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Demographically-Corrected Normative Data for the Hopkins Verbal Learning Test–Revised and Brief Visuospatial Memory Test–Revised in an Elderly Sample

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Abstract

Demographic variables, such as age, education, and gender, routinely affect performance on neuropsychological tests. Whereas normative data is available to correct for these variables on many tests, it is lacking on the Hopkins Verbal Learning Test – Revised (HVLTR) and Brief Visuospatial Memory Test – Revised (BVMTR), especially in the elderly. The current study examines the influence of age, education, and gender on HVLTR and BVMTR scores in 290 cognitively intact older adults. Age negatively correlated with nearly every score on the HVLTR and BVMTR, and education positively correlated with most scores on these same two memory tests. There were fewer gender differences on these tests. Using stepwise multiple regression, HVLTR and BVMTR scores were predicted from age, education, and/or gender. When observed scores are compared to these demographically-adjusted predicted scores, clinicians can make assumptions about how an individual compared to his/her age, education, and gender-matched peers. The current co-norming of these two memory tests also allows for direct comparison between verbal and visual memory in older patients.

Keywords

memory; tests; geriatric

Introduction

The assessment of learning and memory is an important part of most neuropsychological evaluations (Scott & Schoenberg, 2011), especially in elderly patients with suspected cognitive impairments (e.g., dementia, Mild Cognitive Impairment). Two such memory tests are the Hopkins Verbal Learning Test – Revised (HVLTR), which uses semantically-related words as the items to be remembered, and the Brief Visuospatial Memory Test – Revised (BVMTR), which uses geometric designs and locations on a page as the items to be remembered. Both the HVLTR and BVMTR have been shown to be reliable and valid assessment instruments (Benedict, 1997; Brandt & Benedict, 1997). Since these memory tests are relatively brief, have 6 alternate forms, and follow similar procedures (e.g., 3

learning trials, 20 – 25 minute delayed recall trial, recognition trial), they are often given together in a larger battery.

Despite the advantages of the HVLTR and BVMT-R, demographic corrections for these measures are lacking. For example, normative data from the manual for each test corrects only for age, even though other demographic variables (e.g., education, gender) can affect performances (Heaton, Grant, & Matthews, 1991). In the HVLTR manual (Brandt & Benedict, 1997), it was reported that education and gender did account for additional variance in the scores (<5%), but these demographic variables were not included in the normative data. In the BVMT-R manual (Benedict, 1997), it was noted that after correcting for age, education and gender did not appear to contribute much to the scores.

Surprisingly, there have been relatively few attempts to augment the normative data for these memory tests in older adults. Vanderploeg and colleagues (2000) provided age and gender corrections for Form 1 of the HVLTR in a sample of 394 elderly participants. Consistent with other studies, age was negatively associated with performance on this learning and memory measure, and females tended to score higher than males. These authors also examined education, but they found that it did not significantly contribute to the variance of the HVLTR scores. Despite the contribution of these normative data above the test's manual, this study had some weaknesses. For example, the participants were selected to match census data in Florida, which may or may not be reflective of other parts of the country. Additionally, these subjects were part of a study on healthy aging, but little detail was presented about how they were deemed healthy or if this also meant cognitively intact. In fact, compared to the normative data in the HVLTR manual, Vanderploeg's sample had a mean T-score on Total Recall of approximately 42 (21st percentile). These authors also used a modified version of the HVLTR that had a cued delayed recall trial, which may have affected scores on the recognition trial.

Supplemental normative data for the BVMT-R was presented by Gale et al. (2007) and Kane and Yochim (2014). In the Gale study, they examined a sample of 172 healthy older adults and developed age- and gender-corrections. As expected, older age was associated with lower BVMT-R scores, with females tending to perform slightly better than males. Education did not appear to contribute to these test scores. Although this study provided potentially useful corrections for BVMT-R scores in an older cohort, it had some noteworthy limitations. For example, this study used only Form 4 of the BVMT-R. This study also presented corrections for only 3 BVMT-R scores (Total Recall, Delayed Recall, Recognition hits), when clinicians may utilize a wider range of the scores on the BVMT-R (e.g., individual learning trials, percent retention, false positives). The subjects in this study also seemed to have unexpected low scores for a healthy group (e.g., Total Recall T-score of 43 [24th percentile]). Kane and Yochim examined 109 individuals aged 60 and above on the BVMT-R (Form 1) and other neuropsychological measures. Although they found that age and education correlated with Total and Delayed Recall on this test, their sample of 80+ year olds was too small to provide normative data stratified by education. They found no gender effects in their sample. Finally, two other studies have reported demographic corrections for the HVLTR and BVMT-R (Cherner et al., 2007; Norman et al., 2011), but these were in non-elderly cohorts (e.g., ages 20 – 65 year old).

Overall, demographically-corrected normative data for the HVLt-R and BVMT-R remain inadequate, especially for older cohorts. The first purpose of the current study was to add to the limited research in this area by examining the relationship between age, education, and gender and test scores on the HVLt-R and BVMT-R in a large geriatric sample. It was expected that age would negatively correlate with these test scores, education would positively correlate with them, and that females would tend to do better than males. The second purpose was to develop normative data that corrected for these various demographic variables. It was expected that age, education, and gender would be predictive of HVLt-R and BVMT-R scores in an elderly cohort. One advantage of this study would be the co-norming of these two memory tests, which would allow for direct comparison between verbal and visual memory in older patients.

Methods

Participants and Procedures

Two hundred ninety community-dwelling older adults (aged 65 years and older) participated in this study. Most were female (80%), nearly all were Caucasian (98% Caucasian, 1% Hispanic, 1% African American), their mean age was 77.1 (7.5) years (range = 65 – 96), and their mean years of education were 15.4 (2.6) (range = 8 – 22).

The research protocol and all study procedures were approved by the University of Iowa and University of Utah Institutional Review Boards prior to study commencement. Recruitment involved talks and advertisements in the community, at senior centers, and independent living facilities. All participants expressed interest in research in memory and aging. Written informed consent was obtained from participants and monetary compensation was provided. Potential participants were screened over the telephone for possible dementia and cognitive impairment with the modified Telephone Interview of Cognitive Status. Those scoring below 19 on this measure were excluded from further participation, as this suggests significant cognitive impairment (Lines, McCarroll, Lipton, & Block, 2003). All other individuals were invited to participate in the study, and were scheduled for an in-person visit as described below.

The in-person visit consisted of a brief clinical interview, the Geriatric Depression Scale (GDS) to assess depressive symptoms, Wide Range Achievement Test-4 (WRAT-4) Reading subtest to estimate premorbid intellect, and the Repeatable Battery for the Assessment of Neuropsychological Status (RBANS) Form A to assess overall cognitive functioning. Additional cognitive measures collected include two measures of learning and memory: HVLt-R and BVMT-R. Measures were administered and scored according to their respective test manuals, and data was collected by trained research assistants. The clinical interview was used to collect relevant demographic information, presence of memory complaints, report of activities of daily living, and medical and psychiatric history. Participants' self-report was corroborated via collateral source (e.g., family member, spouse, close friend) when possible. Participants with significant history of major neurological (e.g., dementia, traumatic brain injury, stroke) or psychiatric illness (e.g., Bipolar Disorder, Schizophrenia), dementia (using the telephone and in-person cognitive screening battery) or current depression (30-item GDS >15) were excluded.

Measures of Interest

The HVLT-R (Brandt & Benedict, 1997) is a word list learning and recall task. In this task, an individual is aurally presented a list of 12 words (4 words from 3 semantic categories). After hearing the list, the individual attempts to freely recall as many of the words as he/she can, in any order. There are 2 additional learning trials, each followed by free recall. Correct responses across these 3 learning trials are summed for the Total Recall score (range = 0 – 36). After a 20 – 25 minute delay, free recall of the words is again attempted by the individual. The Delayed Recall score is the correct responses on this trial (range = 0 – 12). Immediately following the Delayed Recall trial is the Delayed Recognition trial, where an individual is aurally presented with a list of 24 words (12 from the list [“hits] and 12 distractors [false positive errors]), and he/she must identify which words were on the list and which ones were not. Two other scores are routinely calculated on the HVLT-R: Retention and Recognition Discrimination Index. Retention is calculated as (Delayed Recall / higher score Trials 2 or 3)×100. Recognition Discrimination Index is calculated as number of hits – number of false positives. For all HVLT-R scores, higher values indicating better performance, except false positive errors, which is the opposite.

The BVMT-R (Benedict, 1997) is design and location learning and recall task, which has many similarities to the HVLT-R. In this task, an individual is visually presented a card that contains 6 geometric designs in 6 locations on the card. After viewing the card for 10 seconds, the individual attempts to freely draw as many of the designs as he/she can, attempting to place them in their correct location on the page. Points are given for accurate drawing of the design and accurate placement on the page (1 point for each). There are 2 additional learning trials, each followed by free recall. Correct responses across these 3 learning trials are summed for the Total Recall score (range = 0 – 36). After a 20 – 25 minute delay, free recall of the designs and locations is again attempted by the individual. The Delayed Recall score is the correct responses on this trial (range = 0 – 12). Immediately following the Delayed Recall trial is the Delayed Recognition trial, where an individual is visually presented with 12 designs (6 from the list [“hits] and 6 distractors [false positive errors]) and he/she must identify which designs were on the card and which ones were not. Like with the HVLT-R, Retention and Recognition Discrimination Index can be calculated on the BVMT-R using the same equations noted above. For all BVMT-R scores, higher values indicating better performance, except false positive errors, which is the opposite.

Data Analyses

First, to examine the influence of age and education on the HVLT-R and BVMT-R, Pearson correlations were calculated between the various raw test scores and these demographic variables. Gender differences on these two memory measures were also compared with independent t-tests. Second, to generate demographically-corrected normative data, raw scores were converted into normal quantiles and standardized into scaled scores with a mean of 10 and a standard deviation of 3 (Cherner et al., 2007; Norman et al., 2011). Next, a series of stepwise linear regression were calculated. In each regression model, the scaled scores on the HVLT-R and BVMT-R were the criterion variables, and age, education, and gender were the predictor variables. Given the large number of analyses examined, a p-value <0.01 was used throughout.

Results

Table 1 contains demographic information about the sample, as well as performances on other relevant measures collected in this study. Table 2 provides HVLTR and BVMT-R scores for this sample, as well as summarizes the correlations between age, education, and the scores on the HVLTR and BVMT-R. Using a cutoff of $p < 0.01$, females outperformed males on HVLTR Trial 2 raw score ($t[287] = 3.99$, $p < 0.001$), HVLTR Trial 3 raw score ($t[287] = 3.51$, $p = 0.001$), HVLTR Total Recall raw score ($t[287] = 3.41$, $p = 0.001$), HVLTR Delayed Recall raw score ($t[287] = 3.08$, $p = 0.002$), and HVLTR Recognition Discrimination Index ($t[287] = 3.03$, $p = 0.003$). No gender differences were observed on any BVMT-R scores.

The results of the regression analyses for the HVLTR and BVMT-R are presented in Table 3. Briefly, age significantly contributed to all 9 HVLTR scores. Gender also contributed to all 9 HVLTR scores. Education contributed to 7 HVLTR scores, all except Recognition Hits and Recognition Discrimination Index. On the BVMT-R, age contributed to all 9 scores, education to 5 scores, and gender to 2 scores.

Discussion

The current study sought to add to the limited literature on demographic corrections for normative data for the HVLTR and BVMT-R for older patients. In 290 cognitively intact, community dwelling older adults, age and education significantly correlated with most scores on these widely used measures of learning and memory. Gender differences were less evident, appearing on 5 of 9 HVLTR scores and none of the BVMT-R scores. However, the magnitude of these associations tended to be small. For example, age tended to share approximately 11% of the variance with HVLTR scores and 10% of the variance with BVMT-R scores. Education accounted for even less variance on these memory tests (e.g., HVLTR = 2%, BVMT-R = 2%). These results are largely consistent with those reported in the test manuals and in prior studies (Cherner et al., 2007; Gale et al., 2007; Kane & Yochim, 2014; Norman et al., 2011; Vanderploeg et al., 2000). Overall, this seems to raise the question as to how much shared variance is needed before it is worthwhile to correct for other demographic variables. Both the HVLTR and BVMT-R manuals seem to suggest that education and gender accounted for too little variance, making it unnecessary to develop separate corrections for these factors. However, others within neuropsychology have indicated that these demographic corrections are needed. For example, the normative data for the extended Halstead Reitan Battery (Heaton et al., 1991) corrects for age, education, and gender. Similarly, the newest versions of the Wechsler intelligence and memory scales allow for corrections of multiple demographic variables (Pearson, 2009). While there may not be consensus in neuropsychology about the need for these additional corrections, it would appear that they could be useful for certain patients, especially those at the extremes (e.g., very old, very high or low levels of education).

Given the potential utility of demographic corrections, the current study also developed regression-based normative data for the HVLTR and BVMT-R in an elderly cohort. Using age, education, and occasionally gender, predicted scores could be generated for all HVLTR-

R and BVMT-R scores. Similar to the correlational analyses, the amount of variance accounted for in these equations tended to be low (e.g., HVLT-R = 17%, BVMT-R = 14%). Nonetheless, the predicted score can be compared to the observed score to provide a frame of reference as to how much the individual deviates from expectations of demographically-similar peers. These normative equations could provide enhanced clinical interpretation, above and beyond from the test manuals. For example, in the entire current cohort, their mean age-corrected scores from the test manuals generally met expectations for the HVLT-R (Total Recall T-score: $M = 52.7$, $SD = 10.7$; Delayed Recall T-score: $M = 47.0$, $SD = 13.1$), but fell below expectations for the BVMT-R (Total Recall T-score: $M = 39.9$, $SD = 11.6$; Delayed Recall T-score: $M = 42.2$, $SD = 13.2$). Without corrections for education, especially in this relatively highly educated group, BVMT-R scores tended to appear low. The learning and memory scores of the current sample also appeared well below expectations when compared to demographically-corrected normative data from the younger cohort of Norman et al. (2011): HVLT-R (Total Recall T-score: $M = 34.6$, $SD = 13.0$; Delayed Recall T-score: $M = 29.8$, $SD = 14.2$) and BVMT-R (Total Recall T-score: $M = 37.5$, $SD = 7.7$; Delayed Recall T-score: $M = 33.2$, $SD = 10.0$). Compared to older cohorts, the HVLT-R and BVMT-R scores still seemed to deviate further from “normal” than expected for this large, healthy sample (Vanderploeg et al. [2000] HVLT-R Total Recall T-score: $M = 57.5$, Delayed Recall T-score: $M = 48.0$; Kane et al. [2014] BVMT-R Total Recall T-score: $M = 43.5$, Delayed Recall T-score: $M = 40.0$). Of the older cohorts, the normative corrections by Gale et al. (2007) seemed to most accurately reflect “average” performances in our group (BVMT-R Total Recall T-score: $M = 47.5$, Delayed Recall T-score: $M = 46.5$). Overall, it is challenging to compare these different normative values and determine one “better” than the others, but each appears to add unique contributions to the accurate assessment of diverse samples of patients.

Clinicians unfamiliar with the use of regression-based normative data might benefit from a few examples. A 65-year old female with 16 years of education obtains a T-score of 35 on HVLT-R Total Recall based on the test manual. This score would roughly fall at the 7th percentile. However, if the regression equation from Table 3 is used (predicted scaled score for HVLT-R Total Recall = $17.98 - [.16 * \text{age}] + [.19 * \text{ed}] + [1.66 * \text{gender}] = 68.66 - [16 * 65] + [.19 * 12] - [1.66 * 1] = 12.28$, which would be a T-score of approximately 57), then this woman is seen to have dropped over 20 T-score points from her demographically-expected score. When the difference of her observed and predicted scores are divided by the standard error of the estimate of this regression equation (SEE), the difference between her scores is more precisely quantified. Her observed T-score for HVLT-R Total Recall of 35 is equal to a scaled score of approximately 5.6. Her predicted scaled score for HVLT-R Total Recall is 12.3. So, the discrepancy between these two scores is -6.7 (i.e., $5.6 - 12.3$), which when divided by the SEE is -2.62 (i.e., $-6.7/2.56$). This resulting value is a z-score that might allow for a more sensitive assessment by considering the demographic influences of age, education, and gender. For example, this z-score indicates that she has declined to below 1st percentile. A 92-year old male with 12 years of education obtains a T-score of 40 (or scaled score of 7) on HVLT-R Total Recall based on the test manual. This score falls around the 16th percentile, perhaps indicating low average verbal learning. If the same regression equation from Table 3 is used (predicted scaled score for HVLT-R Total Recall =

$17.98 - [.16 * \text{age}] + [.19 * \text{ed}] + [1.66 * \text{gender}] = 68.66 - [.16 * 90] + [.19 * 12] - [1.66 * 0] = 5.86$, then this man is seen to have dropped only about 1 scaled score units from his demographically-expected score. The difference between his scores is quantified as $z = -0.44$ ($[\text{observed scaled score for HVLT-R Total Recall} - \text{predicted scaled score for HVLT-R Total Recall}] / \text{SEE} = [5.86 - 7] / 2.56 = -0.44$). A change from demographic expectations of this magnitude would be much milder than indicated by the manual norms (33rd percentile vs. 16th percentile). As noted above, the current equations yield z-scores; however, these could easily be converted to T-scores by multiplying the z-score times 10 and then adding 50. Similarly, they could be converted to standard scores by multiplying the z-score times 15 and then adding 100. Regardless of the metric, with certain cases, the “small” amount of variance shared between HVLT-R and BVMT-R scores and demographic variables may make clinically meaningful differences in the interpretation of these learning and memory scores. The interested reader can contact the author to obtain an Excel spreadsheet that will automatically calculate these corrected values.

Despite the potential benefits of these new normative data, the current study also raises a number of unanswered questions. First, given the relatively low R^2 values in our regression models (i.e., still a lot of variance that remains unexplained), there must be other demographic variables that need to be considered in the prediction of test scores. For example, we did not have the highest occupational status of our participants, but this may be another important factor in predicting test scores. Similarly, others have shown that premorbid intellect may be useful in predicting cognitive test scores (Crawford, Nelson, Blackmore, Cochrane, & Allan, 1990; Duff, 2010). Although years of education were included as a predictor variable, quality of education (Manly, Jacobs, Touradji, Small, & Stern, 2002) may be more useful. Even though our sample was almost exclusively Caucasian, future studies that use a more diverse sample might improve their prediction equations by including ethnicity as a variable. For example, Friedman et al. (2002) provided normative data that corrected for age, education, and gender in a large cohort of African American older adults. Second, it is interesting to note that a verbal/visual discrepancy existed in our sample when the test manual normative data was used. Combining the Total and Delayed Recall scores, our sample performed nearly a standard deviation higher on the HVLT-R compared to the BVMT-R using the manual norms (mean T-score = 49.8 vs. 41.0, respectively). It remains unclear why this discrepancy occurred, but it is consistent with the prior report by Gale et al. (2007). However, when the current normative data was used, the differences between the two tests were much smaller (mean HVLT-R z-scores = -0.09 , mean BVMT-R z-scores = -0.05). This is one of the distinct advantages of co-norming tests.

There are a number of strengths of the current study. First, to our knowledge, other studies have not presented co-normed demographic corrections for the HVLT-R and BVMT-R using an elderly cohort. The two recent studies that have co-normed these memory measures used non-geriatric samples (Cherner et al., 2007; Norman et al., 2011). With normative data on these 2 measures in the same sample, clinicians can feel more confident in directly comparing these verbal and visual memory scores. Second, unlike prior elderly normative studies on these tests that used descriptive data and/or cumulative frequency distributions (Gale et al., 2007; Kane & Yochim, 2014; Vanderploeg et al., 2000), stepwise linear regression was used to develop the current norms. This method is very similar to that used in

other normative studies (Cherner et al., 2007; Heaton et al., 1991; Norman et al., 2011) and allows for a fuller use of the data. Third, Form 1 of each test was used. It is suspected that Form 1 is likely the most widely used, despite each measure having 6 alternate forms. Fourth, an independent method was used in this study to screen out those with significant cognitive impairment. We used a cutoff on a telephone screening measure of cognition to exclude subjects that might already meet criteria for dementia. By excluding these individuals, clinicians can be more confident in the decisions made using this normative data.

Despite the strengths mentioned above, some limitations are also worth mentioning. First, the demographic characteristics of our sample were limited. The sample was almost exclusively Caucasian. Although this demographic does adequately represent the geographic areas from where data was drawn (i.e., IA and UT), it is unclear how accurate this normative data would be in ethnically diverse patients. Similarly, the sample was predominantly female, which may also skew the gender corrections generated from this cohort. Lastly, all individuals were 65 years or older, and it is not recommended that these demographic corrections be applied to younger patients. Second, the current sample was highly educated (e.g., mean years of education = 15.4), which may limit the applicability of these norms to lower educated patients. Third, in our study, we focused on 9 common raw score variables from the HVLT-R and BVMT-R. Although these are the scores typically used in clinical practice, there may be other variables of interest to clinicians or researchers. Interested parties may contact the author for normative data on other test scores. Finally, as mentioned earlier, the regression equations indicated that the demographic variables examined in this study accounted for limited variance in memory test scores. Clearly, other variables need to be considered to more accurately predict these scores.

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Table 1

Demographic and cognitive scores in the sample.

Variable	M (SD) Range
Age (years)	77.1 (7.5) 65 – 96
Education (years)	15.4 (2.6) 8 – 22
mTICS	35.3 (4.8) 20 – 48
WRAT-4 Reading ^I	108.9 (8.3) 81 – 145
RBANS Total ^I	103.1 (14.3) 75 – 146
GDS	4.3 (3.6) 0 – 15

Note. All test scores are raw scores unless otherwise noted.

^I age-corrected standard score.

mTICS = modified Telephone Interview of Cognitive Status, WRAT-4 = Wide Range Achievement Test-4, RBANS = Repeatable Battery for the Assessment of Neuropsychological Status, GDS = Geriatric Depression Scale.

Table 2

HVLT-R and BVMT-R scores in the sample.

Variable	M (SD) Range	r with age	r with education
HVLT-R Trial 1	6.6 (1.9) 2 – 12	−0.41 *	0.20 *
Trial 2	8.7 (2.2) 2 – 12	−0.40 *	0.14
Trial 3	9.6 (2.1) 3 – 12	−0.37 *	0.15 *
Total Recall	24.8 (5.7) 5 – 36	−0.43 *	0.18 *
Delayed Recall	7.4 (3.6) 0 – 12	−0.36 *	0.18 *
Hits	11.2 (1.2) 6 – 12	−0.25 *	0.01
False Positives	1.3 (1.4) 0 – 8	0.21 *	−0.14
Retention (%)	72.6 (31.1) 0 – 128	−0.30 *	0.16 *
RDI	9.9 (2.0) 3 – 12	−0.30 *	0.10
BVMT-R Trial 1	2.8 (1.9) 0 – 10	−0.32 *	0.16 *
Trial 2	5.3 (2.6) 1 – 12	−0.37 *	0.19 *
Trial 3	6.6 (2.8) 1 – 12	−0.39 *	0.17 *
Total Recall	14.6 (6.9) 3 – 32	−0.40 *	0.19 *
Delayed Recall	6.0 (3.2) 0 – 12	−0.45 *	0.19 *
Hits	5.5 (0.8) 2 – 6	−0.25 *	0.01
False Positives	0.3 (0.7) 0 – 6	0.25 *	−0.09
Retention (%)	83.5 (32.7) 0 – 150	−0.34 *	0.11
RDI	5.2 (1.1) 0 – 6	−0.34 *	0.07

Note. All test scores are raw scores. HVLT-R = Hopkins Verbal Learning Test – Revised (HVLT-R), BVMT-R = Brief Visuospatial Memory Test – Revised, RDI = Recognition Discrimination Index.

*
p<0.01.

Table 3

Regression equations for demographically-corrected scores on HVLT-R and BVMT-R.

Variable	F(df), p, R ²	Equation	SEE
HVLT-R Trial 1	F(3,288)=23.9, p<0.001, R ² =0.20	$18.08 - (.15*\text{age}) + (.17*\text{ed}) + (.82*\text{gender})$	2.55
Trial 2	F(3,288)=29.2, p<0.001, R ² =0.24	$17.71 - (.15*\text{age}) + (.15*\text{ed}) + (1.78*\text{gender})$	2.53
Trial 3	F(3,288)=24.7, p<0.001, R ² =0.21	$16.94 - (.14*\text{age}) + (.16*\text{ed}) + (1.58*\text{gender})$	2.53
Total Recall	F(3,288)=31.7, p<0.001, R ² =0.25	$17.98 - (.16*\text{age}) + (.19*\text{ed}) + (1.66*\text{gender})$	2.56
Delayed Recall	F(3,288)=21.7, p<0.001, R ² =0.19	$16.08 - (.13*\text{age}) + (.19*\text{ed}) + (1.45*\text{gender})$	2.62
Hits	F(3,287)=12.4, p<0.001, R ² =0.08	$12.43 - (.05*\text{age}) + (.59*\text{gender})$	1.54
False Positives	F(3,284)=9.2, p<0.001, R ² =0.09	$10.71 + (.04*\text{age}) - (.13*\text{ed}) - (1.43*\text{gender})$	2.32
Retention (%)	F(3,265)=16.5, p<0.001, R ² =0.16	$16.02 - (.13*\text{age}) + (.20*\text{ed}) + (1.88*\text{gender})$	3.08
RDI	F(2,277)=19.5, p<0.001, R ² =0.12	$17.36 - (.11*\text{age}) + (1.23*\text{gender})$	2.50
BVMT-R Trial 1	F(3,288)=13.7, p<0.001, R ² =0.13	$16.07 - (.12*\text{age}) + (.16*\text{ed}) + (.88*\text{gender})$	2.86
Trial 2	F(2,288)=26.4, p<0.001, R ² =0.16	$18.20 - (.14*\text{age}) + (.16*\text{ed})$	2.72
Trial 3	F(2,288)=28.0, p<0.001, R ² =0.16	$19.07 - (.14*\text{age}) + (.13*\text{ed})$	2.68
Total Recall	F(2,288)=30.5, p<0.001, R ² =0.18	$19.15 - (.15*\text{age}) + (.16*\text{ed})$	2.68
Delayed Recall	F(2,267)=40.8, p<0.01, R ² =0.24	$22.15 - (.18*\text{age}) + (.13*\text{ed})$	2.63
Hits	F(1,288)=19.5, p<0.001, R ² =0.06	$13.15 - (.05*\text{age})$	1.54
False Positives	F(2,288)=15.1, p<0.001, R ² =0.10	$6.46 + (.06*\text{age}) - (.55*\text{gender})$	1.59
Retention (%)	F(1,259)=22.6, p<0.001, R ² =0.08	$19.70 - (.12*\text{age})$	2.95
RDI	F(1,288)=35.6, p<0.001, R ² =0.11	$14.44 - (.07*\text{age})$	1.52

Note. All test scores are raw scores. HVLT-R = Hopkins Verbal Learning Test – Revised (HVLT-R), BVMT-R = Brief Visuospatial Memory Test –Revised, RDI = Recognition Discrimination Index, SEE = standard error of the estimate from regression model., age = years old, ed = years of education, gender was coded as male = 0 and female = 1.