Neuropsychological deficit profiles in senile dementia of the Alzheimer’s type

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Abstract

Recent studies using Wide Range Achievement Test — Revised (WRAT-R) Reading scores as estimates of premorbid abilities have demonstrated that distinct neuropsychological deficit profiles may be associated with specific cognitive disorders such as traumatic brain injury [Brain Inj. 9 (1995) 377] and lupus [Appl. Neuropsychol. 7 (2000) 96], and that these deficit scores predict both functional and financial outcomes [J. Head Trauma Rehab. 14 (1999) 220]. Although the main cognitive deficits associated with senile dementia of the Alzheimer’s type (SDAT) are well known, the relative degree of impairment in each has yet to be adequately determined. The present study calculated indices of relative decline ($z_{\text{Diff}}$) for 32 patients with probable SDAT by comparing estimates of premorbid functioning to concurrent neuropsychological test scores. The results suggest that intelligence is least declined in SDAT [Wechsler Adult Intelligence Scale — Revised (WAIS-R) FIQ, $z_{\text{Diff}} = -0.72$], followed by attention [Wechsler Memory Scale — Revised (WMS-R) Attention Index, $z_{\text{Diff}} = -1.14$], memory (WMS-R General Memory, $z_{\text{Diff}} = -2.12$; WMS-R Delay Memory, $z_{\text{Diff}} = -2.33$), speed of processing (Trails A, $z_{\text{Diff}} = -2.85$), and cognitive flexibility (Trails B, $z_{\text{Diff}} = -5.33$). Clinical and research implications are discussed. © 2002 National Academy of Neuropsychology. Published by Elsevier Science Ltd.

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1. Introduction

Senile dementia of the Alzheimer’s type (SDAT) is a common dementing disorder whose prevalence is likely to increase given the aging of the population. Because of the personal, financial, emotional, and family stressors associated with SDAT, numerous studies have attempted to identify those neuropsychological impairments most commonly associated with the disorder. If specific deficits associated with SDAT can be identified at an early stage, appropriate cognitive and behavioral compensation strategies can be developed to assist in improving patient and family adjustment.

Several longitudinal studies and review articles have identified the most common cognitive deficits associated with SDAT (Berg et al., 1990; Botwinick, Storandt, & Berg, 1986; Johnstone, 1992; Kasniak, Wilson, Fox, & Stebbins, 1986; Masur, Sliwinski, Lipton, Blau, & Crystal, 1994), with general consensus that memory is the cognitive ability most affected by the disease, with associated problems in expressive language, attention, visuospatial abilities, praxis, reasoning, and information processing (speed and complexity).

For several decades, researchers have attempted to determine if a specific profile of neuropsychological deficit can be identified (Becker, Hubb, Nebbes, Holland, & Boller, 1988; Chui, Teng, Henderson, & Moy, 1985; Crowe & Hoogenraad, 2000; Jacobs et al., 1994; Loring & Largn, 1985), although some investigators argue that this may be difficult given that different subtypes of Alzheimer’s dementia have been proposed to exist (Fisher et al., 1996; Mayeux, Stern, & Spanton, 1985; Weintraub & Mesulam, 1993). Although researchers generally agree on the most common impairments associated with Alzheimer’s, studies to date (and the studies previously cited) have not yet adequately determined the relative degree of decline from premorbid status that occurs in each cognitive domain. For example, Christensen, Hadzi-Pavlovic, and Jacomb (1991) used a meta-analysis to estimate the degree to which distinct cognitive abilities decline in SDAT. They compared mean size effects between SDAT and normal populations in various cognitive domains and reported that memory is most significantly affected in SDAT (2.78), followed by orientation (2.64), language (1.94), praxis (1.40), problem solving (1.32), and perception (1.24). Although important in demonstrating the relative degree of impairment in different neuropsychological abilities associated with SDAT, the findings are limited in their generalizability in that they are based on between-group differences evaluated in a meta-analysis. If strengths and weaknesses associated with SDAT are to be more precisely determined, then within-subject comparisons are warranted.

Ideally, tests of premorbid intelligence should be used to estimate the extent to which individuals decline in specific cognitive abilities, although premorbid testing is rarely available. An alternative approach is to compare subjects’ concurrent cognitive abilities to an estimate of premorbid intelligence, which allows for a determination of relative degree of decline in specific cognitive abilities. Several studies suggest that reading scores, and particularly the Wide Range Achievement Test — Revised (WRAT-R; Jastak & Wilkenson, 1984), are appropriate estimates of premorbid abilities (Johnstone & Wilhelm, 1996), and are superior to other estimates such as the North American Adult Reading Test (Johnstone, Callahan, Kapila, & Bouman, 1996).
Johnstone, Hexum, and Ashkanazi (1995) used a within-subject design to determine the degree of deficit in neuropsychological abilities associated with traumatic brain injury (TBI). Specifically, they compared concurrent cognitive test $z$-scores with an estimate of premorbid intelligence (i.e., WRAT-R Reading $z$-score) to yield $z$-difference scores ($z_{\text{Diff}}$) reflecting decline from estimated premorbid abilities. Their results indicated that general intelligence is least affected in TBI [Wechsler Adult Intelligence Scale — Revised (WAIS-R) FIQ, $z_{\text{Diff}} = -0.27$], followed by attention [Wechsler Memory Scale — Revised (WMS-R) Attention, $z_{\text{Diff}} = -0.31$], memory (WMS-R General and Delayed Memory, $z_{\text{Diff}} = -0.51$ to $-0.57$, respectively), speed of processing (Trails A, $z_{\text{Diff}} = -1.90$), and cognitive flexibility (Trails B, $z_{\text{Diff}} = -2.65$). Similarly, Skeel, Johnstone, Yangco, Walker, and Komatireddy (2000) conducted a profile analysis of 17 persons diagnosed with systemic lupus erythematosus (SLE), and reported a very distinct profile from TBI. Specifically, it was found that individuals with SLE have relatively few neuropsychological impairments, and in fact, demonstrated no impairments in memory: WAIS-R FIQ, $z_{\text{Diff}} = 0.12$; WMS-R Attention, $z_{\text{Diff}} = -0.41$; WMS-R General and Delayed Memory, $z_{\text{Diff}} = 0.25$ to 0.23, respectively; Trails A, $z_{\text{Diff}} = -0.40$; and Trails B, $z_{\text{Diff}} = -0.13$. The utility of such profile analysis using reading scores as estimates of premorbid intelligence has been validated in a recent study by Ivnik et al. (2000).

In addition to identifying distinct profiles of cognitive deficits that may assist in making differential diagnoses, the determination of indices of relative decline from premorbid abilities also appears to hold promise for the prediction of functional and financial outcomes. For example, Johnstone, Schopp, Harper, and Koscuilek (1999) reported that indices of relative degree of decline (i.e., $z_{\text{Diff}}$ scores) were more strongly related to vocational and financial outcomes than indices of absolute level of cognitive functioning (i.e., raw and standard scores) for persons with TBI.

The current study determined the relative degree of cognitive impairment associated with SDAT in intelligence, attention, memory (immediate and delayed), speed of processing, and cognitive flexibility. In order to estimate relative degrees of deficit, it was assumed that if someone was of a certain level of intelligence (e.g., average, low average), they would most likely also be of that level of ability for other cognitive abilities (e.g., memory, attention, speed of processing, cognitive flexibility). Using this assumption, the degree of decline could be determined for these specific cognitive abilities.

2. Method

2.1. Participants

Participants included 32 individuals who were previously included in a study evaluating the efficacy of a short form of the WAIS-R for individuals with SDAT (Schopp, Callahan, Johnstone, & Schwake, 1998). Please refer to that study for specific information regarding the sample. The 32 participants were part of an original sample of 158 outpatients who were consecutively referred to a university neuropsychology laboratory for evaluation of progressive dementia. The 32 selected for the study were diagnosed with probable SDAT based
on their physician’s diagnosis and the neuropsychological test results included in the study. All final diagnoses were based on guidelines for diagnosing probable SDAT suggested by the National Institute of Neurological and Communicative Disorders and Stroke and the Alzheimer’s Disease and Related Disorders Association (NINCDS–ADRDA; McKhann et al., 1984). Subjects were excluded if they had history of any other medical disorder associated with cognitive dysfunction (e.g., thyroid dysfunction, TBI, cerebral vascular accident, Parkinson’s disease, psychiatric disorders, diabetes, vascular disease, neuroradiological evidence of lesions, etc.) that could account for their cognitive deficits. Their average age was 71.6 years (S.D. = 8.5; range = 52–89 years), and their mean education was 12.6 years (S.D. = 3.1; range = 8–20 years). Of these, 13 were male and 19 were female; all 32 were Caucasian; and 31 were right-handed and 1 was left-handed. Patients were also excluded if they had a history of learning disability, as WRAT-R Reading scores cannot be used as estimates of premorbid abilities for this population.

2.2. Procedures

All subjects were administered comprehensive neuropsychological evaluations by trained psychometrists. The total number and type of measures varied depending on the individual and referral question, but all evaluations included the WAIS-R (Wechsler, 1981), WRAT-R Reading subtest (Jastak & Wilkenson, 1984), WMS-R (Wechsler, 1987), and Trail Making Test (Reitan, 1986).

2.3. Determining relative degree of deficit

Degree of deficit was calculated in the same manner as that reported in Johnstone et al. (1995). Specifically, level of performance in cognitive domains (i.e., intelligence, memory, attention, speed of processing, cognitive flexibility) was compared to an estimate of premorbid intelligence to determine the relative degree of decline ($z_{\text{Diff}}$):

1. The WRAT-R Reading Standard Score (SS) was used as an estimate of premorbid intelligence. Each individual WRAT-R score was subtracted from 100 (test mean) and divided by 15 (test standard deviation) to yield a $z$-score indicating the subject’s estimated premorbid level of intelligence.
2. Standard scores for the WAIS-R and WMS-R Indices, and raw scores from the Trail Making Test, were used to determine the current level of functioning in each respective cognitive area. Mayo Older Americans Normative data (MOANS) corrections were applied for participants 75 years of age and older.
3. All standard and raw scores were transformed into $z$-scores using normative data reported for normal samples. For the WAIS-R and WMS-R scores, the $z$-score was determined using a mean of 100 and standard deviation of 15 (reported in the manuals). Effects of age were automatically controlled for since the WAIS-R and WMS-R use age to calculate standard scores. For the Trail Making Test, age-related normative data reported by Mitrushima et al. (1993) was used to determine relative performance in speed of processing and cognitive flexibility. Intelligence did not need to be controlled
for, since all comparisons were intra-individual, with subjects’ own reading scores serving as an estimate of premorbid intelligence (WRAT-R Reading SS).

4. The $z$-scores of the WRAT-R were then subtracted from the cognitive ability $z$-scores $[(\text{Cognitive } z\text{-score}) - (\text{WRAT-R } z\text{-score})]$ to determine the approximate degree of decline ($z_{\text{Diff}}$) associated with SDAT for each cognitive ability. For Trails A and B, the opposite of the $z$-score was used, as lower scores on these tests indicate better performance.

To evaluate if deficits in specific abilities were statistically different from one another, an ANOVA was conducted followed by Tukey’s method for multiple comparisons to identify which deficit scores differed from one another.

3. Results

Table 1 lists the means, standard deviations, and score ranges for all variables. Table 2 lists the means, standard deviations, and score ranges for all variable $z$-scores. Table 3 lists the estimated degree of decline in standard deviations ($z_{\text{Diff}}$ score) for each cognitive ability.

### Table 1
Test means, standard deviations, and ranges for raw scores

<table>
<thead>
<tr>
<th>Test</th>
<th>$X$</th>
<th>S.D.</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>WRAT-R Reading SS</td>
<td>100.4</td>
<td>11.8</td>
<td>71–121</td>
</tr>
<tr>
<td>WAIS-R FIQ(^a)</td>
<td>89.6</td>
<td>13.3</td>
<td>66–130</td>
</tr>
<tr>
<td>WMS-R</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>General Memory Index(^a)</td>
<td>68.7</td>
<td>13.5</td>
<td>50–97</td>
</tr>
<tr>
<td>Delayed Memory Index(^a)</td>
<td>65.5</td>
<td>11.4</td>
<td>50–92</td>
</tr>
<tr>
<td>Attention Index(^a)</td>
<td>83.3</td>
<td>18.6</td>
<td>50–128</td>
</tr>
<tr>
<td>Trails A (s)</td>
<td>66.1</td>
<td>33.0</td>
<td>25–154</td>
</tr>
<tr>
<td>Trails B (s)</td>
<td>199.6</td>
<td>81.5</td>
<td>47–390</td>
</tr>
</tbody>
</table>

\(^a\) MOANS corrections applied for participants 75 and older.

Wide Range Achievement Test — Revised (WRAT-R); Wechsler Adult Intelligence Scale — Revised (WAIS-R); Wechsler Memory Scale — Revised (WMS-R); Trail Making Test Parts A and B (Trails A, Trails B).

### Table 2
Means, standard deviations, and ranges for $z$-scores

<table>
<thead>
<tr>
<th>Test</th>
<th>$X$ (z-scores)</th>
<th>S.D.</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>WRAT-R Reading SS</td>
<td>+0.03</td>
<td>0.78</td>
<td>−1.93− +1.40</td>
</tr>
<tr>
<td>WAIS-R FIQ(^a)</td>
<td>−0.69</td>
<td>0.89</td>
<td>−2.27− +2.00</td>
</tr>
<tr>
<td>WMS-R</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>General Memory Index(^a)</td>
<td>−2.09</td>
<td>0.90</td>
<td>−3.33−0.20</td>
</tr>
<tr>
<td>Delayed Memory Index(^a)</td>
<td>−2.30</td>
<td>0.76</td>
<td>−3.33−0.53</td>
</tr>
<tr>
<td>Attention Index(^a)</td>
<td>−1.11</td>
<td>1.24</td>
<td>−3.33−1.87</td>
</tr>
<tr>
<td>Trails A (s)</td>
<td>−2.82</td>
<td>3.31</td>
<td>−14.80−0.85</td>
</tr>
<tr>
<td>Trails B (s)</td>
<td>−5.30</td>
<td>3.81</td>
<td>−12.00−1.53</td>
</tr>
</tbody>
</table>
The results indicate that of the cognitive abilities assessed in this study, intelligence is least affected in SDAT (WAIS-R FIQ, $z_{\text{Diff}} = -0.72$). Attention (WMS-R Attention, $z_{\text{Diff}} = -1.14$) was less affected than memory (WMS-R General Memory, $z_{\text{Diff}} = -2.33$; WMS-R Delay Memory, $z_{\text{Diff}} = -2.33$), while speed of processing ($z_{\text{Diff}} = -2.85$) and cognitive flexibility ($z_{\text{Diff}} = -5.33$) declined the most (see Fig. 1).

An ANOVA indicated that differences among the $z_{\text{Diff}}$ scores were statistically significant ($F = 7.91; P < .0001$). Tukey’s test indicated that the $z_{\text{Diff}}$ scores for the WAIS-R FIQ, WMS-R Attention Index, WMS-R General Memory Index, and WMS-R Delay Memory Index were not significantly different from one another. However, each of these four tests were different from both Trails A and Trails B $z_{\text{Diff}}$ scores, which in turn statistically differed from one another, with the Trails B $z_{\text{Diff}}$ score being the most declined.

![Fig. 1. Neuropsychological deficits in SDAT.](image-url)
4. Discussion

The results suggest that a distinct profile of cognitive deficits occurs in SDAT, with some cognitive abilities more significantly affected than others. The results can be summarized as follows:

1. Intelligence appears to be relatively less affected than other neuropsychological abilities in the beginning stages of SDAT (WAIS-R FIQ, \( z_{\text{Diff}} = -0.72 \)), as FIQ scores were estimated to decline an average of 11 points on the WAIS-R.

2. Attention (WMS-R Attention, \( z_{\text{Diff}} = -1.14 \)) appears to be more intact than memory in SDAT, at least as measured by the WMS-R (General Memory, \( z_{\text{Diff}} = -2.12 \); Delay Memory, \( z_{\text{Diff}} = -2.33 \)). The average decline on the WMS-R Memory Indices was approximately 31 to 37 points, compared to the average decline of 17 points on the Attention Index. Of note, the ability to remember information over a delay was most compromised.

3. In contrast to the findings of Christensen et al. (1991), speed of mental processing \( (z_{\text{Diff}} = -2.85) \) and cognitive flexibility \( (z_{\text{Diff}} = -5.33) \) were the most significantly declined abilities among this sample diagnosed with SDAT. However, it should be noted that the greater degree of deficit in these abilities compared to intelligence, attention, and memory may be related to psychometric as well as clinical factors. Table 3 shows that the range of \( z \)-scores for Trails A and B is greater than for the WAIS-R and WMS-R subtests, with Trails scores positively skewed. Regardless, these results suggest that individuals who suffer from SDAT are most likely to demonstrate objective cognitive deficits on the Trail Making Test, and particularly Trails B.

These findings can be used to help educate those experiencing dementia and their families. It can be stressed that the global effects of dementia will likely only minimally interfere with overall intellectual abilities. More noticeable changes initially associated with SDAT will likely be evident in memory and information processing (speed and flexibility). Memory is likely to be globally impaired (immediate and delay processes) and more impaired than attention. In addition, an individual’s ability to think as quickly as before, and particularly their ability to process complex information, may be most significantly compromised.

4.1. Future directions

Profile analysis is likely to assist in making differential diagnoses between cognitive disorders, as discriminant analyses can statistically compare different profiles of cognitive impairment associated with distinct clinical populations (i.e., SDAT, Parkinson’s disease, Huntington’s chorea, alcohol dementia, multi-infarct dementia, TBI, lupus, etc.). Of equal importance, determination of distinct deficit profiles can better identify individual’s cognitive strengths and weaknesses, which can assist in determining treatment plans (e.g., determining appropriate interventions for the areas of greatest impairment). Further research should also focus on determining relative degree of impairment in other cognitive (e.g., abstract reasoning, word finding, visual–perceptual abilities, etc.) and behavioral domains (e.g.,
depression, irritability, impulsivity, etc.), and if profile analysis is predictive of functional and financial outcomes for disorders other than TBI. The current results and previous studies (Ivnik et al., 2000) suggest it may be beneficial for researchers to further investigate the utility of measures of both absolute functioning (i.e., raw/standard scores) and indices of relative decline from premorbid abilities.

References


