Using an Implicit Memory Task to Estimate Premorbid Memory

Robin C. Hilsabeck\textsuperscript{a,b,c,}\textsuperscript{*}, Patricia B. Sutker\textsuperscript{a}

\textsuperscript{a}Texas Tech University Health Sciences Center, 3601 4th Street, Lubbock, TX 79430, USA
\textsuperscript{b}South Texas Veterans Health Care System, San Antonio, TX 78229-4404, USA
\textsuperscript{c}University of Texas Health Sciences Center at San Antonio, 7703 Floyd Curl Drive, San Antonio, TX 78229, USA

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Abstract

Clinicians are often asked to determine if significant memory loss has occurred. Clinical judgment figures prominently in making these determinations, because there is no accepted, objective method for estimating premorbid memory. Two studies were designed to explore the utility of an implicit memory task, Anagrams Solutions, for estimating premorbid memory ability. A secondary goal was to identify predictors of immediate and delayed memory measured by the Repeatable Battery for the Assessment of Neuropsychological Status using selected intellectual (IQ) and demographic variables. Participants in both studies were administered the implicit memory task, explicit memory measures, and IQ estimate. Results revealed that Anagrams Solutions was not a useful estimate of premorbid memory and that a combination of IQ and demographic variables accounted for 24–31% of the variance in measured memory performances. Findings point to the need for caution in interpreting scores on these variables as valid estimates of premorbid memory functioning.

Keywords: Premorbid IQ; Premorbid cognitive functioning; Dementia; Brain injury; Mild cognitive impairment

Evaluating patients with degenerative brain diseases or traumatic brain injuries often requires determination of whether there has been significant cognitive decline or loss. To determine whether decline has occurred, clinicians make judgments about pre-illness cognitive abilities. The most accurate way to make these judgments is to compare pre-illness performance on tests of cognitive ability with current test performance; however, premorbid test results rarely are available. Therefore, clinicians may rely on clinical judgment to estimate the amount of decline using demographic information (e.g., education, occupation) and/or clinical presentation. The primary problem with this method is that there is considerable variation in the application of these indicator variables. For example, one clinician may associate a bachelor’s degree with an IQ of 115 and another may associate a bachelor’s degree with an IQ of 110. If a patient obtains a current IQ score of 100, the first clinician may conclude that there has been a significant decline in functioning whereas the second may not. It is difficult to determine which hypothesis is correct.

To address this problem, researchers have searched for objective methods of estimating premorbid cognitive ability, and most of this work has focused on premorbid IQ. However, in many brain diseases and injuries, IQ may not be affected significantly until relatively late in the disease course and sometimes not at all. Using estimates of premorbid IQ does not always provide a sensitive index of change, especially in mild brain injuries or early stages of neurodegenerative disease. For this reason, it may be beneficial to estimate premorbid declarative memory ability (i.e., capacity for conscious recollection of facts or events; cf. Reber, Knowlton, & Squire, 1996) in addition to premorbid IQ. From this point forward, whenever “memory” is mentioned, we are referring to declarative or explicit memory to contrast it with implicit or nondeclarative memory, which is introduced later.

In many cases, premorbid memory ability is approximated by using the current tested IQ or estimates of premorbid IQ, but the relationship of IQ to memory is not necessarily robust. In the standardization sample of the Memory Assessment Scales...
ance without conscious awareness or intentional recollection of that experience (Graf & Schacter, 1985). Although it had been
the brain disease or injury in question and (b) it would be associated strongly with memory scores in cognitively intact indi-
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relationships between IQ and memory and between demographic variables and memory are not robust. Thus, there
Appollonio, 2005; Wechsler, 2001). Thus, these attempts have not been successful probably due to the observations above
damage. Thus, implicit memory tests may prove highly significant in attempting to derive a measure of premorbid memory
functioning may be misleading.
Researchers studying premorbid IQ have achieved better predictive accuracy using a combination of demographic variables
and current test performance than using demographic variables alone (Krull, Scott, & Sherer, 1995; Schoenberg, Lange, Iverson, Chelune, Scott & Adams, 2006; Vanderploeg, Schinka, & Axelrod, 1996). This method is successful only if it is
certain that the brain disease or injury in question does not adversely affect the current test variable being used as a predictor. Because word reading skill is relatively unaffected by traumatic brain injuries and early stages of many neurodegenerative dis-
edases, researchers have attempted to predict premorbid memory by combining word reading estimates of premorbid IQ with
demographic variables (Gladjo, Heaton, Palmer, Taylor, & Jeste, 1999; Isella, Villa, Forapani, Piamarta, Russo, & Appollonio, 2005; Wechsler, 2001). Thus, these attempts have not been successful probably due to the observations above
that relationships between IQ and memory and between demographic variables and memory are not robust. Thus, there
remains a need to develop ability-specific predictors of premorbid memory for clinical use.
Extrapolating from what has been learned from efforts to predict premorbid IQ, we posited that the ideal estimate of pre-
morbid memory ability would meet the following criteria: (a) it would be a current measure of memory that is not affected by
the brain disease or injury in question and (b) it would be associated strongly with memory scores in cognitively intact indi-
viduals. The first criterion is satisfied by implicit memory tasks, which assess the influence of prior experience on task perform-
ance without conscious awareness or intentional recollection of that experience (Graf & Schacter, 1985). Although it had been
believed widely for years that if one component of memory was impaired, then all components of memory were impaired, this
belief was shattered with the discovery that persons with significant memory deficits on standard recall or recognition tests (i.e.,
explicit memory tests) performed like cognitively intact individuals on implicit memory tests (Graf, Squire, & Mandler, 1984;
Wechsler, 1997), only 22% of the variance in WMS-III Immediate and General Memory Index scores was accounted for by WTAR standard scores (p. 44). These findings raise questions about the validity of judging memory loss based on IQ.

There have been few attempts to identify other methods of estimating premorbid memory ability. One of the primary reasons
for the paucity of research in this area may have been because, until relatively recently, normative standards of memory func-
tioning in large, heterogeneous samples were unavailable (Williams, 1997). Without large normative databases, relationships
between memory functioning and individual characteristics could not be explored adequately, and predictor variables could not be
identified. Efforts to develop and norm the Wechsler Memory Scale, Revised (Wechsler, 1987) yielded one of the largest
and most representative data by which to study the relationship between memory performance and individual characteristics
(N = 316). However, only the relationship of education to memory functioning was reported in the manual (r’s ranged from .42
to .49). Williams (1992) was among the first to examine predictive relationships between memory performance and demo-
graphic variables using the normative sample of the MAS (N = 843). He found that a combination of race, gender, education,
and occupation explained only 20% of the variance in global memory ability (r = .45). These data suggest that although demog-
graphic variables are significantly related to memory performance, reliance on them as sole predictors of premorbid memory
functioning may be misleading.

Study 1

Study 1 was designed to explore the usefulness of a modified version of Anagrams Solutions for estimating premorbid
memory ability. Anagrams Solutions is an implicit memory task in which words are processed in a study phase, and
memory is cued in a test phase by asking examinees to solve single-solution anagrams (e.g., EXIT is the only solution for
anagram XITE). This implicit memory task was selected for two reasons. First, research has shown that patients with probable
Alzheimer’s disease are equally able to solve anagrams and benefit from priming as are cognitively intact individuals on this
task (Perfect, Downes, de Mornay Davies, & Wilson, 1992; Scott, Wright, Rai, Exton-Smith, & Gardiner, 1991). Unlike other
Implicit memory tasks (e.g., word fragment completion, word stem completion), this is a consistent finding across studies (Fleischman & Gabrieli, 1998; Jelicic, 1996).

Second, this implicit memory task could be modified in a manner that would allow for practical clinical use. It was surmised that clinicians would be more apt to use a task that was brief, easy to administer and score, and portable, requiring minimal specialized equipment or test materials. The latter criterion eliminated implicit memory tasks that rely on reaction time to indicate priming, because a computer is needed to measure reaction time differences at the level of milliseconds. To facilitate task administration, the Anagrams Solutions task was shortened by reducing the number of items to 20 in the study phase (number of study items usually ranges between 40 and 60) and by removing nonstudied and filler items (usually between 10 and 20 items each) in the test phase (cf. Perfect et al., 1992). The interval between study and test phase was increased from 10 to 20 min to reduce the likelihood that examinees would notice the relationship between study and test items, particularly since nonstudied and filler items were removed. Masking the relationship between study and test items was important to ensure that examinees would not use conscious recollection to aid task performance since that would change the nature of the task from implicit to explicit. Scoring was simplified by totaling the number of anagrams solved correctly rather than calculating proportion correct as is customary when nonstudied and filler items are used. It was reasoned that these modifications, while making the task more user-friendly, would not nullify the priming effects.

The primary goal of Study 1 was to replicate previous findings (Perfect et al., 1992; Scott et al., 1991), using this modified version of Anagrams Solutions. It was hypothesized that persons with memory impairment perform similarly to cognitively intact persons on the modified version of the task. A second goal of Study 1 was to test the hypothesis that implicit memory scores correlate strongly with explicit memory scores in cognitively intact persons but not in memory-impaired persons, suggesting that this task could be applied as an estimate of premorbid memory functioning.

Materials and Methods

Participants

Participants were recruited from a residential retirement community for persons ages 65 and older in a mid-sized west Texas town. This community includes independent living residences, assisted living apartments, and a traditional 120-bed convalescent and custodial care center. One floor of the convalescent and custodial care center is dedicated to individuals with Alzheimer’s disease. Twenty-seven cognitively intact persons (i.e., control group), most from independent living residences, and 20 patients diagnosed with dementia (i.e., dementia group), most from the Alzheimer’s disease program, were participants in this study. Control participants were recruited using flyers posted in the residential complexes, and participants with dementia were identified as potential volunteers by nursing staff. In the interest of maintaining patient confidentiality, nurses working with patients who had diagnoses of dementia in their medical charts approached patients and respective family members to ascertain interest in participating in a research study. When interest was indicated, nurses contacted the study coordinator with the patient name and family member, and an appointment to obtain written informed consent was made. It is unknown how many patients and/or family members identified as potential study participants indicated no interest in study participation, but the number is estimated to be very low since nursing staff were well acquainted with the residents and their families and were unlikely to approach individuals unwilling to participate.

Exclusionary criteria for control participants were current or past neurologic or psychiatric illness, history of significant head trauma (i.e., loss of consciousness >20 min or persisting neurologic sequelae), and current substance abuse or dependence as indicated by self-report. As one means of identifying individuals with an undiagnosed dementia process, control participants were excluded if they obtained a Mini-Mental Status Examination (MMSE; Folstein, Folstein, & McHugh, 1975) score more than 1.5 standard deviations below age- and education-corrected norms (Crum, Anthony, Bassett, & Folstein, 1993), or if they scored in the impaired range on the explicit memory measures employed in this study (i.e., an index score < 70). Control participants obtaining a score greater than 5 on the Geriatric Depression Scale – Short Form (GDS-SF; Lesher & Berryhill, 1994; Sheikh & Yesavage, 1986) were also excluded to reduce the possibility of depressive symptoms affecting performance on the study measures.

Exclusionary criteria for participants with dementia included active psychosis, active substance dependence, and cognitive impairment so severe to prohibit ability to participate in the study. These criteria were ruled out by nursing staff in the course of identifying potential study participants. In addition, patients obtaining MMSE scores less than 18 were excluded, because this is the cut-off score associated with moderate to severe dementia (Juva, Sulkava, Erkinjuntti, Ylikoski, Valvanne, & Tilvis, 1994). Because a related goal of the study was to detect memory loss early in the disease process, focusing on mildly affected patients was judged most appropriate. Moreover, patients with more severe levels of dementia are likely to have deficits in
domains other than memory (e.g., language) that may interfere with performance on the implicit memory task and obscure study findings.

**Measures**

*Wechsler Abbreviated Scale of Intelligence (WASI; Wechsler, 1999)*

This short form of the Wechsler Intelligence Scales is comprised of the following four subtests: information, vocabulary, block design, and matrix reasoning. Administration of these subtests provides an estimate of verbal, performance, and full scale IQs in half the time it takes to administer the entire WAIS-III. Inclusion of an IQ estimate was important for characterizing the general cognitive ability of the sample.

*Repeatable Battery for the Assessment of Neuropsychological Status (RBANS; Randolph, 1998)*

The RBANS is a screening battery for detecting neuropsychologic impairment that has been used successfully in samples of patients with dementia, as well as the unimpaired elderly (Duff, Patton, Schoenberg, Mold, Scott, & Adams, 2003; Hillary, Gontkovsky, Ledakis, Testa, Ross, & Scott, 2001; Randolph, 1998). The RBANS provides five Index scores of cognitive functioning: Language, Visuospatial/Constructional, Attention, Immediate Memory, and Delayed Memory. In this study, the Immediate and Delayed Memory Index scores served as the explicit memory measures that would be correlated with the implicit memory measure, Anagram Solutions. The Immediate Memory Index is comprised of two subtests, a list-learning task and a story-learning task. The Delayed Memory Index is comprised of four subtests, free recall of the word list, recognition memory of the word list, free recall of the story, and free recall of a previously copied figure.

*Anagrams Solutions*

This is an implicit memory task containing words that are processed in a study phase and cued in a test phase by asking examinees to solve anagrams without informing them that the solutions to the anagrams were presented previously. In the study phase, examinees were presented a list of 20 four- and five-letter words and asked to read each word aloud to check their reading level. For the test phase, examinees were provided the following instructions:

I am going to show you some words, but the letters are in the wrong order. Try to figure out each word and tell me your answer as quickly as you can. You have 10 s to figure out each word. Are you ready? Here’s the first word.

Examinees then were presented the anagrams in large print, one at a time, on 5 × 7 index cards, and the examiner recorded their responses. Solutions provided within the time frame were scored as correct (i.e., maximum score was 20). Due to an oversight, 3 of the 20 items had more than one solution, but only solutions from the reading list were scored as correct.

**Procedure**

This study was approved by the IRB at Texas Tech University Health Sciences Center (TTUHSC), and participants provided written informed consent. In patients with dementia, an appropriate family member was asked to provide written informed consent with the patient’s permission. Following completion of the consent process, participants were administered a demographic/screening questionnaire, the MMSE, and the GDS-SF. Participants meeting inclusion/exclusion criteria then were administered the above measures in the following fixed order: (a) reading list (implicit task study phase), (b) WASI, (c) Anagrams Solutions (implicit memory test phase), and (d) RBANS. All tests were administered and scored according to standardized procedures by a trained technician.

**Data Analyses**

Descriptive statistics (e.g., means, standard deviations, proportions) were used to characterize each group. Group differences in demographic variables were investigated using t-tests for interval data (i.e., age, education) and chi-square for nominal data (i.e., gender, ethnicity). Univariate and multivariate analyses of variance (ANOVA), with demographic covariates entered where appropriate, were used to examine group differences in raw scores for the MMSE, GDS-SF, and Anagrams Solutions and index scores for the WASI and RBANS. Relationships among implicit memory scores and interval data were explored using Pearson’s r, whereas relationships among implicit memory scores and nominal data were examined using Spearman’s rho. Given the exploratory nature of this project, alpha was set at .05 for all analyses.
Results

The dementia group was significantly older than the control group, with the average age of the former at 84.90 years (SD = 4.94) compared with an average age of 79.81 years (SD = 4.94) for the latter [t (45) = -3.29, p = .002]. The dementia group also consisted of a greater percentage of women, 95% versus 67% [χ² (1) = 5.51, p = .019]. There were no significant group differences in education, with both groups averaging just over 15 years [t (45) = -.253, p = .802], and all participants were Caucasian. After adjusting for age and gender, there were significant group differences in average MMSE and GDS-SF raw scores [F(1) = 23.08 and 8.55, respectively; p < .001 and .006, respectively]. Dementia participants obtained significantly lower MMSE raw scores than control participants [MMSE = 24.60 (SD = 3.30) vs. 29.04 (SD = 1.06); ES = .35] and significantly higher GDS-SF raw scores [3.85 (SD = 3.53) vs. 1.07 (SD = 1.17); ES = .17]. However, neither group obtained GDS-SF raw scores in the clinically significant range. There was a significant group difference in WASI Full Scale IQ after adjusting for gender [F(1) = 33.50, p < .001], with the dementia group scoring significantly lower than the control group [97.00 (SD = 10.35) vs. 117.52 (SD = 11.98); ES = .43]. Because WASI Full Scale IQ scores are age-corrected, age was not entered as a covariate in this analysis. Analysis of WASI Full Scale IQ using uncorrected raw scores while covarying age and gender revealed similar results. Group means and standard deviations for these sample characteristics are presented in Table 1.

On the RBANS, dementia participants performed significantly worse than controls on all indices after accounting for gender, with average index scores ranging from 59.55 on Delayed Memory to 81.35 on Language [F(5,40) = 19.11; p < .001]. By comparison, index scores of control participants ranged from 101.56 (SD = 11.13) on Language to 106.70 (SD = 14.42) on Immediate Memory. Since RBANS index scores also are age corrected, only gender was entered as a covariate. As with the WASI, results did not differ when uncorrected raw scores were analyzed using age and gender as covariates.

Dementia and control participants did not differ significantly on Anagrams Solutions after removing the effects of age and gender, and although the difference approached significance [F(1) = 3.72; p = .06], the effect size was small (ES = .08). The dementia group obtained an average score of 7.80 (SD = 4.36) on Anagrams Solutions, and the control group obtained an average score of 10.81 (SD = 4.14). Group means, standard deviations, and ESs for the RBANS indices and Anagrams Solutions raw scores are presented in Table 2.

Correlation coefficients between Anagrams Solutions scores and age, gender, education, and GDS-SF raw scores suggested no significant relationships in control or dementia participants. Moderately strong and statistically significant relationships were found between Anagrams Solutions scores and global cognitive functioning in the control group only (r = .45 and .44 for the MMSE raw score and WASI Full Scale IQ score, respectively). Correlations using raw scores rather than age-corrected WASI and RBANS index scores did not differ meaningfully and thus are not presented. Moderately strong relationships reaching statistical significance were also found between Anagrams Solutions scores and RBANS scores on Language, Attention, and Total Scale indices (i.e., r = .42, .63, and .55, respectively) in control but not dementia participants. Correlation coefficients by measure are shown in Table 3.

Discussion

Research has shown that patients with memory impairment perform similarly to cognitively intact individuals on the Anagrams Solutions implicit memory task. The primary purpose of this study was to replicate this finding using a modified version of the task designed to be more user-friendly for clinicians and easily incorporated into a neuropsychologic test battery. Results of this study support prior findings in that the dementia group performed similarly to a control group on

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Table 1. Demographic characteristics by group for Study 1

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Control (N = 27)</th>
<th>Dementia (N = 20)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)*</td>
<td>79.81 (4.94)</td>
<td>84.90 (5.61)</td>
</tr>
<tr>
<td>Education (years)</td>
<td>15.41 (2.58)</td>
<td>15.60 (2.58)</td>
</tr>
<tr>
<td>Gender (% women)*</td>
<td>67</td>
<td>95</td>
</tr>
<tr>
<td>Race (% Caucasian)</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>MMSE raw score*</td>
<td>29.04 (1.06)</td>
<td>24.60 (3.30)</td>
</tr>
<tr>
<td>WASI Full Scale IQ*</td>
<td>117.52 (11.98)</td>
<td>97.00 (10.35)</td>
</tr>
<tr>
<td>GDS-SF raw score*</td>
<td>1.07 (1.17)</td>
<td>3.85 (3.53)</td>
</tr>
</tbody>
</table>

*Significant group difference.

Notes: MMSE = Mini-Mental Status Examination; WASI = Wechsler Abbreviated Scale of Intelligence; GDS-SF = Geriatric Depression Scale – Short Form.
the modified Anagrams Solutions task after controlling for group differences in age and gender. Thus, it appears that the modifications made to the Anagrams Solutions task (i.e., reducing the number of study items, removing nonstudied and filler items, lengthening the delay between study and test, and altering the scoring procedure) did not alter its properties to the extent that priming could not occur. Priming has been shown to be a robust phenomenon, occurring in a variety of study/test conditions with varying intervals and scoring methods (Roediger & McDermott, 1993; Vaidya, Gabrieli, Keane, Monti, Gutierrez-Rivas, & Zarella, 1997). These results are consistent with previous work in which the Anagrams Solutions task was modified in various ways without losing the priming effect (Antonietti & Girotti, 1991; Jacoby & Dallas, 1981; McAndrews & Moscovitch, 1990; Perfect et al, 1992; Srinivas & Roediger, 1990).

The second hypothesis, i.e., that Anagrams Solutions performance would correlate strongly with explicit memory efforts in the control but not the dementia group, was not supported. Instead, Anagrams Solutions scores were found to correlate moderately with RBANS Language, Attention, and Total Scale Index scores. The strongest correlation was found between Anagrams Solutions and RBANS Attention. Results suggest that implicit memory as measured by the modified version of Anagrams Solutions used in this study may be measuring other cognitive functions, such as attention, in addition to memory. Since attention is theorized to be an important precursor to effective learning and recall (Cowan, 1995), it is possible that the modified Anagrams Solutions may be still be useful in estimating premorbid memory functioning.

A potential explanation for lack of the expected relationships between implicit and explicit memory task performance may lie in the composition of the groups. Participants in the dementia group were identified and referred by nursing staff, but diagnostic accuracy was not verified by psychiatric or psychological evaluation, and the presence of other disease processes that might affect cognition could not ruled out. While it is clear from RBANS index scores that they were demented as a group, there was a wide range of scores on each index (ranges ranged from 38 points on the Attention Index to 63 points on the Delayed Memory Index) and, possibly, participants with language impairment that may have affected performance on Anagrams Solutions were not excluded (i.e., RBANS Language Index scores ranged from 47 to 97). A similar problem exists with regard to the control group, because there was high variability in RBANS scores (ranges ranged from 45 points on the Language Index to 61 points on the Attention Index). Although participants scoring below 70 on either the Immediate or Delayed Memory Index were excluded, it is possible that some of the control participants were in the early

Table 2. Means and standard deviations for RBANS and Anagrams Solutions by group for Study 1

<table>
<thead>
<tr>
<th></th>
<th>Control (N = 27)</th>
<th>Dementia (N = 20)</th>
<th>Effect size</th>
</tr>
</thead>
<tbody>
<tr>
<td>RBANS Immediate Memory</td>
<td>106.70 (14.42)</td>
<td>70.85 (12.71)</td>
<td>.61</td>
</tr>
<tr>
<td>RBANS Visuospatial/Constructional</td>
<td>103.56 (13.80)</td>
<td>73.05 (14.52)</td>
<td>.49</td>
</tr>
<tr>
<td>RBANS Language</td>
<td>101.56 (11.13)</td>
<td>81.35 (12.68)</td>
<td>.41</td>
</tr>
<tr>
<td>RBANS Attention</td>
<td>103.93 (14.36)</td>
<td>78.35 (11.69)</td>
<td>.46</td>
</tr>
<tr>
<td>RBANS Delayed Memory</td>
<td>105.00 (10.38)</td>
<td>59.55 (17.94)</td>
<td>.71</td>
</tr>
<tr>
<td>RBANS Total Scale</td>
<td>105.48 (13.97)</td>
<td>65.55 (10.32)</td>
<td>.70</td>
</tr>
<tr>
<td>Anagrams Solutions</td>
<td>10.81 (4.14)</td>
<td>7.80 (4.36)</td>
<td>.08</td>
</tr>
</tbody>
</table>

Notes: RBANS = Repeatable Battery for the Assessment of Neuropsychological Status.

Table 3. Correlation coefficients for Anagrams Solutions by group for Study 1

<table>
<thead>
<tr>
<th></th>
<th>Control (N = 27)</th>
<th>p</th>
<th>Dementia (N = 20)</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>−.17</td>
<td>.39</td>
<td>−.22</td>
<td>.35</td>
</tr>
<tr>
<td>Education (years)</td>
<td>−.13</td>
<td>.51</td>
<td>.14</td>
<td>.55</td>
</tr>
<tr>
<td>Gender</td>
<td>.11</td>
<td>.60</td>
<td>.28</td>
<td>.23</td>
</tr>
<tr>
<td>MMSE raw score</td>
<td>.45</td>
<td>.02</td>
<td>.25</td>
<td>.30</td>
</tr>
<tr>
<td>WASI Full Scale raw score</td>
<td>.44</td>
<td>.02</td>
<td>.33</td>
<td>.15</td>
</tr>
<tr>
<td>GDS-SF raw score</td>
<td>.00</td>
<td>.99</td>
<td>.04</td>
<td>.88</td>
</tr>
<tr>
<td>RBANS Immediate Memory raw score</td>
<td>.28</td>
<td>.16</td>
<td>.17</td>
<td>.48</td>
</tr>
<tr>
<td>RBANS Visuospatial/Constructional raw score</td>
<td>.24</td>
<td>.24</td>
<td>.44</td>
<td>.06</td>
</tr>
<tr>
<td>RBANS Language raw score</td>
<td>.42</td>
<td>.03</td>
<td>.26</td>
<td>.26</td>
</tr>
<tr>
<td>RBANS Attention raw score</td>
<td>.63</td>
<td>&lt;.001</td>
<td>.08</td>
<td>.73</td>
</tr>
<tr>
<td>RBANS Delayed Memory raw score</td>
<td>−.03</td>
<td>.87</td>
<td>.10</td>
<td>.67</td>
</tr>
<tr>
<td>RBANS Total Scale raw score</td>
<td>.55</td>
<td>.003</td>
<td>.31</td>
<td>.18</td>
</tr>
</tbody>
</table>

Notes: Significant correlation coefficients indicated in bold. MMSE = Mini-Mental Status Examination; WASI = Wechsler Abbreviated Scale of Intelligence; GDS-SF = Geriatric Depression Scale – Short Form; RBANS = Repeatable Battery for the Assessment of Neuropsychological Status.
stages of a neurodegenerative disease process (e.g., the Visuospatial/Constructional Index score ranged from 69 to 121, and the Delayed Memory Index score ranged from 78 to 126). These limitations and the promising finding of a significant relationship between implicit memory and attention led to the design and implementation of Study 2.

Study 2

The primary purpose of Study 2 was to examine further the possible utility of the modified Anagrams Solutions task as an estimate of premorbid memory ability by employing a research design that addressed the above concerns about the sample composition of Study 1. Secondary goals were to explore further the moderately strong relationship between Anagrams Solutions and RBANS Attention scores and to identify the best set of predictors of current memory functioning in control participants. The following three hypotheses were investigated: (a) that control participants would obtain significantly higher scores than memory-impaired participants on the explicit memory tasks but not on the implicit memory task; (b) that implicit memory scores would correlate strongly with explicit memory scores and/or attention in control participants but not memory-impaired participants; and (b) that implicit memory scores would correlate more strongly with explicit memory scores than measures of IQ in control participants.

Method

Participants

Memory-impaired participants were 13 men and 18 women (N = 31) recruited from the Neuropsychology and Memory Disorders Clinics at TTUHSC. All memory-impaired participants underwent comprehensive neurologic and neuropsychologic evaluations to establish diagnoses and to rule out confounding factors such as active substance use, psychosis, and other physical illnesses that might contribute to cognitive dysfunction. In most cases, memory-impaired participants were interviewed jointly by a neuropsychiatrist (who completed separate neurology and psychiatry residencies and was board certified in both specialty areas) and a neuropsychologist and completed a 3-hr neuropsychologic test battery, an electroencephalogram, MRI of the brain, and laboratory tests to rule out acute medical causes of mental status changes. Diagnoses were determined by consensus of the neuropsychiatrist and neuropsychologist after reviewing data from all procedures, including MRI and EEG reports from appropriately trained professionals. A few of the memory-impaired participants underwent neurologic evaluations, including a diagnostic interview by a neurologist/neuropsychiatrist, MRI of the brain, and laboratory tests, and then were referred for neuropsychologic evaluation to confirm diagnoses. In these cases, a separate interview by the neuropsychologist was conducted and the same 3-hr neuropsychologic test battery was completed. Only cases in which agreement was found between neurologic and neuropsychologic diagnoses were included.

Eighteen memory-impaired participants were diagnosed with dementia of the Alzheimer’s type, 10 were diagnosed with Mild Cognitive Impairment, amnestic subtype (Petersen, 2004), and 3 were diagnosed with other types of dementia (i.e., one with vascular dementia, one with dementia with Lewy bodies, and one with dementia not otherwise specified). As in Study 1, memory-impaired participants with MMSE scores < 18 were excluded. Average age of memory-impaired participants was 74.94 years (SD = 6.92), and average education was 13.35 years (SD = 2.74). Women comprised 58% of the sample, and 94% were Caucasian (one was Hispanic). Average MMSE score was 25.70 (SD = 2.94; range 19–30), and average GDS-SF score was 2.65 (SD = 2.68; range 0–10).

To obtain a sufficiently large sample of cognitively intact persons to identify predictor variables of current memory functioning, 100 control participants (57 men and 43 women) were recruited from the community using flyers offering monetary compensation in exchange for study participation. Flyers were posted at the health science center and academic campus and asked for volunteers aged 60 years or younger who were fluent in English to participate in a study of memory. Persons aged over 60 years were excluded to lessen the likelihood than an undiagnosed neurodegenerative disease process would obscure the study findings. Other exclusion criteria were the same as in Study 1; that is, no current or past neurologic or psychiatric illness, no history of significant head trauma (i.e., loss of consciousness >20 min or persisting neurologic sequelae), and no current substance abuse or dependence as indicated by self-report. Average age of the control group was 24.68 years (SD = 8.34), and average education was 14.67 years (SD = 1.94). Women comprised 43% of the control group, 64% were Caucasian, 19% were Hispanic, and 17% were of other ethnicities.
Measures

The RBANS and Anagrams Solutions were administered as described in Study 1. Instead of the WASI, a short form of the Wechsler Adult Intelligence Scale – Third Edition (WAIS-III; Wechsler, 1997) was administered to estimate the current IQ. The short form consisted of six subtests, namely Information, Vocabulary, Similarities, Picture Completion, Block Design, and Matrix Reasoning. Administration of these six subtests allowed computation of Verbal Comprehension and Perceptual Organization index scores, as well as a four-subtest estimate of global IQ (i.e., Information, Vocabulary, Block Design, and Matrix Reasoning), which has a validity coefficient of .92 (Sattler & Ryan, 1998). Note that these are the same four subtests used to derive the WASI Full Scale IQ. Finally, the Wechsler Test of Adult Reading (WTAR; Wechsler, 2001) was administered to estimate premorbid IQ.

Procedure

This study was approved by the IRB at TTUHSC, and all participants provided written informed consent prior to study procedures. In cases where family members accompanied memory-impaired participants, family members served as witnesses to the informed consent procedure and signed the consent as such. Memory-impaired participants were administered the study measures at the beginning of a neuropsychologic evaluation for memory problems. Control participants first completed a demographic questionnaire and then were administered the study measures if inclusion/exclusion criteria were met. Control participants were paid $15 for participation regardless of whether inclusion/exclusion criteria were met. All participants were administered the study measures in the following fixed order: (a) RBANS, (b) reading list (implicit task study phase), (c) WAIS-III Short Form, (d) Anagrams Solutions (i.e., implicit memory test phase), and (e) WTAR.

Data Analyses

Group differences in demographic variables were investigated using t-tests for interval data and chi-square for nominal data. Univariate and multivariate ANOVA, with demographic covariates entered where appropriate, were utilized to examine group differences in test index scores. Relationships among implicit memory scores and interval data were explored using Pearson’s r, and relationships among implicit memory scores and nominal data were examined using Spearman’s rho. Multiple regression analyses were employed to identify predictor variables for RBANS Immediate and Delayed Memory indices in the control group. As in Study 1, alpha was set at .05 for all analyses.

Results

Participants in the memory-impaired group were significantly older \( t(129) = -30.44, p < .001 \) and had significantly less formal education \( t(129) = 2.96, p = .004 \) than control participants. The memory-impaired group was comprised of significantly more Caucasian participants than the control group \( \chi^2(1) = 10.03, p = .002 \). There were no significant group differences in gender \( \chi^2(1) = 2.16, p = .14 \). Demographic characteristics of control and memory-impaired participants are presented in Table 4.

Because RBANS and WAIS-III index scores are age-corrected, multivariate ANOVAs were conducted using education and ethnicity as covariates. Results showed that memory-impaired participants performed significantly worse than control participants on all five indices of the RBANS \( F(5,122) = 27.29; p < .001 \). RBANS Index scores of memory-impaired participants ranged from 67.53 (SD = 19.83) on Delayed Memory to 89.30 (SD = 16.34) on Visuospatial/Constructional, whereas RBANS

<table>
<thead>
<tr>
<th>Table 4. Demographic characteristics by group for Study 2</th>
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<tbody>
<tr>
<td>Control (N = 100)</td>
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<tr>
<td>Age (years)a</td>
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<tr>
<td>Education (years)a</td>
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<tr>
<td>Gender (% women)</td>
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<tr>
<td>Race (% Caucasian)a</td>
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<tr>
<td>MMSE raw score</td>
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<tr>
<td>GDS-SF raw score</td>
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Notes: MMSE = Mini-Mental Status Examination; GDS-SF = Geriatric Depression Scale – Short Form; N/A = not administered.

aSignificant group difference.
index scores of control participants ranged from 92.56 (SD = 15.46) on Language to 102.89 (SD = 14.30) on Visuospatial/Constructional. When using uncorrected RBANS raw scores and covarying age, education, and ethnicity, similar results were obtained. Significant group differences also were found on the three WAIS-III indices \([F(3,123) = 9.96, p < .001]\), with memory-impaired participants obtaining significantly lower scores than control participants on all three measures. However, when using uncorrected raw scores for WAIS-III IQ indices and entering age, education, and ethnicity as covariates, significant group differences disappeared.

Although the WTAR corrects for age, education, and ethnicity, it does not correct for ethnicities other than White, Black, and Hispanic. Therefore, univariate ANOVA correcting for ethnicity was employed and revealed a significant group difference \([F(1) = 6.56, p = .01]\), with the dementia group scoring significantly lower than the control group. Significant group differences remained when an independent samples \(t\)-test was performed without over correcting for ethnicity. Uncorrected raw scores for the WTAR were unavailable for analysis.

For Anagrams Solutions, univariate ANOVA using age, education, and ethnicity as covariates indicated no significant differences between memory-impaired and control participants \([F(1) = 2.82, p = .10]\), with the former obtaining an average score of 7.83 (SD = 4.10) and the latter an average score of 13.09 (SD = 3.28). Results did not change when WTAR scores were used as covariates in the analysis. Group means, standard deviations, and ESs for the RBANS, WAIS-III, WTAR, and Anagrams Solutions are shown in Table 5.

Correlation coefficients between Anagrams Solutions and demographic variables were weak in both groups, with \(r\) ranging from \(-.01\) (i.e., gender in the memory-impaired group) to \(.21\) (i.e., education in the control group). Low correlations (yet statistically significant in the control group) were found between Anagrams Solutions and most IQ variables, with the exception of WAIS-III Perceptual Organization in both groups (\(r\) ranged from \(-.03\) on WAIS-III Perceptual Organization in the memory-impaired group to \(.31\) on WAIS-III Verbal Comprehension in the control group). Anagrams Solutions correlated weakly with RBANS indices in the control group (\(r\) ranged from \(.06\) on Visuospatial/Construction to \(.25\) on Immediate Memory) and only slightly more strongly, overall, in the memory-impaired group (\(r\) ranged from \(.12\) on Visuospatial/Construction to \(.45\) on Total Scale). Correlation coefficients by measure are shown in Table 6. Correlations using raw scores rather than age-corrected RBANS and WAIS-III index scores were not meaningfully different and are not reported.

In contrast, moderately strong and statistically significant correlations were found between WAIS-III estimated Full Scale IQ and RBANS memory indices in both groups (\(r\) ranged from \(.36\) on Delayed Memory in the control group to \(.72\) on Immediate Memory in the memory-impaired group). Estimated premorbid IQ (i.e., WTAR scores) correlated less strongly in both groups (\(r\) ranged from \(.19\) on Delayed Memory in the control group to \(.47\) on Immediate Memory in the memory-impaired group). Table 7 displays correlation coefficients of estimated current and premorbid IQ and RBANS memory indices by group.

To identify predictors of memory functioning in the control group, demographic variables and WAIS-III subtests noted to be relatively resilient to brain injury and early dementia processes (Lezak, Howieson, Loring, Hannay, & Fischer, 2004; Schoenberg, Duff, Scott, & Adams, 2003) were entered into two regression equations, one to predict RBANS Immediate Memory and one to predict RBANS Delayed Memory. The following variables were used as predictors in both analyses: age, education, gender, ethnicity, and raw scores for WAIS-III Vocabulary, Information, Picture Completion, and Matrix Reasoning. Anagrams Solutions was not entered as a predictor because correlations with RBANS Immediate and Delayed

<table>
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<tr>
<th>Table 5. Means and standard deviations for RBANS, WAIS-III, WTAR, and Anagrams Solutions by group for Study 2</th>
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<tbody>
<tr>
<td>Control (N = 100)</td>
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</tr>
<tr>
<td>RBANS Immediate Memory*</td>
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<td>RBANS Visuospatial/Constructional*</td>
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<td>RBANS Language*</td>
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<td>RBANS Attention*</td>
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<td>RBANS Delayed Memory*</td>
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<td>RBANS Total Scale*</td>
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<tr>
<td>WAIS-III Estimated Full Scale IQ*</td>
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<td>WAIS-III Verbal Comprehension*</td>
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<td>WAIS-III Perceptual Organization*</td>
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<td>WTAR*</td>
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<tr>
<td>Anagrams Solutions</td>
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</table>

Notes: RBANS = Repeatable Battery for the Assessment of Neuropsychological Status; WAIS-III = Wechsler Adult Intelligence Scale – Third Edition; WTAR = Wechsler Test of Adult Reading.

*Significant group difference.
Index scores were low (i.e., ≤ .25). The regression equation for RBANS Immediate Memory was significant \([F(8, 91) = 5.01, p < .001]\) and accounted for 31% of the variance. Follow-up stepwise regression analysis showed that Matrix Reasoning entered into the equation first, followed by gender, and Information. These three variables accounted for 28% of the variance in RBANS Immediate Memory. The regression equation for RBANS Delayed Memory also was significant \([F(8, 91) = 3.66, p = .01]\), accounting for 24% of the variance. Follow-up stepwise regression analysis revealed that Matrix Reasoning entered into the equation first, gender second, and Vocabulary third, accounting for 20% of the total variance in RBANS Delayed Memory. To double-check the assertion that Anagrams Solutions would not add to the equation, it was entered as a predictor in both regression equations, and the results were unchanged.

**Discussion**

The primary purpose of Study 2 was to re-examine the utility of the modified Anagrams Solutions task as an estimate of premorbid memory ability by application of a research design that characterized more carefully the memory-impaired group and ensured that the control group was free of an undiagnosed neurodegenerative disease process. This was achieved by recruiting memory-impaired participants who had undergone comprehensive neurologic and neuropsychologic diagnostic evaluations and control participants aged less than 60 years. Results supported Hypothesis 1, because the control group performed significantly better on all RBANS indices than the memory-impaired group, and there were no significant group differences on Anagrams Solutions scores after correcting for demographic differences. The control group also performed significantly better than the memory-impaired group on all three WAIS-III indices and the WTAR. These group differences in current and estimated premorbid IQ may be explained by declines in intellectual functioning associated with neurodegenerative disease in the memory-impaired group and/or by the advantages of relative youth in the control group (i.e., mostly undergraduate students and employees at a local university and medical school).

Although there were no significant group differences on Anagrams Solutions performances, scores on the Anagrams Solutions task did not correlate strongly with RBANS memory index scores in the control group as predicted by
Hypothesis 2. In fact, Anagrams Solutions performances did not correlate strongly with efforts on any measures in the control group, including RBANS Attention, which was found in Study 1. Further, scores on IQ measures correlated more strongly than those on Anagrams Solutions with RBANS memory index scores, contrary to Hypothesis 3. The magnitude of correlations between IQ and memory index scores used in this study were similar to those reported previously (Williams, 1992), although correlations between an estimate of premorbid IQ (i.e., WTAR) and memory were lower than previously reported (Wechsler, 2001).

With regard to predicting memory functioning in the control group, a combination of demographic variables and WAIS-III subtest raw scores accounted for 31% and 24% of the variance in RBANS Immediate and Delayed Memory Index scores, respectively. Matrix Reasoning scores and gender were significant predictors in both equations, while Information added significantly to the prediction of Immediate Memory, and Vocabulary added significantly to the prediction of Delayed Memory. These results are consistent with well-documented gender differences in memory, with women usually showing an advantage over men, and the noted role memory plays in performance on both Vocabulary and Information subtests (Lezak et al., 2004). It is less clear why Matrix Reasoning contributed significantly to the prediction of both immediate and delay memory as there is no obvious memory component to this task. One possible explanation is that verbal-mediated executive skills underlying Matrix Reasoning performance (cf. Dugbartey, Sanchez, Rosenbaum, Mahurin, Davis, & Townes, 1999) contribute to memory performance on the RBANS. This possibility is supported by recent findings of significant relationships between RBANS Immediate and Delayed Memory indices and measures of language and executive functioning (Larson, Kirschner, Bode, Heinemann, & Goodman, 2005).

General Discussion

Two studies were conducted to explore the possible usefulness of an implicit memory task, Anagrams Solutions, as an objective measure of premorbid memory ability. Results failed to support the use of a modified version of this task for this purpose. In the first study, the dementia group performed similarly to the control group on Anagrams Solutions, but scores on this measure did not correlate significantly with those on explicit memory measures in the control group. However, a moderately strong correlation was found between Anagrams Solutions and attention, prompting further examination of the potential utility of Anagrams Solutions. In the second study, memory-impaired participants again performed similarly to control participants on Anagrams Solutions, and again this measure did not correlate strongly with explicit memory measures. Further, scores on Anagrams Solutions did not correlate significantly with attentional efforts as found in Study 1, suggesting that Anagrams Solutions is not a useful measure for predicting memory functioning.

Consistent with prior research, relationships between IQ and memory index scores in cognitively intact individuals were in the low to moderate ranges. Interestingly, relationships between an estimate of premorbid IQ, the WTAR, and memory indices were weak. Taken together, results can be seen as reason to caution clinicians against relying too heavily on IQ measures as estimates of premorbid memory abilities, especially those measures involving basic reading skills. Findings from Study 2 also revealed that a combination of IQ and demographic characteristics accounted for only a quarter to a third of the variance in memory performance, which is similar to that found by Williams (1997) using demographic variables alone. Again, findings point to the need for caution in using these variables for estimating premorbid memory functioning.

Results must be considered within the context of study limitations. Overall, participants in both studies were well educated and primarily Caucasian, although the control group in Study 2 was more ethnically diverse, with 19% Hispanic and 17% of various other ethnicities. In addition, the control group in Study 2 was comprised primarily of persons in their early 20s in spite of concerted efforts to recruit persons between ages 18 and 59. Results may not generalize to other samples, although it is encouraging that findings of the relationships between IQ and memory indices were similar to those seen in large, demographically stratified samples used for norming purposes. An additional limitation may be the explicit memory measures used in these studies. The memory indices of the RBANS may not be as sensitive as other memory measures and may have shown a ceiling effect in some participants. However, it is unlikely that this limitation can account for study findings completely, since the means and standard deviations of the control groups were near those of normative studies (i.e., mean of 100 and standard deviation of 15), suggesting adequate ranges of performances on the average.

Development of methods for estimating premorbid memory functioning is a difficult but important goal. An objective method for estimating premorbid memory ability would allow clinicians to quantify the extent of loss that has occurred, possibly leading to earlier detection and treatment of degenerative brain diseases and to identification of realistic recovery goals for rehabilitation. The work described is illustrative of critical questions to consider and methodologies that can be applied toward this end, and results provide a point of reference for future research designed to investigate relationships between premorbid memory, premorbid IQ, current cognitive functioning, and current memory in particular.
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References


