OPERANT CONDITIONING IN OLDER ADULTS WITH ALZHEIMER’S DISEASE

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Behavioral interventions based on operant principles are commonly attempted to manage agitation in older adults with dementia. The extent to which operant conditioning can occur in persons with particular dementias, however, is unclear. The present study involved use of a button-pressing task to evaluate the sensitivity of the responding of older individuals with and without probable Alzheimer’s disease (AD) to changes in schedules of reinforcement. It was expected that participants with AD would acquire the experimental task and that they would demonstrate less sensitivity to changes in schedules of reinforcement than participants without AD. Results indicated that operant conditioning can occur in older adults with AD and that they can respond to different schedules of reinforcement. The responding of 3 participants with AD was highly sensitive to a transition from a fixed interval schedule to an extinction schedule. Two participants with AD demonstrated responding that was sensitive to a more subtle transition. Participants with AD failed to show spontaneous recovery of responding after a delay. The performances of participants with and without AD are compared, and implications of findings for behavioral interventions in AD are discussed.

Alzheimer’s disease (AD) is the most common cause of dementia, affecting approximately 4 million Americans (Alzheimer’s Association, 2002). Approximately 10% of adults older than 65 years and almost half of those over 85 years have the disease (Alzheimer’s Association). The organic pathology that underlies AD can produce a variety of maladaptive behaviors, including aggression, screaming, and wandering, typically referred to as agitation (Cohen-Mansfield and Billig, 1986). Agitation...
is exhibited by 55% to 90% of persons with dementia, depending on the setting (Ballard et al., 2001; Cohen-Mansfield, Werner, Watson, & Pasis, 1995), and not only places the patient and others in the immediate environment at physical risk but also increases stress in caregivers (Bourgeois, Schulz, & Burgio, 1996).

Various approaches have been used to treat agitation in individuals with dementia, including behavioral interventions in which the antecedents and consequences of a target behavior are identified through functional assessment procedures and then are manipulated to change behavior. Many accounts of behavioral interventions for agitation in older adults with dementia have been published (e.g., Birchmore & Clague, 1983; Bird, Alexopoulos, & Adamowicz, 1995; Haley, 1983; Hussian & Brown, 1987; Namazi, Rozner, & Calkins, 1989). The results of these studies and reviews of the literature suggest that clinicians be optimistic regarding the ability of behavioral interventions to reduce agitation in some older adults with dementia (e.g., Allen-Burge, Stevens, & Burgio, 1999; Kasl-Godley & Gatz, 2000; Plaud, Moberg, & Ferraro, 1998; Spira & Edelstein, 2006). However, the heterogeneity of both cause and severity of dementia observed among participants described in the applied literature hinders researchers’ ability to draw conclusions about the ability of persons with particular varieties of dementia to respond to contingencies of reinforcement.

Basic research, conducted within a controlled laboratory environment with an etiologically homogeneous sample of older adults with dementia, is necessary to evaluate the degree to which the behavior of members of this population can come under the control of contingencies of reinforcement. A traditional, mechanized operant paradigm, in which the consequences of behavior are systematically manipulated, is the most appropriate methodological context for this research because it provides an excellent experimental analogue of the natural environment while allowing for maximal control of the variables that can threaten the validity of such studies (e.g., bias in reinforcer delivery, inaccurate recording of responding).

Although a number of basic operant studies have been conducted with cognitively intact older adults (e.g., Baron & Menich, 1985; Baron, Menich, & Perone, 1983; Perone & Baron, 1982; Plaud, Gillund, & Ferraro, 2000), to our knowledge, only two basic studies of the degree to which operant learning can occur in older adults with dementia have been published (Ankus & Quarrington, 1972; Burgess, Wearden, Cox, & Rae, 1992) and we know of none that have appeared since 1992. Although the results of prior investigations suggest that the responding of older adults with dementia may be sensitive to changes in contingencies of reinforcement, researchers in these studies evaluated operant learning in persons with dementia that arose from varied and, at times, poorly characterized causes. Given that distinct causes of dementia can have idiosyncratic effects on particular brain regions—and, in turn, on particular aspects of behavior—the failure of these studies of operant behavior to replicate findings in a population with a unitary diagnosis and underlying
neuropathology precludes researchers from drawing conclusions about the abilities of persons with a particular brain disease to respond to contingencies of reinforcement.

To advance this area of research, the present study was conducted to further evaluate operant learning in both older adults with probable AD and healthy control subjects, using a button-pressing task and a single-subject design. Sensitivity to changes in contingencies of reinforcement was measured by means of change in response rates across experimental conditions. We expected that older adults with and without probable AD would acquire the experimental task and that the responding of older adults with AD would demonstrate less sensitivity to changes in contingencies of reinforcement compared to that of those without AD. Further, we expected that participants with AD would exhibit impaired recall of the experimental task during a retention trial and that controls would not.

Method

Participants

Participants with AD were 4 older adults (1 male; mean age = 79.5 years; range = 68–86 years; see Table 1) in whom probable AD had been diagnosed by a neurologist according to criteria of the National Institute of Neurological and Communicative Disorders and Stroke–Alzheimer’s Disease and Related Disorders Association (NINCDS-ADRDA; McKhann, Drachman, Folstein, Katzman, Price, & Stadlan, 1984). They were recruited from the Memory Disorders Clinic of the West Virginia University School of Medicine, from nursing homes in the area, and from the community. Participants and surrogate decision makers were informed that they would have the opportunity to earn money by participating in an investigation of learning in older adults. Exclusionary criteria for older adults with AD were (a) sensory or other physical deficits that could interfere with participation (e.g., severe, uncorrected visual or auditory impairment, paralysis); (b) psychiatric diagnoses of schizophrenia or bipolar disorder; (c) other dementing illnesses, including Parkinson’s disease, Huntington’s disease, Pick’s disease; and (d) dementia due to vascular insult or substance abuse. The experimenter obtained informed, written consent from participants’ surrogate decision makers. Participants with AD provided written assent. Comparison participants of similar age (n = 4; mean age = 74.25 years; range = 70–81 years; see Table 1) were recruited from senior centers and by means of signs placed in a public library. Exclusionary criteria for comparison participants were (a) sensory or other physical deficits that could interfere with participation; (b) any psychiatric diagnoses or disorders; (c) use of psychotropic medications; and (d) neurological illness or injury. Comparison participants provided informed consent for participation. Participants with AD were generally older than comparison participants.
Measures

Data were collected in participants’ homes in the community, in long-term care facilities, or in a research laboratory at West Virginia University. After obtaining consent and assent, the experimenter conducted a clinical interview (to screen for psychosis, mood disorders, anxiety disorders, substance abuse, and eating disorders) and administered the neuropsychological test battery recommended by the Consortium to Establish a Registry for Alzheimer’s Disease (CERAD; Morris et al., 1989).

**Animal Naming.** Subjects were asked to name as many animals as they could within 1 min as a test of verbal fluency. This task has been used extensively to evaluate the verbal fluency of persons with dementia whose abstract thinking abilities are too severe to permit the use of other such tests (Lezak, 1995).
**Boston Naming Test.** The Boston Naming Test (Kaplan, Goodglass, & Weitnraub, 1978, 1983) is a 60-item test of the ability to name objects depicted in line drawings (Spree & Strauss, 1998). The test has been shown to have good 6-month response consistency when used with individuals with AD (Henderson, Mack, Freed, Kempler, & Andersen, 1990). A 15-item version of the test is used in the CERAD battery. According to Lezak (1995), this version is sensitive to the presence and severity of dementia.

**Mini–Mental State Examination.** The Mini–Mental State Examination (MMSE; Folstein, Folstein, & McHugh, 1975) is a brief, standardized screen of cognitive functioning. The MMSE yields a maximal score of 30; persons without cognitive impairment generally score between 24 and 30. The MMSE has high 24-hr test-retest reliability (Folstein et al.) and is sensitive to progressive decline associated with degenerative dementia (Morris et al., 1989).

**Word List Memory, Recall, and Recognition.** The CERAD Word List Memory task involves 10 printed words (Morris et al., 1989). The subject reads the list of words out loud three times, in three different orders. Recall is tested after each of these trials; the maximal score is 30. There is also a delayed-recall component, which is followed by a recognition component (the presentation of target words and foils, with subjects being asked to identify words from the original list). The maximal score on each of these tests is 10.

**Constitutional Praxis.** The CERAD Constructional Praxis (Morris et al., 1989) task requires subjects to copy four simple line drawings (circle, diamond, intersecting rectangles, cube).

**15-Item Geriatric Depression Scale.** The 15-Item Geriatric Depression Scale (Sheikh & Yesavage, 1986) is an abbreviated version of the 30-item screening tool for depression (Yesavage et al., 1983). The 15-item test utilizes a clinical cutoff of either 6 or 7 and has been shown to correlate well with the original 30-item version (Sheikh & Yesavage).

**Bristol Activities of Daily Living Scale.** The Bristol Activities of Daily Living Scale (BADLS; Bucks, Ashworth, Wilcock, & Siegfried, 1996) is a 20-item measure of adaptive functioning in older adults with cognitive impairment. The scale is completed by a caregiver. Each item measures an individual’s functioning in a different behavioral domain during the preceding 2 weeks. Higher scores indicate greater impairment.

**Apparatus**

Subjects were seated in front of a table containing the experimental console, which consisted of a wooden apparatus housing a coin-delivery mechanism, two backlit buttons, and a basket into which reinforcers were delivered. Only one of the two buttons was active during the study; the other was covered with a sheet of black paper. The apparatus was connected to a computer that controlled the delivery of reinforcers (i.e., nickels). A program written in Visual Basic v 6.0 recorded all events that occurred during experimental sessions, including the time at which
responses occurred (relative to the beginning of the experimental session), the beginning and end of each reinforcement cycle, response rate, and interreinforcer interval (IRI; i.e., the amount of time that elapsed between the delivery of two consecutive reinforcers). In addition, a small, locked, opaque cash box with a coin slot in the lid was placed on the table in front of subjects.

Procedure
This study was designed to evaluate the sensitivity of participants’ responding to transitions between fixed ratio (FR), fixed interval (FI), and extinction (EXT) schedules. This series of schedules was selected because comparable tests of sensitivity have been described by other authors (Madden, Chase, & Joyce, 1998) and have been used with human participants in the past (Hayes, Brownstein, Haas, & Greenway, 1986). Experimental sessions began when subjects were cued that they could begin button pressing and the backlit button on the experimental console was illuminated. Sessions ended when the light behind the button was turned off.

Reinforcement. Button pressing was reinforced by the delivery of nickels (5-cent coins) according to an FR schedule or an FI schedule. The reinforcement cycle began with a tone. Then the light behind the button was turned off, and the button was deactivated. Approximately 1 s later, the coin mechanism dispensed a nickel into the basket next to the console. After coin delivery, the tone continued until participants placed the coin in the coin box. At this point the tone ceased and the button was illuminated, signaling the end of the reinforcement cycle and the beginning of the next trial.

Preliminary training. Subjects were trained to respond on an increasingly lean series of FR schedules (beginning with FR 1). Training took place in 3-min blocks. To begin training, the experimenter read the following to subjects:

At times during this study you can earn nickels by pressing this button [Experimenter points to button]. You can keep all of the nickels that you earn. Each time you earn a nickel, you must place it in the box [Experimenter points to cash box]. You do not have to press the button; you can start pressing the button or stop pressing the button whenever you want. I cannot speak to you until this part of the study is over. Also, you can get up and walk around if you like, but please stay in the room until the study is over. Do you have any questions? [Experimenter addresses questions.] If you would like to, you may begin pressing the button now. Please remember to put any coins that you earn in the box.

If participants did not begin pressing the button independently within 1 min, the experimenter manually placed their hands on the manipulandum and completed a response. In addition, verbal prompts (e.g., “Please press the button”) were provided to increase the likelihood that subjects
contacted the programmed contingencies. These prompts were faded as responding stabilized. Each time a nickel was earned, the experimenter observed participants to ensure that they placed it in the cash box. If participants failed to do so, the experimenter instructed them to “please place the nickel in the box” while pointing to the nickel and then the cash box. The experimenter responded to subjects’ questions by stating, “I cannot answer questions until the study is over.”

The experimenter gradually increased the number of responses required for reinforcement to occur, with the goal of obtaining a mean IRI of approximately 5 s by the time responding stabilized. Responding was considered stable when response rates during three consecutive 3-min blocks did not differ from the mean of those blocks by more than 20%.

**Test conditions.** After preliminary training, subjects were exposed to three sequential experimental conditions: an FR, an FI, and an EXT condition. Each condition was composed of a series of 3-min blocks. Distinct stimuli were associated with the FR and FI conditions. Upon transition to the FI condition, a small yellow light adjacent to the backlit button was illuminated. This light remained illuminated throughout the FI condition (including during reinforcement intervals), and the backlit button continued to function as before (i.e., it continued to be turned off during reinforcement intervals). The change from FR to FI was signaled to increase the likelihood of obtaining sensitive responding in older adults with AD to a subtle change in contingencies. The stimulus conditions for the EXT condition were the same as in the FI condition.

The ratio value that was in effect when participants’ responding stabilized during preliminary training was used as the FR parameter during the FR condition. This variable created the possibility of between-subject differences in FR parameters. Although the experimenter attempted, during preliminary training, to adjust the schedule to create an IRI of approximately 5 s, it was not possible to obtain absolute control over responding. Thus, not all participants entered the FR condition with a mean IRI of exactly 5 s. During the FR condition, responding was considered stable when response rate during three consecutive blocks did not differ from the mean of those blocks by more than 20%.

The FI condition began after responding stabilized. The length of the FI during this condition was programmed to be equal to the mean IRI obtained by subjects during stable responding in the FR condition, creating the possibility of between-subject differences in FI parameters. The same stability criteria implemented in the prior condition were implemented in the FI condition.

The EXT condition began when responding stabilized. It continued until the mean response rate over two consecutive blocks fell to 25% or less of the mean response rate during stable blocks of the FI condition. At this point, the session ended.

**Retention test.** Memory deficits are a core feature of AD. To evaluate the effect of the disease on the retention of acquired responses, participants were reexposed to the EXT condition 24 to 48 hours after the end of the
initial button-pressing session. This part of the test was referred to as the retention condition (RET). The experimenter read the following instructions: “The machine works just like it did last time. I cannot speak to you until this part of the study is over. You do not have to press the button; you can start pressing the button or stop pressing the button whenever you want.”

Reductions during RET in the number of blocks to extinction criteria (i.e., from the number obtained in the initial session) were viewed as an indication of retention of prior learning.

Results

Cognitive and Functional Measures

Participants’ performances on the CERAD neuropsychological battery are presented in Table 2. The performances of all participants with AD diagnoses were demonstrative of cognitive impairment in the mild to moderate range. Given his very high level of education (23 years), participant AD31 is probably more impaired, relative to his baseline score, than his z scores imply. Two participants with AD scored above the clinical cutoff on the Geriatric Depression Scale. All participants with AD exhibited difficulties in activities of daily living, as measured with the BADLS. As expected, comparison participants performed in the normal range on all of these measures.

Table 2

<table>
<thead>
<tr>
<th></th>
<th>MMSE</th>
<th>Fluency</th>
<th>BNT</th>
<th>Trial 1</th>
<th>Trial 2</th>
<th>Trial 3</th>
<th>Delay</th>
<th>Recog yes</th>
<th>Recog no</th>
<th>Praxis</th>
</tr>
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<tbody>
<tr>
<td>Participants with AD</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AD23</td>
<td>10 (-8.00)</td>
<td>2 (-3.35)</td>
<td>5 (-8.45)</td>
<td>0 (-3.00)</td>
<td>0 (-3.88)</td>
<td>0 (-4.00)</td>
<td>0 (-3.53)</td>
<td>8 (-1.08)</td>
<td>9 (-3.00)</td>
<td>8 (-0.42)</td>
</tr>
<tr>
<td></td>
<td>17 (-4.82)</td>
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<td></td>
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<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>AD28</td>
<td>26 (-2.23)</td>
<td>9 (-1.95)</td>
<td>14 (-0.71)</td>
<td>1 (-2.56)</td>
<td>3 (-3.58)</td>
<td>2 (-4.43)</td>
<td>0 (-4.08)</td>
<td>0 (-19.86)</td>
<td>10 (0.33)</td>
<td>7 (-2.31)</td>
</tr>
<tr>
<td>AD30</td>
<td>23 (-4.54)</td>
<td>14 (-0.76)</td>
<td>11 (-5.00)</td>
<td>0 (-2.19)</td>
<td>4 (-2.75)</td>
<td>3 (-3.71)</td>
<td>1 (-3.47)</td>
<td>9 (-1.00)</td>
<td>10 (0.33)</td>
<td>6 (-3.08)</td>
</tr>
<tr>
<td>AD31</td>
<td>27 (-1.73)</td>
<td>9 (-1.50)</td>
<td>14 (-1.03)</td>
<td>3 (-4.00)</td>
<td>4 (-2.07)</td>
<td>5 (-2.31)</td>
<td>0 (-3.53)</td>
<td>6 (-4.63)</td>
<td>10 (0.29)</td>
<td>11 (-7.98)</td>
</tr>
<tr>
<td>Comparison participants</td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>OA13</td>
<td>29 (0.08)</td>
<td>11 (-1.46)</td>
<td>14 (-0.71)</td>
<td>5 (-0.08)</td>
<td>7 (-0.25)</td>
<td>9 (0.57)</td>
<td>9 (1.24)</td>
<td>10 (0.43)</td>
<td>10 (0.33)</td>
<td>10 (0.00)</td>
</tr>
<tr>
<td>OA20</td>
<td>30 (0.85)</td>
<td>23 (1.38)</td>
<td>15 (0.71)</td>
<td>7 (1.19)</td>
<td>9 (1.42)</td>
<td>10 (1.29)</td>
<td>8 (0.65)</td>
<td>10 (0.43)</td>
<td>10 (0.33)</td>
<td>11 (0.77)</td>
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<tr>
<td>OA28</td>
<td>30 (0.85)</td>
<td>21 (0.80)</td>
<td>15 (0.71)</td>
<td>8 (1.18)</td>
<td>9 (1.42)</td>
<td>10 (1.29)</td>
<td>9 (1.24)</td>
<td>10 (0.43)</td>
<td>10 (0.33)</td>
<td>11 (0.77)</td>
</tr>
<tr>
<td>OA27</td>
<td>30 (0.85)</td>
<td>18 (0.19)</td>
<td>15 (0.71)</td>
<td>6 (0.56)</td>
<td>8 (0.58)</td>
<td>10 (1.29)</td>
<td>9 (1.24)</td>
<td>10 (0.43)</td>
<td>10 (0.33)</td>
<td>11 (0.77)</td>
</tr>
</tbody>
</table>

Note. AD = Alzheimer’s disease, BNT = Boston Naming Test, MMSE = Mini-Mental State Examination, OA = older adult without AD, Recog. = recognition.

A quantitative index of the sensitivity of participants’ responding to changes in contingencies of reinforcement was calculated. This sensitivity index was calculated by dividing the mean response rate during the stable
blocks of each condition by the mean response rate during the stable blocks of the condition that preceded it. A similar index was employed by Hayes et al. (1986). Because this index is more intuitively understood when it is expressed as the percentage change in response rate during stable responding after each change in contingencies, sensitivity data are presented accordingly. A negative value indicates a decrease in response rate from FR to FI or from FR to EXT conditions; a positive value indicates an increase. A value of 1.0 would indicate identical mean response rates across conditions. Increasing deviations from 1.0—either negative or positive—are indicative of greater sensitivity (see Table 4).

Table 3
Parameters for FR and FI Schedules and Mean Response Rates Obtained by Participants Across Conditions

<table>
<thead>
<tr>
<th>FR parameter</th>
<th>Mean FR</th>
<th>FI parameter</th>
<th>Mean FI</th>
<th>Mean EXT</th>
<th>Mean RET</th>
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<td>Participants with AD</td>
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<tr>
<td>AD23</td>
<td>5</td>
<td>170</td>
<td>5.46</td>
<td>165</td>
<td>9.5</td>
</tr>
<tr>
<td>AD28</td>
<td>5</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>AD30</td>
<td>15</td>
<td>662.67</td>
<td>4.02</td>
<td>673.33</td>
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</tr>
<tr>
<td>AD31</td>
<td>9</td>
<td>320.33</td>
<td>5.06</td>
<td>228</td>
<td>23.5</td>
</tr>
<tr>
<td>Comparison participants</td>
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<td></td>
</tr>
<tr>
<td>OA13</td>
<td>10</td>
<td>234.67</td>
<td>7.05</td>
<td>135.67</td>
<td>13.5</td>
</tr>
<tr>
<td>OA20</td>
<td>7</td>
<td>185.67</td>
<td>7.168</td>
<td>274</td>
<td>53.5</td>
</tr>
<tr>
<td>OA26</td>
<td>8</td>
<td>274.33</td>
<td>5.29</td>
<td>289.67</td>
<td>55.5</td>
</tr>
<tr>
<td>OA27</td>
<td>15</td>
<td>513.33</td>
<td>5.26</td>
<td>66.33</td>
<td>0.0</td>
</tr>
</tbody>
</table>

Note. AD = Alzheimer’s disease, EXT = extinction, FI = fixed interval, FR = fixed ratio, OA = older adult without AD, RET = retention.

Table 4
Sensitivity Indices, Percentage Change, and Retention Savings

<table>
<thead>
<tr>
<th></th>
<th>FI/FR</th>
<th>EXT/FI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sensitivity*</td>
<td>Percentage Change</td>
<td>Sensitivity</td>
</tr>
<tr>
<td>Participants with AD</td>
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<tr>
<td>AD23</td>
<td>0.9706</td>
<td>−2.94</td>
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<tr>
<td>AD28</td>
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<td>—</td>
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<tr>
<td>AD30</td>
<td>1.0161</td>
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<tr>
<td>AD31</td>
<td>0.7118</td>
<td>−28.82</td>
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<tr>
<td>Comparison participants</td>
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<td></td>
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<tr>
<td>OA13</td>
<td>0.5781</td>
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</tr>
<tr>
<td>OA20</td>
<td>1.4757</td>
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</tr>
<tr>
<td>OA26</td>
<td>1.0559</td>
<td>+5.59</td>
</tr>
<tr>
<td>OA27</td>
<td>0.1292</td>
<td>−87.08</td>
</tr>
</tbody>
</table>

Note: AD = Alzheimer’s disease, EXT = extinction, FI = fixed interval, FR = fixed ratio, OA = older adult without AD.
* Sensitivity indices were calculated by dividing the mean response rate across blocks of stable responding in one condition by the mean response rates across blocks of stable responding in the condition that preceded it.
† Retention savings reflect the number of blocks to meet extinction criteria during initial button pressing session, minus the number of blocks to meet extinction criteria during the retention test.
Of the 4 participants with probable AD, 3 acquired the operant task (see Figure 1). Of these 3, 2 (AD23, AD31) demonstrated responding that was clearly sensitive to the transition from an FR to an FI schedule. Although participant AD23 did not exhibit a significant change in response rate between FR and FI conditions, her increasing response rate began to decrease immediately upon transition to the FI schedule, indicating some sensitivity to this change in contingencies. All 3 of the participants
who acquired the task were sensitive to the transition from an FI schedule to EXT. None of the participants with AD demonstrated spontaneous recovery of the responding that had been extinguished during the previous EXT condition. The responding of all 3 of the participants with AD who completed the protocol met EXT criteria more rapidly during RET than during the initial EXT condition. Only one of the 4 participants with AD, AD28, was unable to acquire the task.

Only 1 of the 4 cognitively intact participants (OA27) exhibited responding that was clearly sensitive to the transition from FR to FI schedules (see Figure 2). The responding of participants OA13 and OA20 might have been sensitive to this change in contingencies. However, in these participants' cases, schedules of reinforcement were changed when response rate was either increasing or decreasing. As a result, firm conclusions regarding the sensitivity of these participants' responding to the transition from FR to FI schedules cannot be drawn. Participant OA20's responding increased somewhat after transition from the FR to the FI schedule, although a decrease in response rate would have been a more efficient response to this change in schedules. The responding of each older comparison participant was sensitive to the change from FI to EXT schedules. During RET, all older control subjects demonstrated spontaneous recovery of responding that had been extinguished during the EXT condition of the previous session. Of these 4 participants, 2 exhibited responding that took longer to meet stability criteria during RET than during EXT.
On the basis of sensitivity indices and percentage change in response rates, participants with AD demonstrated greater sensitivity to the transition from the FI condition to EXT than did comparison participants (see Table 4). Comparison participants exhibited larger changes in response rates after transition to the FI condition than did older adults with AD.
Discussion

The present study utilized a button-pressing task to evaluate the extent to which operant conditioning can be demonstrated in older adults with and without probable AD. Findings were somewhat consistent with the expectations that the participants would learn an operant task and exhibit sensitivity to different schedules of reinforcement. Specifically, 3 of 4 older adults with mild to moderate AD acquired a novel task when reinforcement was provided according to FR schedules, and their responding was maintained on both FR and FI schedules. Two participants demonstrated responding that was sensitive to the FR-to-FI transition, and 3 demonstrated responding that met extinction criteria during EXT. The timing of the transition between FR and FI conditions precludes in-depth analysis of comparison participants’ sensitivity to this change and the drawing of between-groups comparisons concerning this transition. Older adults with AD demonstrated greater sensitivity to the FI-to-EXT transition than did their cognitively intact peers. Although participants without AD exhibited spontaneous recovery of responding during a retention test, participants with AD did not. The performances of the participants with AD, like those reported by Ankus and Quarrington (1972) and Burgess et al. (1992) provide further evidence of the possibility of operant learning among older adults with dementia. The use of the NINCDS-ADRDA criteria (McKhann et al., 1984) for inclusion in the present study enables researchers, for the first time, to make statements about the potential for operant conditioning among older adults with probable AD.

The primary implication of these findings is that clinicians should attempt to implement interventions based on operant principles with older adults with mild to moderate AD who exhibit behavior problems. Indeed, psychologists, nursing staff, and caregivers (both formal and informal) of older adults with AD should be made aware of these findings, which along with the results of previous studies could dispel—or at least qualify—commonly held beliefs regarding the inability of older adults with AD to respond to contingencies of reinforcement.

Another noteworthy finding was that older adults with mild to moderate AD discriminated between schedules of reinforcement that were highly dissimilar (i.e., FI and EXT schedules) even when the transition between them was unsignaled. In addition, results indicate that the responding of some persons with mild to moderate AD might be sensitive to finer-grained changes in contingencies (i.e., from an FR schedule to an FI schedule). These findings suggest that clinicians consider making changes in contingencies of reinforcement highly salient. One means of doing so is to implement the new contingencies to change a behavior highly discrepant from those that previously maintained that behavior. For example, if a resident in a long-term care facility is exhibiting disruptive vocalization that is being maintained on a thin FR schedule, staff might opt to increase the richness of the reinforcement schedule prior to implementing an extinction intervention. This sort of manipulation has been used repeatedly within
It is interesting that participants with AD took no longer to meet extinction criteria during RET than during the initial EXT, although two of the comparison participants (OA20, OA27) did. Although it initially might seem counterintuitive, these apparently superior performances during RET of older participants with probable AD could actually be attributed to their memory deficits. During this study’s conception, it seemed that reexposing participants (after a delay) to the last schedule of reinforcement that they experienced during their initial button-pressing session would be an effective means of investigating the impact of AD on longer-term retention of a recently learned response. This sort of memory would be relevant to the day-to-day retention of learned adaptive responses, the likes of which might be introduced in behavioral interventions with this population. However, the final schedule to which participants were exposed during the initial session was EXT. Thus, in this study, greater “retention” would be evidenced by rapid extinction of responding upon reexposure to this contingency. Although participants with AD tended to demonstrate greater retention after a delay (i.e., rapid extinction), this finding is more parsimoniously explained by reduced memory of the task itself. That is, older adults with AD may well have shown greater retention (i.e., reached EXT criteria more rapidly) than older controls because they had forgotten either how to perform the task or that button pressing had at one time been rewarded with nickels.

A related finding is that control subjects demonstrated spontaneous recovery of previously extinguished responding during RET, whereas older adults with AD did not. Reduced memory for the button-pressing task was offered above as the most parsimonious explanation for the observation that older adults with AD tended to take less time to meet extinction criteria during RET than during EXT. The absence of spontaneous recovery among these participants also could be explained by this memory deficit. A noteworthy clinical implication follows from this finding: extinction-based interventions might be more easily implemented among older adults with AD than among persons without a memory disorder.

**Limitations and Recommendations for Future Research**

One limitation of the present study was the age difference between the two groups, with comparison participants generally younger than those with AD. This discrepancy is not surprising, given the increased prevalence of AD among adults of more advanced age. However, we are unable to rule out the possibility of age as a potential confound of results. Future studies in this domain would do well to match groups on the basis of age to eliminate this potential confound.

Another limitation of the present study is that participants were, in general, taking a number of medications. We cannot readily determine the extent to which medications affected performance on psychological
measures or the operant task. In addition, all participants were taking medications to slow the progression of AD, including donepezil, galantamine, and memantine. It is not currently clear whether or to what extent such medications affect operant learning. Initial studies indicate that cholinesterase inhibitors such as tacrine and pyridostigmine bromide can affect performance on operant tasks (Ohta, Matsumoto, Shimizu, & Watanabe, 1994; Shih et al., 1991).

In the present study, we investigated sensitivity to two changes in conditions: from FR to FI schedules and from FI to EXT schedules. Future studies to investigate sensitivity to changes in schedules of reinforcement among older adults with dementia might address sensitivity to transitions among a broader range of schedules. In addition, clinicians working in long-term care settings might benefit from further research into the extent to which the behavior of older adults with AD can be maintained on thin schedules of reinforcement. Increased knowledge regarding the maintenance of behavior on thinner schedules could lead to interventions that are less demanding of staff and more likely to be implemented as designed.

Furthermore, future studies in this domain might benefit from the investigation of different tasks. The present study relied on a single button-pressing task. It could be that a different or a more familiar task (e.g., turning a light switch on and off) would produce different patterns of responding.

In the present study, we examined the behavior of 4 older adults with AD. Replications of this study are encouraged, to evaluate the reliability of the results obtained. In addition, systematic examination of schedule control with older participants with other well-defined dementias and different severities of impairment would be helpful in determining the range of populations in which interventions based on operant conditioning are appropriate. Furthermore, this task and others like it might be of some utility in the clinic. To the extent that patients’ sensitivity to schedule changes in such tasks generalizes to contingency changes in the natural environment, performance on these tasks could be a predictor of the potential utility of operant interventions.

In a related area, future studies of operant conditioning in older adults with AD might include participants with more severe degrees of cognitive impairment, as they are more likely to exhibit higher rates of disruptive behavior that requires management or modification. One limitation of the present study was its use of participants with mild to moderate AD, as measured by means of neuropsychological test performance.

Finally, given the problems with interpreting the meaning of the retention data collected in the present study, it is suggested that future studies in this domain examine retention differently. Instead of exposing participants to an extinction schedule and testing for retention of extinguished responding (i.e., a lack of responding) after a delay, researchers are encouraged to test for retention of an experimental task.
References


