(2, 108) = 11.79, p < .0001$. A post hoc Newman–Keuls test showed that the individuals with DAT produced reliably more intrusion errors than did the old adults ($p < .05$), who in turn produced reliably more errors than the young adults ($p < .05$).

Discussion

Negative Priming in Young and Old Adults

The negative priming results replicate those of Experiment 1. Reliable and similar-size negative priming was obtained in the young and old adults in the IR condition but not in the IS condition. Moreover, the negative priming effect for the IR condition was obtained despite sample sizes similar to those used by Kane, Hasher, et al. (1994), who failed to obtain an effect with written word stimuli in old adults. Also note that Earles et al. (1994, Experiment 1) reran the Kane, Hasher, et al. (1994) study with a much larger sample size ($n = 123$ old adults). Although the Earles et al. results revealed reliable negative priming in the old adults, the magnitude of the effect was reliably smaller than for the young adults. One possible explanation for the fact that the Kane et al. (1994) and Earles et al. (1994) studies found age-related differences in negative priming while the present study did not is that both studies used nonoverlapping word displays, while the present study did not. Thus, it is possible that overlapping word stimuli may engage the inhibitory mechanism to a greater degree than nonoverlapping word stimuli. This notion, however, may not provide an adequate explanation for the discrepant negative priming results in old adults. This is because other studies have failed to obtain negative priming in old adults with overlapping letter stimuli (McDowd & Oseas-Kreger, 1991), whereas at least one study has observed no age-related decrement with nonoverlapping letter stimuli (Kramer et al., 1994).

Negative Priming in Individuals With DAT

The results of the planned comparison and the nonparametric sign test replicated those of Experiment 1 as they again failed to show negative priming in individuals with DAT (see Footnote 2). More important, unlike as in Experiment 1, this result also was supported by reliable differences in negative priming between the old adults and individuals with DAT. However, although the estimated power of detecting a reliable effect in the DAT individuals was larger than in Experiment 1, it was still lower than that for the young and old adults. Therefore, to further assess this issue, we conducted an analysis of the critical negative priming effect across both experiments. We calculated an ANOVA with experiment (Experiments 1 and 2) and group (Old and DAT) as the independent variables and with control–IR difference score as the dependent variable. The results showed that the effect of experiment and the interaction between experiment and group were not reliable ($Fs < 1.0$). The difference in negative priming between the two groups approached significance, $F(1, 116) = 3.67$, $p < .058$, $MSE = 1726$. A post hoc analysis revealed that reliable negative priming was obtained for the old adults, $F(1, 59) = 18.37$, $p < .001$, but not for the individuals with DAT, $F(1, 57) < 1.0$. Power estimates for these tests, assuming a 15- to 20-ms effect in the population, were .98 to .99 for the old adults and .62 to .85 for the individuals with DAT.

In summary, there are several reasons why we believe these results provide evidence consistent with an inhibitory breakdown in DAT individuals. First, models of cognitive slowing show that effect size increases as overall reaction time increases (e.g., Cerella, 1991; Hale, Myerson, & Wagstaff, 1987; Nebes & Brady, 1991; Salthouse, 1985). Thus, we might expect the negative priming effect in the DAT individuals, whose naming latencies were slower in both experiments, to increase rather than decrease as was observed in the present study. Moreover, to the extent that cognitive slowing predicts larger difference scores, we have underestimated the power of our tests because the true expected effect size would need to be larger in the DAT individuals than in the old adults to obtain equivalent negative priming. Finally, although the negative priming effect is small, ranging from 10 to 20 ms in approximately 75% to 80% of young and old adults, there are reports in the literature of similar small effect sizes, which actually increase in DAT individuals. For example, Balota and Duchek (1991) reported an 11-ms semantic priming effect that reliably increased to 23 ms in DAT individuals. Thus, it is not necessarily the case that because of overall variability in these subjects, one cannot detect a group-related change with a small effect size.

Distractor Interference

The naming latency results from the distractor interference tasks provide a replication of those obtained in Experiment 1. All three groups were slower to name a target when an unrelated distractor was present than when no distractor was present. In addition, a semantically related distractor again failed to slow naming latencies over and above an unrelated distractor. These results suggest that DAT does not impair the ability to selectively attend.

However, the analyses conducted on the interference measures did not take into account the fact that the DAT individuals' naming latencies were slower than those of the young and old adults. As noted above, models of cognitive slowing predict that the absolute magnitude of the interference effect should increase with increases in overall naming latency (e.g., Faust, Balota, & Ferraro, 1995; Hale et al., 1987; Myerson, Hale, Wagstaff, Poon, & Smith, 1990; Salthouse, 1985). The fact that there was no increase in the interference effect raises the question of whether or not controlling for the difference in overall speed would reveal that the individuals with DAT were not processing the distractors as well as the young and old adults. To examine this, we conducted a ratio analysis of the perceptual interference effect. That is, for each subject, we calculated the proportional amount of interference with the following formula: (unrelated condition median naming latency minus alone median naming latency)/alone median naming latency. The proportions for each group were then entered into separate ANOVAs for each experiment with group as a between-subjects factor. If the individuals with DAT were not processing the distractors as well as the young and old adults, we would expect the magnitude of the interference effect to be proportionately smaller. The results of these analyses showed that the proportional amount of interference did not differ across groups for either Experiment 1, $F(2, 53) = 1.36, p > .05, MSE = .006$, or Experiment 2, $F(2, 108) < 1.0$, $MSE = .004$. Thus, although the error data seem to be reflecting momentary breakdowns in the ability to select targets in the presence of distractors, the naming latency data of the DAT individuals are indeed showing similar amounts of interference to those of the young and old adults.

Although these results contrast with the majority of distractor interference studies of individuals with DAT, which have shown increased effects (e.g., Fisher et al., 1990; Koss et al., 1984; Massman, Delis, Filoteo, Butters, Salmon, & Demadura, 1993; Spieler et al., 1994), they are consistent with two distractor interference studies conducted by Filoteo et al. (1992) and Nebes and Brady (1989). Overall, the distractor interference studies suggest that the inhibitory mechanism *underlying* DAT individuals' ability to suppress the selection of activated distractors may be functioning but deficient. Whether or not an inhibitory deficit is revealed in these tasks appears to be dependent on whether or not the distractor competes strongly for selection. For example, the studies that have found increased interference in DAT individuals have used Stroop-type stimuli. In these tasks, the distractor is not only similar to the target in terms of response compatibility but also becomes available first. Thus, it competes strongly with the target for selection. In contrast, individuals with DAT appear to efficiently suppress weakly activated distractors, such as those used in the present experiment, that are not only unrelated to the targets but have an equivalent speed of access. Note also that a distractor competes weakly for selection when target selection is cued, for example, by color (Nebes & Brady, 1989).

In contrast to the naming latency results, the results of the overall error analyses for the perceptual interference effect failed to replicate the interaction observed in Experiment 1. That is, the individuals with DAT did not produce more errors than the young or old adults in the unrelated condition than in the alone condition. The finding of increased perceptual interference in DAT individuals for pictures, but not words, may simply reflect their increased difficulty in initially parsing the picture displays. That is, DAT individuals' ability to read words is maintained long after their ability to name pictures has deteriorated (Fromm, Holland, Nebes, & Oakley, 1991; Nelson & McKenna, 1975; Ruddle & Bradshaw, 1982).

In contrast, a Group × Semantic Interference effect was observed. Both young and old adults produced reliably fewer errors in the presence of a semantically related distractor than in the presence of an unrelated distractor, whereas the individuals with DAT produced more errors. In addition, as in Experiment 1, individuals with DAT produced more intrusion errors than either young or old adults in the presence of semantically related distractors but not in the presence of unrelated distractors. These findings are consistent with those of Balota and Ferraro (1993) and Spieler et al. (1994) and provide further evidence that DAT decreases the ability to suppress one of two competing responses.

Positive Priming

Finally, with regard to the positive priming conditions, we found an effect only for the AR condition. However, unlike the results of Experiment 1, in which naming latencies were facilitated, naming latencies were unexpectedly inhibited. That is, naming latencies to a selected word in the probe display were slowed when that same word was named as a selected word in the previous prime display. Moreover, the magnitude of this effect was the same for all three groups. We are unaware of any current theories of visual word recognition that can explain this result. However, there are at least two ways of accounting for the observed inhibition.

First, one might suggest that this effect is related to a type of within-lexical inhibitory mechanism that is necessary to prevent reselection of a previously accessed lexical representation (Dell, 1988; Levelt, 1989; MacKay, 1987). Second, a more viable explanation for this inhibitory effect may be related to a verification process that is instantiated when a stimulus is repeated. Although both hypotheses are possible, the important point to note in the present results is that the inhibition occurred with written words but not with pictures. In a recent negative priming study, Milliken, Joordens, and Tipper (1994, Experiment 8) reported significant facilitation in a similar task in which subjects were asked to silently read a single word prime and then select and read one of two overlapping words in a subsequent probe display. Note that the task used in Experiment 2 is similar to that of Milliken et al. with the exception that subjects also had to select and name one of two overlapping words in the prime display. Thus, the presence of the same target in similar prime and probe displays in the present experiment may have induced subjects to verify that they had not responded to the probe display, which would have slowed their naming latencies. This would not occur when only a single prime word is presented, because the context for selection of the same item in the probe display would be different. However, the fact that this inhibition is seen for words and not pictures suggests that there may be a time course to this effect. Given that words are accessed faster than pictures, the word probe displays appear for naming before the picture probe displays. As a result, the repeated word stimuli may be more likely than pictures to cause subjects to initially interpret the probe displays as similar to the prime displays in the AR condition. This would have an effect of overriding any preactivation of the target produced by naming the selected prime. This explanation makes the prediction that the inhibition in the present task should turn into facilitation with a longer response stimulus interval.

General Discussion

Negative Priming in Young and Old Adults

In these experiments we obtained both reliable and similar-size negative priming in young and old adults for both picture and word stimuli. These results contrast with those in other studies in that age-related decrements in negative priming have been consistently found with word stimuli (Earles et al., 1994; Kane et al., 1994) but not with picture stimuli (see Earles et al., 1994, vs. Tipper, 1991). However, to ensure that there were no differences in the magnitude of the effect as a function of age and stimulus type, we conducted the following analysis. We examined whether or not the magnitude of the negative priming effect in the IR condition for the young and old adults differed for pictures (Experiment 1) and words (Experiment 2). Across the two experiments, the young adults were matched on age, $F(1, 45) < 1.0$, and the old adults were matched on age, $F(1, 59) = 1.64, p > .05$, and education $F(1, 59) < 1.0$. Therefore, the control minus IR difference scores from the young and the old adults were entered into separate ANOVAs with experiment (picture vs. words) as a factor. This analysis showed that the difference in the magnitude of negative priming between pictures and words was not reliably different for either the young adults, $F(1, 45) < 1.0$, or the old adults, $F(1, 57) < 1.0$. Thus, at least within the present experimental paradigm, pictures and words are indeed equally likely to show negative priming effects of similar size in young and old adults.

To date, in contrast to other studies investigating age-related changes in negative priming, the experimental design used in the present study has consistently produced reliable negative priming of a similar magnitude in both young and old adults (Sullivan & Faust, 1993). Why might this be the case? One explanation has recently been offered by May et al. (in press), who argued that the negative priming effect obtained with the Sullivan and Faust (1993) design may not reflect inhibitory function but slowing due to a response conflict in the ignored condition.

Two explanations have been proposed to explain the slowing of responses associated with the negative priming effect. The conventional view of negative priming assumes that following an automatic activation of both the selected and to-be-ignored stimuli, the active mental representation of the to-be-ignored stimulus is directly inhibited (Neill, 1979; Tipper, 1985). In a recent series of negative priming experiments, Tipper and his colleagues (Milliken, Tipper, & Weaver, 1994; Tipper, Weaver, & Houghton, 1994) have expanded this view, which they have called "distractor inhibition," by providing evidence that inhibition is flexible in that it can be adjusted to meet task demands. That is, inhibition does not necessarily operate against all properties of a distractor but rather only against those that compete for the control of action. As a result, properties of the distractor that do not compete remain active and can guide subsequent behavior.

Alternatively, Neill and his colleagues (Neill & Valdes, 1992; Neill, Valdes, Terry, & Gorfein, 1992) have recently attributed the inhibition underlying negative priming to a type of episodic retrieval and response conflict.[3] On the basis of Logan's (1988) instance theory of automatization, Neill proposed that on negative priming trials, selection of a target stimulus in a probe display causes the episodic retrieval of nonresponse information associated with the to-be-ignored distractor stimulus that occurred in the previous prime display. Thus, response times are slowed because of the time needed to resolve the conflict between the nonresponse information associated with the stimulus and the current task that requires a response to the same stimulus.

Rather than viewing these as two possible accounts of the same phenomenon (Milliken et al., 1994; Neill et al., 1995), May et al. (in press) have argued that they reflect two independent mechanisms. That is, depending on the experimental context, negative priming effects may result primarily from prime distractor inhibition or primarily from a response conflict induced by an episodic retrieval of nonresponse information encoded as part of the prime distractor. Moreover, they argued that one possible explanation for the inconsistent finding of reliable negative priming in old adults may be accounted for by considering whether the experimental conditions induce the operation of one or the other mechanism. In other words, May et al. (in press) argued that reliable negative priming will be obtained in old adults only when the experimental conditions induce episodic retrieval, which is

[3] Some forms of negative priming can also be explained by a conflict created by a mismatch between the features of an ignored stimulus in a prime display and a selected stimulus in a subsequent probe display (Milliken et al., 1994; Park & Kanwisher, 1994). This form of negative priming is more germane to spatial localization tasks than to identity tasks, which were used in the present experiments.

preserved, and not when they induce inhibitory function, which is diminished (Hasher & Zacks, 1988).

May et al. (in press) suggested that the inclusion of repeated targets (i.e., AR condition) in the Sullivan and Faust (1993) study may explain their finding of reliable and similar-size negative priming in old adults. That is, the inclusion of the AR condition may have encouraged episodic retrieval rather than inhibitory function, as was suggested by Sullivan and Faust (1993). Given that the AR condition was also included in the present set of experiments, it is also possible that the present two experiments did not measure inhibitory function.

However, although negative priming may be multiply determined, the inclusion of repeated targets may not be a necessary condition for inducing episodic retrieval, which according to May et al. (in press) would produce reliable and similar-size negative priming in young and old adults. This is because there are two studies that did not contain a repeated target condition (or other conditions that would induce or enhance episodic retrieval) but which obtained reliable and similar-size negative priming in young and old adults (Earles et al., 1994; Kramer et al., 1994). Thus, at this point in time, the exact mechanism (or mechanisms) responsible for the negative priming effect in the Sullivan and Faust (1993) study and in the present study does not appear to be totally attributable to episodic retrieval induced by the AR condition.

Negative Priming in Individuals With DAT

In these experiments we administered negative priming and distractor interference tasks to obtain converging support for the notion that DAT produces an impairment in the ability to suppress distracting or irrelevant information (Balota & Duchek, 1991; Hasher & Zacks, 1988). The results from both experiments were consistent with an inhibitory breakdown in individuals with DAT as both the young and old adults produced reliable and similar-size IR negative priming, whereas the individuals with DAT did not. Moreover, as discussed above, the error data provide some converging support for this notion. However, the naming latency data from the distractor interference measures suggest otherwise. In both experiments, the amount of perceptual interference produced by an unrelated distractor did not differ across the three groups.

The dissociation between the naming latency measures of negative priming and distractor interference raises the question of whether or not DAT produces an impairment of selective attention and, more important, whether or not the absence of negative priming provides converging support for an inhibitory breakdown.

Distractor Inhibition Explanation

With regard to the distractor inhibition account, the negative priming data may indeed reflect an impairment of the inhibitory mechanism underlying selective attention. That is, the individuals with DAT appear to be having difficulty suppressing the identity of either a partially activated picture or partially activated word. However, to the extent that distractor interference tasks also provide a measure of the *ability to selectively attend*, we must reconcile the fact that the magnitude of the perceptual interference effect in the naming latency data did not differ across the three groups in either experiment.

Several researchers have suggested that the inhibition associated with measures of negative priming may be the same inhibition that functions to determine the degree of distractor interference (Neill & Westberry, 1987; Tipper, 1985). However, there is growing evidence to suggest that inhibition does not operate during, but after, selection to maintain the distinction between target and nontarget information (May et al., in press; Stoltzfus et al., 1993; Tipper, Weaver, Cameron, Brehaut, & Bastedo, 1991). In other words, inhibition does not occur with short prime–probe intervals (20–50 ms; Lowe, 1985), but once engaged, remains constant. That is, the effect has been shown to persist for up to 8 s (Neill & Valdes, 1992), and more recently, Triesman and DeSchepper (1994) reported an effect that lasted for 24 hr. Thus, it may be erroneous to assume that inhibitory function underlies these results. Rather, measures of distractor interference may simply reflect the time needed to resolve the conflict created by the differential activation of the target and distractor. Interestingly, similar to the results of the present study, dissociations between measures of negative priming and distractor interference have been previously obtained. That is, each effect can occur in the presence or the absence of the other (Beech, Agar, & Baylis, 1989; Driver & Tipper, 1989; Stoltzfus et al., 1993; Sullivan & Faust, 1993; Tipper et al., 1991; Tipper, Weaver, Kirkpatrick, & Lewis, 1991). Thus, the inhibition underlying distractor interference may not necessarily modulate the magnitude of negative priming. Rather, as discussed above, the effect of distractor interference may depend on how strongly a distractor is initially activated or on selection difficulty (e.g., overlapping vs. nonoverlapping displays) before inhibition operates (Neill et al., 1995).[4] To the extent that the inhibitory mechanism is operating normally, the magnitude of suppression may be greater against strongly activated distractors than against weakly activated distractors (Neill et al., 1995; but see Driver & Tipper, 1989). However, if there is a decrement in inhibitory function, as appears to be the case in the individuals with DAT, then the amount of inhibition directed toward weakly activated distractors may be sufficient for selection of a concurrent target but not strong enough to produce negative priming. Moreover, attempts to measure negative priming from strongly activated distractors may also fail because they override the weak suppression.

An alternative explanation for the absence of negative priming in DAT individuals is based on Neill's episodic retrieval account (Neill & Valdes, 1992; Neill et al., 1992). That is, given that DAT individuals' episodic memory is impaired (Morris & Kopelman, 1986), they may have difficulty retrieving the nonresponse information associated with the prime distractor, despite the fact that the design included repeated primes and targets, which may have enhanced episodic retrieval (May et al., in press). This explanation would

[4] Moreover, whether or not a relationship between the two measures is obtained may depend on whether or not the goal of selection indexes the same level of processing (Neill et al., 1994; Sullivan & Faust, 1993; Tipper et al., 1994).

also allow for a theoretically coherent account of the dissociation between measures of negative priming and distractor interference, because the slowing of responses would result from two different mechanisms.

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Received September 6, 1994
Revision received December 13, 1994
Accepted March 10, 1995