Published in final edited form as:

Appl Neuropsychol. 2010 October ; 17(4): 278–282. doi:10.1080/09084282.2010.525113.

Predicting premorbid memory functioning in older adults

Kevin Duff

University of Utah Department of Neurology

Abstract

Assessing cognitive change during a single visit requires the comparison of estimated premorbid abilities and current neuropsychological functioning. Although premorbid intellect has been widely examined, estimating premorbid memory abilities has received less attention. The current study used demographic variables and an estimate of premorbid intellect to predict premorbid memory abilities in a sample of 95 community-dwelling, cognitively intact older adults. These prediction formulae were then applied to a sample of 74 individuals with amnesic Mild Cognitive Impairment to look for discrepancies between premorbid and current memory abilities. Despite minimal differences between premorbid and current memory abilities in the intact sample, large and statistically significant differences were observed in the impaired sample. Although validation in larger samples is needed, the current estimates of premorbid memory abilities may aid clinicians in determining change across time.

Keywords

Predicting cognition; learning and memory; assessment

Introduction

Assessing cognitive change across time is an important contribution of neuropsychology. Ideally, two or more neuropsychological evaluations will be used to make this determination. Clinicians, however, are often asked to make this judgment based on a single evaluation by inferring cognitive decline based on a discrepancy between current neuropsychological functioning and estimates of premorbid abilities (Babcock, 1930; Lezak, Howieson, & Loring, 2004; McFie, 1975; Wechsler, 1958).

Multiple techniques have been developed to estimate premorbid general cognitive functioning, and these include: (a) algorithms using a variety of demographic variables (Barona, Reynolds, & Chastain, 1984; Psychological Corporation, 2001; Reynolds & Gutkin, 1979; Schoenberg, Lange, Brickell, & Saklofske, 2007; Vanderploeg, Schinka, Baum, Tremont, & Mittenberg, 1998), (b) current ability, which includes “hold” subtests from the Wechsler Intelligence scales (Vanderploeg & Schinka, 1995) and single word reading tests (Blair & Spreen, 1989; Nelson, 1982; Nelson & O'Connell, 1978), (c) current ability combined with demographic variables (J.R. Crawford, Nelson, Blackmore, Cochrane, & Allan, 1990; Krull, Scott, & Sherer, 1995; Lange, Schoenberg, Chelune, Scott, & Adams, 2005; Schoenberg, Scott, Duff, & Adams, 2002; Vanderploeg & Schinka, 1995), and (d) academic achievement scores (Baade & Schoenberg, 2004). Each of these different techniques has its own strengths and weaknesses in certain situations and with certain

patient samples (Larrabee, Lengen, & Levin, 1985; Patterson, Graham, & Hodges, 1984), and no one method of estimating premorbid abilities appears to be the “gold standard” at this time (Powell, Brossart, & Reynolds, 2003; Schoenberg, Scott, Ruwe, Patton, & Adams, 2004).

Up to this point, most estimates of premorbid abilities have focused on pre-injury/pre-illness intellectual abilities, and little work has been devoted to predicting premorbid memory abilities. In his review of this area, Williams (1997) noted that large discrepancies (e.g., 23 standard score points) are needed between premorbid and current memory scores to infer “change” if only psychometric properties of the tests are used (e.g., reliability of premorbid estimate, reliability of memory test, standard deviation of memory test). However, he noted that using demographic variables and other performance measures may improve the prediction of prior memory abilities. In this vein, Hilsabeck and Sutker (2009) tried to predict premorbid memory functioning in older adults with demographic variables and cognitive measures. Using multiple regression analyses, it was observed that gender and “hold” tests from the Wechsler Adult Intelligence Scale – III could be used to predict premorbid memory abilities. Others (Gladsjo, Heaton, Palmer, Taylor, & Jeste, 1999; Isella et al., 2005; Schretlen, Buffington, Meyer, & Pearlson, 2005) have also found relationships between demographic variables, premorbid intellect estimates, and memory functioning, but the results have been mixed.

The current study sought to use demographic variables and an estimate of premorbid intellect to predict premorbid memory abilities in a sample community-dwelling, cognitively intact older adults. These prediction formulae were then applied to a sample of individuals with amnesic Mild Cognitive Impairment to look for discrepancies between premorbid and current memory abilities. It was expected that some combination of demographic variables and premorbid intellect scores would predict current memory scores in the healthy sample. It was also expected that significant discrepancies would be found between premorbid and current memory abilities in the impaired sample.

Methods

Participants

One hundred sixty-nine community-dwelling older adults participated in the current study, and a subset of these participants have been previously described (Duff et al., 2008). Briefly, these individuals were recruited from senior centers and independent living facilities to prospectively study practice effects in older adults. Their mean age was 78.7 (7.7) years (range = 65 – 96) and their mean education was 15.4 (2.5) years (range = 8 – 20). Most were female (81.1%) and all were Caucasian. Premorbid intellect at baseline was average (Wide Range Achievement Test – 3rd edition [WRAT-3] Reading subtest: $M=107.8$ [6.2], range = 81 – 118). Depression was minimal (Geriatric Depression Scale: $M=4.1$ [3.4]). Using results from a baseline evaluation (described below), these individuals were classified as either cognitively normal ($n = 95$) or amnesic Mild Cognitive Impairment ($n = 74$) according to existing criteria (Petersen et al., 1999). To be classified as amnesic MCI, all participants had to complain of memory problems (i.e., self-reported as yes/no during an interview). These participants had to have objective memory deficits (i.e., age-corrected scores at or below the 7th percentile on two of the delayed recall measures [HVLT-R, BVMT-R] relative to a premorbid intellectual estimate [WRAT-3 Reading]). The 7th percentile is 1.5 standard deviations below the mean, which is a typical demarcation point for cognitive deficits in MCI. Cognition was, otherwise, generally intact (i.e., non-memory age-corrected scores above the 7th percentile) and no functional impairments (e.g., assistance needed with managing money, taking medications, driving) could be reported. To be classified as

“cognitively intact,” all objective memory and non-memory performances were at least above the 7th percentile. All data was reviewed by a neuropsychologist (KD).

Procedures

All participants provided informed consent prior to participation, and all procedures were approved by the local Institutional Review Board. During a baseline visit, all participants completed a battery of neuropsychological tests that included the following: WRAT-3 Reading subtest, Brief Visuospatial Memory Test – Revised (BVM-T-R), Hopkins Verbal Learning Test – Revised (HVLT-R), Trail Making Test Parts A and B (TMT-A and TMT-B), Symbol Digit Modalities Test (SDMT), Controlled Oral Word Association Test (COWAT), and Animal fluency. All tests were administered and scored as defined in their respective manuals by a trained research assistant.

Data Analyses

In only the cognitively normal sample, four separate stepwise linear regression models were used to predict current memory functioning (1. BVM-T-R Total Recall, 2. BVM-T-R Delayed Recall, 3. HVLT-R Total Recall, 4. HVLT-R Delayed Recall) from demographic variables (age, education, gender) and an estimate of premorbid intellect (WRAT-3 Reading). The results of these four regression models were then applied to the entire sample to generate estimates of premorbid memory functioning in all participants. Although the actual test of these formulas would be in the amnesic MCI sample (i.e., premorbid estimate of memory being significantly higher than current memory), we also wanted to examine the difference between premorbid and current memory in the intact elders as a validity check (i.e., premorbid and current memory should be comparable). Repeated measures ANOVA was used, with time (i.e., premorbid memory vs. current memory) as the within-subjects variable and group (i.e., intact vs. MCI) as the between-subjects variable. Most importantly, this method would allow us to examine the interaction of time and group to see if the MCI group demonstrated “decline” across time, whereas the intact group demonstrated “no change.” Age-corrected standard scores were used for the memory and intellect measures. Due to the multiple statistical analyses, an alpha value of $p < 0.01$ was used throughout.

Results

The relevant cognitive test scores for the two samples are provided in Table 1.

In the cognitively normal sample, age and WRAT-3 Reading significantly predicted the BVM-T-R Total Recall score ($F[2,92]=8.65$, $p < 0.001$, $R^2=0.16$). The Delayed Recall score of the BVM-T-R was also significantly predicted by age and WRAT-3 Reading ($F[2,92]=9.14$, $p < 0.001$, $R^2=0.17$). For the HVLT-R Total Recall in the cognitively normal subjects, education and gender were the significant predictors ($F[2,92]=4.47$, $p < 0.01$, $R^2=0.09$). Education and WRAT-3 Reading significantly predicted HVLT-R Delayed Recall in this sample ($F[2,92]=6.98$, $p < 0.001$, $R^2=0.13$). Using the results of these initial four regression models, premorbid memory estimates were calculated for all participants using the formulae in Table 2.

Premorbid memory estimates, based on the formulae in Table 2, are provided in Table 1 for each group. Although the repeated measures ANOVA for all four memory measures was significant for both main effects (Time: all p 's < 0.001 ; Group: all p 's < 0.001), the primary comparison of interest was the interaction of Time and Group. For the BVM-T-R Total Recall, the interaction of Time by Group was statistically significant ($F[1,167]=56.41$, $p < 0.001$, partial eta squared=0.25), as was the interaction for the Delayed Recall trial from this same measure ($F[1,167]=123.82$, $p < 0.001$, partial eta squared=0.43). This same pattern

was also observed on the HVLt-R (Total Recall: $F[1,166]=71.34$, $p<0.001$, partial eta squared=0.30; Delayed Recall: $F[1,166]=149.10$, $p<0.001$, partial eta squared=0.47). In all cases, premorbid memory estimates were 16 – 25 points higher than current memory scores in the individuals with MCI (i.e., “decline across time”), whereas all premorbid and current memory scores were comparable in the intact elders (i.e., “no change across time”).

Discussion

Whereas neuropsychologists have multiple options for predicting premorbid intellect, estimates of premorbid memory functioning have been more elusive for the field. The current study sought to predict premorbid memory abilities with demographic variables and premorbid intellect in a sample of cognitively intact older adults, and then apply those prediction formulae to a sample of cognitively impaired older adults. Consistent with the limited research in this area (Gladsjo et al., 1999; Hilsabeck & Sutker, 2009; Isella et al., 2005; Schretlen et al., 2005; Williams, 1997), current scores on verbal and visual learning and memory measures in cognitively intact elders were predicted by demographic variables and an estimate of premorbid intellect. Interestingly, the estimate of premorbid intelligence (WRAT-3 Reading) significantly contributed to three of the models, as there has been considerable debate within neuropsychology as to how much intelligence and other cognitive abilities should correlate (Dodrill, 1997; Tremont, Hoffman, Scott, & Adams, 1998). Demographic variables also contributed to some of the models (age in 2 models, education in 2 models, gender in 1 model), which is also consistent with past research. Admittedly, the amount of variance accounted for in these prediction models is low (e.g., 9 – 17%), and future studies should attempt to include additional variables that might improve the accuracy of these predictions.

Although other studies have attempted to develop premorbid memory estimates in healthy samples, few have attempted to validate them. In the current study, we compared premorbid memory estimates to current memory functioning in two samples: cognitively intact elders and individuals classified as amnesic MCI. In the cognitively intact group, minimal differences were found between premorbid and current memory scores (<1 standard score point). This finding, however, was not surprising, as these individuals were used to develop the prediction formulae. More informative was that large and statistically significant differences were observed between premorbid memory estimates and current memory scores in the MCI sample. On the learning trials of the BVMT-R and HVLt-R, premorbid memory estimates averaged 16 standard score points higher than current memory scores. For the delayed recall trials of these two measures, premorbid memory estimates were nearly 25 standard score points higher than actual memory scores. With this information, neuropsychologists might be able to better determine “decline” in memory from a single assessment. Future research, however, is needed to determine if the discrepancies between premorbid and current memory scores improves clinical accuracy above and beyond the current memory scores (Lange & Chelune, 2007).

The utility of regression-based models in neuropsychology is not new. These models have routinely been used to predict follow-up scores based on baseline scores, and then assess change across time by comparing actual follow-up scores to predicted follow-up scores (Attix et al., 2009; Duff et al., 2005; McSweeney, Naugle, Chelune, & Luders, 1993; Sawrie, Marson, Boothe, & Harrell, 1999). In these models, neuropsychologists are predicting future performance. Regression-based models, however, can also be used to predict past performance. A number of the techniques for estimating premorbid intellect utilize regression-based formulae (e.g., Barona, North America Adult Reading Test, Wechsler Test of Adult Reading). Few have utilized this methodology to predict other premorbid cognitive abilities. In two notable examples, Crawford and colleagues (J. R. Crawford, Moore, &

Cameron, 1992; J.R. Crawford, Obonsawin, & Allan, 1998) used a premorbid estimate of intelligence to predict premorbid functioning on the Paced Auditory Serial Addition Test and Controlled Oral Word Association Test. These premorbid estimates can then be compared to current cognitive scores to assess change across time with only a single assessment point. Since single assessments are much more probable than repeat assessments, the value of developing additional estimates of premorbid functioning (e.g., memory, attention, executive functioning) in neuropsychology is high.

Despite the promise of regression-based models in neuropsychology, the current study has some notable limitations, which raises caution about the broad applicability of its findings. First, the cognitively intact sample, on which the premorbid memory formulae were developed, is a relatively homogeneous group. Although there was some variation in age and education, they were an older, relatively highly educated, predominantly female, and exclusively Caucasian group. The accuracy of these prediction formulae will likely be lower in individuals that significantly differ from this development sample. Second, the current study only examined two measures of learning and memory, and specific formulae are needed for other memory tests. Third, as noted earlier, the variance accounted for in the current formulae was low, and additional demographic variables (e.g., occupation, significant medical events) or cognitive scores (e.g., Matrix Reasoning (Hilsabeck & Sutker, 2009)) might notably improve the prediction of premorbid memory. Regardless of these limitations, the current results support the search for additional estimates of premorbid memory functioning, as well as their validation in healthy and impaired samples.

Acknowledgments

The project described was supported research grants (R03 AG025850-01; K23 AG028417-01A2) from the National Institutes On Aging. The content is solely the responsibility of the authors and does not necessarily represent the official views of the National Institute On Aging or the National Institutes of Health.

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Table 1

Descriptive information on the samples

Measure	MCI	Cognitively Normal
WRAT-3 Reading	108.9 (5.4)	106.9 (6.7)
BVMT-R Total Recall	73.5 (13.6)	92.6 (16.0)
BVMT-R Delayed Recall	71.3 (16.1)	98.6 (15.3)
HVLT-R Total Recall	89.8 (13.8)	106.8 (12.5)
HVLT-R Delayed Recall	78.4 (15.4)	102.7 (12.9)
Predicted Premorbid BVMT-R Total Recall	89.8 (5.0)	92.7 (6.3)
Predicted Premorbid BVMT-R Delayed Recall	96.2 (4.8)	98.6 (6.2)
Predicted Premorbid HVLT-R Total Recall	106.2 (3.4)	106.8 (3.7)
Predicted Premorbid HVLT-R Delayed Recall	103.4 (4.1)	102.7 (4.7)

Note. All scores are age-corrected standard scores based on the test manuals. WRAT-3 = Wide Range Achievement Test – 3, BVMT-R = Brief Visuospatial Memory Test – Revised, HVLT-R = Hopkins Verbal Learning Test – Revised, MCI = Mild Cognitive Impairment.

Table 2

Premorbid memory estimate formulae

Measure	Prediction Model
BVMT-R Total Recall	$100.702 - (\text{age} \times 0.722) + (\text{WRAT3} \times 0.441)$
BVMT-R Delayed Recall	$95.173 - (\text{age} \times 0.666) + (\text{WRAT3} \times 0.508)$
HVLT-R Total Recall	$83.927 + (\text{education} \times 1.111) + (\text{gender} \times 6.911)$
HVLT-R Delayed Recall	$42.449 + (\text{education} \times 1.084) + (\text{WRAT3} \times 0.407)$

Note. 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.