Predicting Estimates of Premorbid Memory Functioning: Validation in a Dementia Sample

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Abstract

Formulae to estimate premorbid memory functioning in a sample of cognitively intact older adults have been developed. These formulae were validated in a small sample of patients with amnestic Mild Cognitive Impairment. However, further validation is clearly needed. The current study applied these formulae to a sample of 1,059 patients referred to a dementia clinic and compared the premorbid estimates of memory functioning with current memory abilities. Large and statistically significant differences were observed in the current sample, with premorbid memory scores exceeding current memory scores. Although some cautions should be observed when using these estimates clinically, growing support for these estimates of premorbid memory abilities may aid clinicians in determining change across time in older patients.

Keywords: Predicting cognition; Learning and memory; Assessment

Introduction

Neuropsychologists are often asked to make judgments about change in cognitive functioning based on a single evaluation. This is typically accomplished by comparing an estimate of premorbid functioning to current functioning and looking for noteworthy discrepancies between the two. While multiple techniques have been developed to estimate premorbid intellect (Baade & Schoenberg, 2004; Barona, Reynolds, & Chastain, 1984; Blair & Spreen, 1989; Nelson, 1982; Nelson & O’Connell, 1978; Psychological Corporation, 2001, 2009; Schoenberg, Scott, Duff, & Adams, 2002; Vanderploeg & Schinka, 1995), few have been developed to predict premorbid memory abilities.

Most attempts to estimate premorbid memory have followed the lead of those predicting premorbid intellect; that is, using a combination of demographic variables and other current performance measures to estimate premorbid functioning. For example, Hilsabeck and Sutker (2009) estimated premorbid memory functioning with demographic variables and “hold” tests from the Wechsler Adult Intelligence Scale-III. Others (Gladsjo, Heaton, Palmer, Taylor, & Jeste, 1999; Isella et al., 2005; Schretlen, Buffington, Meyer, & Pearlson, 2005) have used similar methods to estimate premorbid memory functioning.

In a more recent study (Duff, 2010), premorbid memory was estimated in a group of cognitively healthy older adults with demographic variables (e.g., age, education, gender) and performance on an estimate of premorbid intellect (i.e., Reading subtest of the Wide Range Achievement Test-3). These premorbid memory formulae were then validated in a group of cognitively impaired older adults. The large discrepancies between premorbid and current memory scores (e.g., 16–25 standard score points) in these impaired patients were interpreted as evidence of “cognitive decline” from a single assessment. Although encouraging, further validation of these premorbid memory formulae is needed. To aid in the generalization of these findings, it would also be useful to know if other estimates of premorbid intellect (besides the Wide Range Achievement Test-3 Reading subtest) could be used to estimate premorbid memory abilities.
Therefore, the current study sought to validate the formulae developed by Duff (2010) in estimating premorbid memory abilities in a large sample of older adults referred to a dementia clinic. It was expected that significant discrepancies would be found between premorbid and current memory abilities in this sample, with estimated premorbid memory scores exceeding current memory scores. If validated, these premorbid memory formulae could be useful for clinicians who are asked to determine change in memory functioning with a single evaluation.

Methods

Participants

Data from 1,059 patients referred to a dementia clinic were used in the current study. Patients were selected if they had been administered a measure of premorbid intellect (either the Wechsler Test of Adult Reading [Psychological Corporation, 2001] or Test of Premorbid Functioning [Psychological Corporation, 2009]) and at least one of the memory measures used in Duff (2010), the Hopkins Verbal Learning Test-Revised (HVLT-R; Brandt & Benedict, 1997) or the Brief Visuospatial Memory Test-Revised (BVMT-R; Benedict, 1997), as part of their clinical neuropsychological evaluation. Their mean age was 71.8 (9.8) years and their mean education was 14.4 (2.8) years. Most were female (56.7%) and Caucasian (96.1%). Premorbid intellect was estimated to be average (age-corrected standard score: $M = 100.9 \pm 14.5$). Although not all patients received all of these measures, global measures of cognition suggested impairment consistent with dementia (e.g., Mini-Mental Status Examination [MMSE, raw score]: $M = 24.5 \pm 4.4$; Dementia Rating Scale-2 Total Score [raw score]: $M = 119.7 \pm 20.0$). However, the range of cognitive impairment tended to be milder (e.g., MMSE: 18% with <21, 23% with 21–24, 29% with 25–27, 30% with 28–30).

Procedures

Approval by the local Institutional Review Board allowed us to use these clinical data for research purposes. During a clinical visit, all participants completed a battery of neuropsychological tests that included at least one measure of premorbid intellect (either the Wechsler Test of Adult Reading or Test of Premorbid Functioning) and at least one measure of current memory (HVLT-R and/or BVMT-R). All tests were administered and scored as defined in their respective manuals by a trained psychometrist. Age-corrected standard scores ($M = 100$, $SD = 15$), converted from normative data in the test manuals, were used for all analyses.

Data Analyses

The premorbid memory formulae of Duff (2010), which are presented in Table 1, were applied to all patients in the current sample, and these yielded predicted scores for Total Recall and Delayed Recall for the HVLT-R and/or BVMT-R. Although Duff used age-corrected standard scores on the Reading subtest of the Wide Range Achievement Test-3 (when applicable) to predict premorbid memory functioning, the current study used age-corrected standard scores from either the Wechsler Test of Adult Reading or Test of Premorbid Functioning. Primary analyses compared these predicted premorbid memory scores to their respective current memory scores with four dependent $t$-tests. Effect sizes (i.e., Cohen’s $d$) were estimated from these $t$-tests. A Bonferroni-corrected alpha value of $p < .0125$ was used for these four primary comparisons. Secondary analyses examined the relationship between the discrepancies of premorbid and current memory scores (i.e., discrepancy score = current score − estimated premorbid score) and global measures of cognition to see if more severely impaired patients (i.e., worse global measures) had greater discrepancies between estimated premorbid and current memory scores. For these secondary

<table>
<thead>
<tr>
<th>Measure</th>
<th>Prediction model</th>
</tr>
</thead>
<tbody>
<tr>
<td>HVLT-R Total Recall</td>
<td>$83.927 + (\text{education} \times 1.111) + (\text{gender} \times 6.911)$</td>
</tr>
<tr>
<td>HVLT-R Delayed Recall</td>
<td>$42.449 + (\text{education} \times 1.084) + (\text{WRAT3} \times 0.407)$</td>
</tr>
<tr>
<td>BVMT-R Total Recall</td>
<td>$100.702 - (\text{age} \times 0.722) + (\text{WRAT3} \times 0.441)$</td>
</tr>
<tr>
<td>BVMT-R Delayed Recall</td>
<td>$95.173 - (\text{age} \times 0.666) + (\text{WRAT3} \times 0.508)$</td>
</tr>
</tbody>
</table>

Notes: BVMT-R = Brief Visuospatial Memory Test-Revised; HVLT-R = Hopkins Verbal Learning Test-Revised. Age is years old. Education is number of years completed. Gender is coded as male = 0 and female = 1. WRAT3 = age-corrected standard score from the Reading subtest of the Wide Range Achievement Test-3. These formulae come from Duff (2010).
analyses, the Pearson correlations and comparison of effect sizes were examined. Also for these secondary analyses, an \( \alpha \) value of \( p < .05 \) was used.

**Results**

The relevant cognitive test scores for the current sample are provided in Table 2. Premorbid estimates of memory functioning, based on Duff (2010), are also presented in Table 2.

For the primary analyses, statistically significant differences were found between the premorbid and current memory scores on the HVLT-R Total Recall, \( t(1026) = -46.0, p < .001, d = 1.97 \), with the premorbid score being larger than the current score. On the HVLT-R Delayed Recall, the premorbid scores were also significantly larger than the current memory scores—\( t(1024) = -46.8, p < .001, d = 1.94 \). This same pattern was also observed on the BVMT-R—Total Recall: \( t(887) = -47.5, p < .001, d = 1.96 \); Delayed Recall: \( t(880) = -49.2, p < .001, d = 2.03 \). Across all four measures, premorbid memory estimates were 25–31 points higher than current memory scores in these patients.

In the secondary analyses, discrepancies between the four premorbid memory estimates and their respective current memory scores were significantly correlated (\( p < .05 \)) with the MMSE. These discrepancies were also significantly correlated (\( p < .05 \)) with the Total score on the Dementia Rating Scale-2. These correlations are presented in Table 3. Additionally, there were statistically significant differences between the premorbid and current memory scores for all memory measures across all subgroups of cognitive impairment (Table 2)—MMSE < 21: HVLT-R Total Recall \( t(145) = -44.2, p < .001, d = 5.28 \), HVLT-R Delayed Recall \( t(144) = -42.0, p < .001, d = 4.83 \), BVMT-R Total Recall \( t(88) = -29.5, p < .001, d = 4.56 \), BVMT-R Delayed Recall \( t(87) = -31.9, p < .001, d = 4.99 \); MMSE = 21–24: HVLT-R Total Recall \( t(189) = -33.5, p < .001, d = 3.35 \), HVLT-R Delayed Recall \( t(188) = -36.9, p < .001, d = 3.60 \), BVMT-R Total Recall \( t(152) = -26.7, p < .001, d = 3.08 \), BVMT-R Delayed Recall \( t(148) = -38.2, p < .001, d = 4.41 \); MMSE = 25–27: HVLT-R Total Recall \( t(243) = -22.4, p < .001, d = 2.02 \), HVLT-R Delayed Recall \( t(243) = -20.3, p < .001, d = 1.88 \), BVMT-R Total Recall \( t(222) = -25.8, p < .001, d = 2.50 \), BVMT-R Delayed Recall \( t(221) = -28.9, p < .001, d = 2.70 \); MMSE = 28–30: HVLT-R Total Recall \( t(233) = -10.4, p < .001, d = 0.92 \), HVLT-R Delayed Recall \( t(233) = -11.2, p < .001, d = 1.00 \), BVMT-R Total Recall \( t(236) = -15.6, p < .001, d = 1.32 \), BVMT-R Delayed Recall \( t(235) = -15.2, p < .001, d = 1.28 \).

**Table 2.** Descriptive information on the entire sample and cognitive subgroups

<table>
<thead>
<tr>
<th>Measure</th>
<th>Entire sample</th>
<th>MMSE &lt; 21</th>
<th>MMSE 21–24</th>
<th>MMSE 25–27</th>
<th>MMSE 28–30</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>( n = 1,059 )*</td>
<td>( n = 150 )</td>
<td>( n = 194 )</td>
<td>( n = 247 )</td>
<td>( n = 248 )</td>
</tr>
<tr>
<td>Premorbid intellect</td>
<td>100.9 (14.5)</td>
<td>90.5 (16.8)</td>
<td>99.0 (13.1)</td>
<td>102.0 (12.8)</td>
<td>106.3 (12.7)</td>
</tr>
<tr>
<td>HVLT-R Total Recall</td>
<td>77.3 (18.7)</td>
<td>61.5 (10.5)</td>
<td>70.1 (13.7)</td>
<td>80.4 (16.0)</td>
<td>91.8 (19.2)</td>
</tr>
<tr>
<td>HVLT-R Delayed Recall</td>
<td>69.8 (19.9)</td>
<td>56.7 (6.7)</td>
<td>61.9 (12.2)</td>
<td>72.5 (19.2)</td>
<td>85.0 (22.6)</td>
</tr>
<tr>
<td>BVMT-R Total Recall</td>
<td>68.5 (16.1)</td>
<td>56.7 (4.2)</td>
<td>61.8 (10.3)</td>
<td>67.4 (13.1)</td>
<td>80.0 (18.6)</td>
</tr>
<tr>
<td>BVMT-R Delayed Recall</td>
<td>68.2 (19.6)</td>
<td>55.5 (5.1)</td>
<td>58.2 (8.3)</td>
<td>66.6 (15.4)</td>
<td>81.7 (23.5)</td>
</tr>
<tr>
<td>Predicted Premorbid HVLT-R Total Recall</td>
<td>103.8 (3.7)</td>
<td>102.9 (3.7)</td>
<td>103.6 (3.7)</td>
<td>103.8 (3.8)</td>
<td>104.5 (3.8)</td>
</tr>
<tr>
<td>Predicted Premorbid HVLT-R Delayed Recall</td>
<td>99.1 (7.8)</td>
<td>94.1 (8.7)</td>
<td>98.0 (7.3)</td>
<td>99.5 (6.9)</td>
<td>101.8 (7.3)</td>
</tr>
<tr>
<td>Predicted Premorbid BVMT-R Total Recall</td>
<td>94.2 (9.3)</td>
<td>87.1 (8.5)</td>
<td>90.7 (8.5)</td>
<td>94.3 (7.8)</td>
<td>99.1 (8.7)</td>
</tr>
<tr>
<td>Predicted Premorbid BVMT-R Delayed Recall</td>
<td>99.5 (9.5)</td>
<td>91.8 (9.0)</td>
<td>96.0 (8.9)</td>
<td>99.6 (8.0)</td>
<td>104.4 (8.9)</td>
</tr>
</tbody>
</table>

**Notes:** All scores are age-corrected standard scores based on normative data in the test manuals (except the MMSE, which is raw score). Premorbid intellect is either from Wechsler Test of Adult Reading or Test of Premorbid Functioning. MMSE = Mini-Mental Status Examination; HVLT-R = Hopkins Verbal Learning Test-Revised; BVMT-R = Brief Visuospatial Memory Test-Revised.

*Two hundred and twenty participants did not have MMSE scores, which reflects the discrepancy between the entire sample and the sum of the MMSE subgroups.

**Table 3.** Correlations between the discrepancies of premorbid and current memory scores and global measures of cognition

<table>
<thead>
<tr>
<th>Discrepancy score</th>
<th>MMSE</th>
<th>DRS-2 Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>HVLT-R Total Recall</td>
<td>( r = .55, p &lt; .001, n = 814 )</td>
<td>( r = .51, p &lt; .001, n = 710 )</td>
</tr>
<tr>
<td>HVLT-R Delayed Recall</td>
<td>( r = .37, p &lt; .001, n = 812 )</td>
<td>( r = .30, p &lt; .001, n = 708 )</td>
</tr>
<tr>
<td>BVMT-R Total Recall</td>
<td>( r = .25, p &lt; .001, n = 702 )</td>
<td>( r = .22, p &lt; .001, n = 580 )</td>
</tr>
<tr>
<td>BVMT-R Delayed Recall</td>
<td>( r = .27, p &lt; .001, n = 695 )</td>
<td>( r = .23, p &lt; .001, n = 575 )</td>
</tr>
</tbody>
</table>

**Notes:** Discrepancy score = current score − estimated premorbid score. HVLT-R = Hopkins Verbal Learning Test-Revised; BVMT-R = Brief Visuospatial Memory Test-Revised; MMSE = Mini-Mental Status Examination; DRS-2 = Dementia Rating Scale-2 Total Score.
Discussion

Whereas neuropsychologists have multiple options for predicting premorbid intellect, estimates of premorbid memory functioning have been lacking. Building on the limited work in this area (Gladisjo et al., 1999; Hilsabeck & Sutker, 2009; Isella et al., 2005; Schretlen et al., 2005; Williams, 1997), Duff (2010) developed prediction formulae to estimate premorbid scores on verbal and visual learning and memory measures in cognitively intact elders. These formulae, which used demographic variables and an estimate of premorbid intelligence, were then validated in a small sample of patients with amnestic Mild Cognitive Impairment. The current study sought to further validate these formulae in a large sample of patients referred to a dementia clinic.

When these formulae were applied to the current sample of patients from a dementia clinic, premorbid estimates of memory were significantly larger than current memory scores. Across the four measures of learning and delayed recall, current scores were 25–31 standard score points below premorbid estimates, which suggests a “decline” of ~2 SD. These discrepancies between premorbid and current memory scores were comparable with those reported between the Test of Premorbid Functioning and Wechsler Memory Scale-IV in patients with probable Alzheimer’s disease (Psychological Corporation, 2009).

In secondary analyses, it is also notable that differences between current and premorbid memory (e.g., current HVLT-R Delayed Recall – premorbid HVLT-R Delayed Recall) were significantly correlated with global cognition (e.g., MMSE, Dementia Rating Scale-2 Total Score). Admittedly, these correlations tended to be small (e.g., r’s = .22–.55, all p’s < .001), but they all indicated that more impaired global cognition was suggestive of greater discrepancies between premorbid and current memory functioning. The sizable differences between premorbid and current memory performances can be used by clinicians as evidence of memory decline across time, even when only a single evaluation has been completed. Not surprisingly, the differences between premorbid and current memory scores were larger than those reported in Duff’s (2010) impaired sample (i.e., 16–25 standard score points), as many of the current patients are likely demented, whereas Duff’s sample had milder impairments. This was also observed in the secondary analyses that divided the current sample by dementia severity (i.e., MMSE levels). More impaired patients (e.g., MMSE ≤ 24) showed larger discrepancies between current and premorbid memory scores, as indicated by larger effect sizes, than less impaired patients (e.g., MMSE ≥ 25).

Another observation that deserves mention is that estimated premorbid abilities, either memory scores or intellect, appear to be affected by the current level of cognitive impairment. For example, in Table 2, as individuals current cognitive impairment increased (as indicated by lower MMSE scores), then their estimated premorbid abilities tended to be lower. This observation raises some cautions for those who utilize these prediction formulae because it suggests that these “premorbid” estimates are not entirely assessing premorbid abilities, but some current abilities. Others have made similar observations when estimating premorbid abilities in patients with traumatic brain injuries (Axelrod, Vanderploeg, & Rawlings, 1999). Ideally, premorbid estimates should not be “moving targets,” but stable estimates unaffected by the current level of impairment. Obviously, additional work is needed to stabilize premorbid estimates.

The current study lends validity to these prediction formulae, but it also extends the work in this area. Whereas Duff (2010) used the Reading subtest of the Wide Range Achievement Test-3 as an estimate of premorbid intellect, the current study utilized two different versions of Wechsler reading tests (Wechsler Test of Adult Reading or Test of Premorbid Functioning). Although the current study was not designed to directly compare these two different measures of premorbid intellect, the current results do seem to suggest that other measures of premorbid intellect can be used to estimate premorbid memory, as long as they are kept on a common metric (e.g., age-corrected standard scores). Future studies might further generalize these findings by examining if other methods of estimating premorbid intellect (e.g., solely demographic predictions, academic records) can also be applied to these formulae. Future studies might also compare these estimated methods of assessing change (e.g., discrepancies between estimated premorbid and current scores) with more concrete methods of assessing change (e.g., Reliable Change Index, standardized regression-based formula).

Despite these encouraging results, the current study has some notable limitations. First, the premorbid memory formulae were developed on a relatively homogeneous group (e.g., older, relatively highly educated, predominantly female, exclusively Caucasian group). The current sample was comparable with the development sample. The accuracy of these prediction formulae in more diverse groups (e.g., younger, ethnically diverse) is unknown and needs further investigation. Similarly, the accuracy of these premorbid formulae in other clinical samples (e.g., traumatic brain injury) is unknown and needs to be examined and validated before they can be used clinically. Second, the current study, like its predecessor, only examined two measures of learning and memory, and specific formulae are needed for other memory tests. Third, although all patients in the current sample were referred to a dementia clinic, the final diagnostic status (e.g., Alzheimer’s disease, frontotemporal dementia, Mild Cognitive Impairment) was not considered. However, global measures of cognition seem to indicate that some type of dementia was common in this group. Fourth, neither the current study nor its predecessor considered the influence of effort or psychiatric status in the estimation of premorbid memory functioning. These variables may dramatically alter discrepancies...
between premorbid and current memory functioning. Finally, the normative data on both memory measures was insufficient to accurately determine the effects of aging on our oldest subjects. For example, even though \( \sim 18\% \) of our sample was \( > 79 \) years old, the normative data from the BVMT-R’s manual only goes to 79 years old. This could underestimate aging effects on our premorbid and current memory scores. However, when only those subjects over the age 79 were examined, the four primary analyses remained statistically significant, with premorbid estimates being significantly larger than current memory scores by between 22 and 34 standard score points.

Regardless of these limitations, the current results support the use of estimates of premorbid memory functioning as a method of assessing change with a single assessment. As alluded to earlier, future studies might further examine the clinical applicability of these premorbid memory estimates in more diverse samples, both demographically (e.g., younger, ethnically) and pathologically (e.g., traumatic brain injury, stroke, psychiatric). Future studies might also develop and validate these discrepancy scores for other measures of learning and memory. Further validation could also be determined in non-clinical geriatric samples, which might allow one to examine other potential modifiers of these prediction estimates (e.g., depression, medical comorbidities).

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**Conflict of Interest**

None declared.

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**References**


