Brief report

Do reaction time measures enhance diagnosis of early-stage dementia of the Alzheimer type

Martha Storandt*, Sherry Beaudreau

Department of Psychology, Washington University, Box 1125, 1 Brookings Drive, St. Louis, MO 63130, USA

Accepted 29 August 2002

Abstract

Reaction times (RT) typically are slower in demented individuals than in healthy older people, but it is unclear if this deficit is useful in diagnosing Alzheimer’s disease, particularly in its early stages. In this study we compared 131 nondemented, 73 very mildly demented, and 45 mildly demented individuals on simple, choice, and choice with distraction RT tasks. Less than half of the demented individuals could be classified correctly using the RT measures in a discriminant function analysis. In addition, the RT measures did not add significantly to correct classification achieved by a previously identified brief battery of standard neuropsychological tests including immediate prose recall, confrontation naming, and digit symbol substitution (Storandt & Hill, 1989); that battery identified 81% of the very mild group and 96% of the mild group as demented. Although substantial slowing of RT may occur in some people in the early stages of dementia, it is far from universal, whereas deficits in other cognitive functions are.

Keywords: Dementia; Reaction times; Alzheimer’s disease

Slowing is one of the hallmarks of aging. Numerous studies demonstrate age-related slowing in performance across diverse tasks, reflecting general age-associated decreases in processing speed (Salthouse & Somberg, 1982). Many studies report significant additional slowing in demented compared with healthy elders on simple reaction time (RT) tasks (e.g., Ferris, Crook, Sathananthan, & Gershon, 1976; Müller, Richter, Weisbrod, & Klingberg, 1991) or on complex RT tasks (e.g., Baddeley & Logie, 1986; Filoteo et al., 1992; Ferris et al., 1976; Gordon & Carson, 1990; Nebes & Brady, 1989). Indeed, in a widely used compendium of neuropsychological tests and assessment techniques Lezak (1995, p. 353) concluded that “simple
reaction time alone may be more sensitive to dementia than any of the usual tests in a large neuropsychological test battery."

The studies cited, however, have primarily examined moderately demented older adults, although some have included mildly demented individuals in their sample (e.g., Hofman et al., 2000; Pirozzolo, Christensen, Ogle, Hansch, & Thompson, 1981). Pate and Margolin (1994) reported their data separately for seven people with very mild and 121 with mild dementia of the Alzheimer’s type (DAT). Those with mild DAT differed significantly from normal controls with respect to both simple and choice RT. The very mild group, however, differed from the control group only in terms of choice RT.

Therefore the purpose of this study was to determine if simple or complex (choice and choice with distraction) RT tasks are useful in the differentiation of early-stage DAT from healthy aging. Storandt and Hill (1989) showed that the Logical Memory subtest of the Wechsler Memory Scale (WMS, Wechsler & Stone, 1973), the Digit Symbol subtest from the Wechsler Adult Intelligence Scale (WAIS, Wechsler, 1955), and the Boston Naming Test (Goodglass & Kaplan, 1983) provided excellent classification of nondemented and mildly demented individuals. These tests were less effective, however, in identifying very mildly demented individuals. We sought to determine if RT measures would provide better classification or if they would add importantly to the existing raw score classification algorithm.

1. Method

1.1. Participants

The community-dwelling individuals who participated in this study were enrolled in longitudinal studies of aging and dementia at the Washington University Alzheimer’s Disease Research Center. There were 131 nondemented individuals, 73 who were very mildly demented, and 45 who were mildly demented. Both demented groups had clinical diagnoses of DAT. Individuals with other potentially dementing conditions that could affect cognition (e.g., stroke, depression, drug reactions) were excluded. Demographic information for the three groups is shown in Table 1. The three groups were comparable in terms of age but differed with respect to years of education. The only significant pairwise least significant difference, however, was between the nondemented and mildly demented groups.

Informed consent was obtained from participants and their collateral sources (usually a spouse or adult child). Other data from some of the people in this sample have been reported in earlier reports from this ongoing project that has continuous enrollment since 1979. Previous data from 11 people in the nondemented group and 2 in the demented group were included in the analysis reported by Storandt and Hill (1989).

1.2. Clinical evaluation

Research-trained clinicians diagnosed and staged the severity of dementia based on a 90-min semistructured interview with the participant and a knowledgeable collateral source and a neurologic examination. The clinician was unaware of the results of previous clinical evaluations
Table 1
Means (and standard deviations) of demographic and reaction time measures for nondemented and demented groups

<table>
<thead>
<tr>
<th>Variable</th>
<th>Nondemented</th>
<th>Very mild</th>
<th>Mild</th>
<th>F(2, 246)</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
<td>131</td>
<td>73</td>
<td>45</td>
<td>0.80</td>
</tr>
<tr>
<td>Age (years)</td>
<td>77.48 (8.26)</td>
<td>78.94 (8.37)</td>
<td>78.60 (9.23)</td>
<td>3.51*</td>
</tr>
<tr>
<td>Education (years)</td>
<td>14.92 (3.04)</td>
<td>14.23 (3.03)</td>
<td>13.56 (3.51)</td>
<td>11.17**</td>
</tr>
<tr>
<td>Simple RT (ms)</td>
<td>370.01 (114.67)</td>
<td>420.82 (154.96)</td>
<td>504.47 (277.27)</td>
<td>29.53**</td>
</tr>
<tr>
<td>Choice RT (ms)</td>
<td>567.66 (90.78)</td>
<td>635.44 (174.60)</td>
<td>760.10 (243.99)</td>
<td>16.01**</td>
</tr>
<tr>
<td>Distraction RT (ms)</td>
<td>590.43 (87.16)</td>
<td>647.89 (152.12)</td>
<td>779.42 (230.83)</td>
<td>63.19**</td>
</tr>
<tr>
<td>Logical Memory</td>
<td>9.75 (3.14)</td>
<td>4.17 (2.55)</td>
<td>2.29 (2.24)</td>
<td>29.53**</td>
</tr>
<tr>
<td>Digit Symbol</td>
<td>45.73 (11.72)</td>
<td>34.76 (12.82)</td>
<td>23.19 (11.80)</td>
<td>72.61**</td>
</tr>
<tr>
<td>Boston Naming</td>
<td>55.24 (5.34)</td>
<td>46.16 (10.39)</td>
<td>37.87 (13.09)</td>
<td>72.61**</td>
</tr>
</tbody>
</table>

* P < .05.
** P < .0001.

or current performance on a psychometric battery. The diagnosis of DAT was based on a history of gradual onset and progressive cognitive impairment relative to the participant’s premorbid abilities. Diagnostic accuracy for Alzheimer’s disease as verified by postmortem examination in 207 individuals from the center is 93% (Berg et al., 1998). Determination of the severity of dementia was based on the Clinical Dementia Rating (CDR) according to published rules (Morris, 1993). It is based on the clinician’s evaluation of the participant in six areas: memory, orientation, judgment and problem solving, community affairs, home and hobbies, and personal care. A value of 0 indicates no dementia, 0.5 reflects very mild dementia, and 1, 2, and 3 represent mild, moderate, and severe dementia, respectively. Only people with CDRs of 0, 0.5, and 1 were included here.

1.3. Measures

Simple, choice, and choice with distraction RTs were obtained using Superlab for Windows (Abboud & Sugar, 1997) on laptop computers placed on the testing table. The stimulus in the simple RT condition was a 35 mm × 35 mm outline of a square that appeared in the middle of the screen following the warning phrase “Get ready,” which was also printed in the center of the screen. Participants rested a finger on a key with a square pictured on it (x for left-handed people and m for those who were right handed). They were instructed to press the key as soon as the square appeared on the screen; the key press terminated the trial. If the key was pressed before the stimulus appeared the phrase “not yet” appeared on the screen and the trial was repeated. Following six practice trials, there were four blocks of nine trials each (total = 36 trials); the intertrial interval was 500 ms. Four 1-s, three 2-s, and two 3-s preparatory intervals were randomized within blocks for each participant.

The choice RT task was similar, but there were four blocks of 18 trials each (total = 72 trials) preceded by six practice trials. The stimulus was a 22 mm × 23.5 mm X in half the trials in a block and an O with a 35 mm diameter in the other half. Depending on which stimulus appeared in the middle of the screen, participants responded by pressing the key labeled X (the x key) with a finger from the left hand or O (the m key) with a finger from the right hand.
If the person pressed the wrong key, the word “Wrong” appeared on screen, and the trial was repeated. The randomized preparatory intervals were similar to those used in the simple RT task, but there were twice as many—one set for X stimuli, one set for O stimuli. The choice RT task with distraction was identical to the choice RT task, but participants were told, “This test is the same as the last test except that you will hear a recording of a weather report during the test.” This method of distraction was patterned after that used in the Computerized Everyday Memory Battery (Larrabee & Crook, 1988). The text was an amalgam of on-line reports taken from the Weather Channel; it was recorded by a male speaker.

1.4. Procedure

Beginning in March 1999 and ending in July 2001 the three RT tasks were administered in the same order (simple, choice, choice with distraction) to all participants at the end of the standard 1.5-h psychometric battery, which was initiated in 1979 and is administered annually to the participants in this longitudinal study. Data from only the first time a person completed the RT tasks are reported here. In addition to median RTs for the simple, choice, and choice with distraction tasks, a composite score of the Wechsler Memory Scale Logical Memory subtest, Wechsler Adult Intelligence Scale Digit Symbol subtest, and Boston Naming Test scores from the psychometric battery was computed according to the raw score formula reported by Storandt and Hill (1989):

$$3.94 - 0.322 \text{ Logical Memory} - 0.031 \text{ Digit Symbol} - 0.026 \text{ Boston Naming; cut point} = 0.$$  

2. Results and discussion

Means (and standard deviations) for the three groups on the three RT tasks as well as the three measures from the psychometric battery that are used to form the composite score are shown in Table 1. A significant effect of group was obtained in one-way analyses of variance when the median RTs from each task were used as the dependent variable; partial $\eta^2 = .08$, .18, and .19 for the simple, choice, and distraction RT tasks, respectively. In each case, post hoc tests showed that each group differed significantly from each of the other two groups. The group differences in choice RT remained significant when simple RT was used as a covariate, although the partial $\eta^2$ dropped from .18 to .12. Similarly, the group differences in choice RT under the condition of distraction also remained significant when simple RT was used as a covariate (partial $\eta^2 = .12$) as well as when both simple and choice RTs were included as covariates (partial $\eta^2 = .03$). Thus responses slowed, and became more variable, with increasing dementia severity for all three tasks (simple, choice, and choice with distraction). In a study published after the present data were collected, Baddeley, Baddeley, Bucks, and Wilcock (2001) reported similar results for simple and choice RT in a sample of people with mild to moderate dementia.

Discriminant function analyses for each of the three RT tasks considered individually revealed that these measures were not effective in identifying the demented people. As shown in Table 2 the percentage of demented individuals classified as demented ranged from 34 to 43%. Including all three measures together did not improve the results. There was substantial
Table 2
Percentage of cases correctly classified by discriminant function analyses using different predictor variables

<table>
<thead>
<tr>
<th>Groups</th>
<th>Nondemented</th>
<th>Demented</th>
</tr>
</thead>
<tbody>
<tr>
<td>RT measures alone</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Simple</td>
<td>81</td>
<td>34</td>
</tr>
<tr>
<td>Choice</td>
<td>82</td>
<td>42</td>
</tr>
<tr>
<td>Distraction</td>
<td>88</td>
<td>43</td>
</tr>
<tr>
<td>Composite a</td>
<td>87</td>
<td>86</td>
</tr>
<tr>
<td>Composite a plus RT (distraction)</td>
<td>87</td>
<td>86</td>
</tr>
</tbody>
</table>

*a The composite includes prose recall, confrontation naming, and digit symbol substitution (Storandt & Hill, 1989).

correlation between simple RT and choice RT, both with and without distraction (.77 and .73, respectively) and between choice RT with and without distraction (.93). Therefore, when all three RT measures were entered in a stepwise fashion, only choice RT with distraction was retained.

Does RT enhance the classification achieved by other psychometric measures? As also shown in Table 2, the percentage (87%) of nondemented individuals classified correctly by the composite of three tests identified by Storandt and Hill (1989) was approximately the same as achieved by the RT measures (81–88%). The composite of the three psychometric measures, however, were much more effective than choice RT with distraction in identifying demented people (86% vs. 43%). As might be expected, prediction by the composite was better for the mildly demented (95%) than for the very mildly demented individuals (81%).

In summary, three easily administered, standard measures of prose recall, confrontation naming, and digit symbol substitution provided very good identification of people in the early stages of DAT. RT was not similarly effective nor did it improve the classification achieved by the psychometric measures. Of course, it should be recognized that the degree of accuracy of classification achieved here by the psychometric tests occurred in a sample that did not include people with other conditions such as depression or overmedication that could interfere with cognition and therefore make the diagnosis of dementia more difficult (e.g., Kaszniak & Christenson, 1994). Having sounded that cautionary note with regard to interpretation of the effectiveness of the psychometric composite, there is no reason to think that RT measures would be helpful in a more challenging venue given their poor performance under favorable conditions such as the ones used here. Although there is slowing of speed of response in the early stages of DAT on a group basis, it is not so profound at the level of the individual as to allow successful diagnostic classification.

Acknowledgments

Supported by National Institute on Aging grants AG 03991 and AG 05681. Diagnosis and staging of dementia was performed by the Clinical Core of the Washington University Alzheimer Disease Research Center, John C. Morris, director.
References


