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Authors

Graves, Lisa V

Simone, Stephanie

Williams, McKenna

et al.

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Revisiting Total Recognition Discriminability in Huntington's and Alzheimer's Disease: New Insights from the CVLT-3

Lisa V. Graves[1,2], **Stephanie Simone**[3], **McKenna Williams**[2], **Troy Courville**[4], **Sarah N. Mattson**[1,2], **Lisa Delano-Wood**[1,3,5], **Mark W. Bondi**[1,3,5], **David P. Salmon**[1,6], **Jody Corey-Bloom**[1,6], **Dean C. Delis**[1,3], **Paul E. Gilbert**[1,2]

[1]San Diego State University/University of California San Diego Joint Doctoral Program in Clinical Psychology, San Diego, CA

[2]Department of Psychology, San Diego State University, San Diego, CA

[3]Department of Psychiatry, University of California San Diego School of Medicine, La Jolla, CA

[4]Professional Education, Georgia Institute of Technology, Atlanta, GA

[5]Veterans Affairs San Diego Healthcare System, San Diego, CA

[6]Department of Neurosciences, University of California San Diego, La Jolla, CA

Abstract

The original and second editions of the California Verbal Learning Test (CVLT) used nonparametric and parametric methods, respectively, to assess Total Recognition Discriminability (RD). In a previous study, we found evidence that the nonparametric formula may be more sensitive than the parametric formula to high false positive (FP) rates and provide more accurate assessments of yes/no recognition in neurodegenerative populations prone to high FP rates, including Alzheimer's disease (AD). In the present study, we extended our investigation to examine the utility of CVLT-3 nonparametric and parametric Total RD indices in the assessment and comparison of yes/no recognition in individuals with Huntington's disease (HD) and AD in mild and moderate stages of dementia. Findings suggested that the CVLT-3 nonparametric Total RD index was more sensitive than the parametric index to HD and AD differences in yes/no recognition across mild and moderate stages of dementia. Additionally, group differences on total FP errors were more closely mirrored by group differences on the nonparametric Total RD index. The present results bolster our previous findings and highlight the utility of examining nonparametric (in addition to parametric) Total RD on the CVLT-3 in assessments of yes/no recognition involving clinical populations prone to high FP rates.

Keywords

California Verbal Learning Test-3; total recognition discriminability; nonparametric; Huntington's disease; Alzheimer's disease

Please address all correspondence to Dr. Paul E. Gilbert, SDSU/UC San Diego Joint Doctoral Program in Clinical Psychology, 6363 Alvarado Court, Suite 103, San Diego, CA, 92120. Tel: (619) 594-7409; Fax: (619) 594-3773; pgilbert@sdsu.edu.

The original and second editions of the California Verbal Learning Test (CVLT and CVLT-II, respectively) included a Total Recognition Discriminability (RD) index that assesses the ability to distinguish List A target items from all (List B and novel) distractor items on the Yes/No Recognition trial. The original CVLT (Delis, Kramer, Kaplan, & Ober, 1987) used a nonparametric formula that incorporated false positive (FP) errors as an absolute proportion or percentage into Total RD scores (see Underwood, 1974). In contrast, the CVLT-II (Delis, Kramer, Kaplan, & Ober, 2000) used a parametric (*d'*) formula based on signal detection theory (Macmillan & Creelman, 1991) that incorporated FP errors as a rate or probability (in the form of a *z*-transformed proportion) into Total RD scores (Delis et al., 2000). The distinction between these two formulas in how they incorporate FP errors into Total RD scores may have implications for assessing yes/no recognition in populations that are particularly prone to generating high numbers of FP errors (e.g., AD).

The memory profiles associated with Huntington's disease (HD) and Alzheimer's disease (AD) have been well characterized. Individuals with HD, particularly those in earlier stages of the disease, have been shown to demonstrate poor recall with improvements on recognition testing, suggesting impaired retrieval processes albeit relatively intact encoding and maintenance mechanisms (Butters, Delis, & Lucas, 1995; Butters, Wolfe, Martone, Granholm, & Cermak, 1985; Delis et al., 1991). In contrast, individuals with AD have been shown to exhibit rapid forgetting due to a more profound encoding deficit and, consequently, perform poorly on recall and recognition (Budson & Kowall, 2013; Dickerson & Atri, 2014; Salmon & Bondi, 2009).

Studies using the CVLT have suggested that HD patients (particularly those in milder stages of the disease) perform better than AD patients on Total RD (Delis et al., 1991; Kramer et al., 1988). However, two studies using the CVLT-II have produced mixed findings. The first study (Fine et al., 2008) demonstrated that standardized parametric Total RD scores were higher in HD patients than in AD patients. In the second study, which was conducted recently by our group (Graves et al., 2017), the nonparametric formula that was used on the CVLT was applied to CVLT-II data to generate raw scores on a nonparametric Total RD index (standardized nonparametric Total RD scores could not be generated or examined as CVLT-II norms on a nonparametric Total RD index were not available). Raw and standardized scores on the parametric Total RD index, which are included by default on the CVLT-II, also were examined. Findings from this study revealed comparable standardized parametric Total RD scores between the HD and AD groups, whereas raw nonparametric and parametric Total RD scores were higher in the HD group than in the AD group. Moreover, exploratory analyses suggested that FP errors were more strongly correlated with nonparametric Total RD scores than with parametric Total RD scores in the AD group but not in the HD group. These findings suggested that the nonparametric formula for Total RD may more fully account for high FP rates, whereas parametric Total RD scores may be inadvertently overestimated in some individuals with AD (i.e., those who are prone to significantly elevated FP rates). That is, given the disproportionately higher number of distractor items relative to target items on the Yes/No Recognition Trial, for those individuals with AD who are prone to generating significantly high numbers of FP errors, the parametric Total RD formula may inadvertently lessen the FP rate and thus mask

impairment. This may explain the comparable standardized scores on the Total RD index between HD and AD groups in the aforementioned study.

Although the memory profiles of HD and AD have been well characterized, evidence suggests that the degree to which yes/no recognition is shown to differ between these populations may depend on the manner in which FP errors are incorporated into assessments of yes/no recognition. Moreover, whether HD and AD comparisons on yes/no recognition vary as a function of dementia severity has not been closely examined. The CVLT-3 includes both a nonparametric and a parametric Total RD index on the Yes/No Recognition trial (Delis, Kramer, Kaplan, & Ober, 2017). In the present study, we extended our investigation to examine the utility of CVLT-3 nonparametric and parametric Total RD indices in the assessment and comparison of yes/no recognition in individuals with HD and AD in mild and moderate stages of dementia. Access to data on additional AD participants yielded a larger sample in the present study relative to our previous study (Graves et al., 2017), which allowed us to categorize HD and AD participants as mild or moderate on dementia severity. Additionally, we were able to apply CVLT-3 algorithms and norms to existing CVLT-II data to generate raw and scaled scores on CVLT-3 nonparametric and parametric Total RD indices. It was hypothesized that relative to the parametric Total RD index, the nonparametric Total RD index – in more fully accounting for high FP rates than the parametric formula – would be more sensitive to HD and AD differences in yes/no recognition across mild and moderate stages of dementia.

Method

Participants

Study participants included 55 individuals with HD and 52 individuals with AD who were each characterized as mild or moderate on dementia severity based on Dementia Rating Scale (DRS; Mattis, 1988) or DRS-2 (Jurica, Leitten, & Mattis, 2001) scores: 120 or above = mild, 100–119 = moderate (mod). The study sample therefore included four groups: HD-mild (n=39), HD-mod (n=16), AD-mild (n=25), and AD-mod (n=27).

Individuals with HD were recruited from the Huntington's Disease Clinical Research Center (HDCRC) at the University of California, San Diego (UC San Diego). Individuals with HD were administered the Unified Huntington's Disease Rating Scale (UHDRS; Huntington Study Group, 1996) by a senior staff neurologist at the HDCRC and were diagnosed with definite HD on the basis of unequivocal motor signs on the UHDRS and a positive family history of HD. In addition, all HD participants had a CAG repeat length greater than 39, indicating that all carried the fully penetrant genetic mutation for HD.

Individuals with AD were recruited from the Shiley-Marcos Alzheimer's Disease Research Center (ADRC) affiliated with UC San Diego. Diagnoses of individuals with probable AD were made by a senior staff neurologist at the ADRC and were consistent with the criteria established by the National Institute of Neurological and Communicative Disorders and Stroke (NINCDS)–Alzheimer's Disease and Related Disorders Association (ADRDA) workgroup (McKhann et al., 1984; McKhann et al., 2011). Portions of the HD and AD groups in the present study overlapped with samples from previous studies (Delis et al.,

2005, Fine et al., 2008; Graves et al., 2017). Specifically, all 55 HD participants and 33 of the 52 AD participants in the present study also were included in our previous study in which we examined HD and AD differences on Total RD using the CVLT-II (Graves et al., 2017). Given the increase in our AD sample, the present study allowed the opportunity to generate multiple subgroups of HD and AD participants to examine whether HD and AD differences on CVLT-3 Total RD indices varied as a function of dementia severity.

Exclusionary criteria for HD and AD participants included the following: a diagnosis of any neurological disorder aside from HD or AD, respectively; a diagnosis of any major medical condition (e.g., cancer); a diagnosis of any psychiatric disorder (with the exception of a mood disorder, for which any current symptoms were well managed based on self-report); a history of traumatic brain injury; and a history of substance use disorder.

CVLT-II data were extracted from archival databases that included data from larger batteries of neuropsychological tests administered by trained research assistants or psychometrists at the HDCRC, ADRC, and Normal Aging Laboratory at UC San Diego. All participants provided informed written consent and the study was approved by the Institutional Review Board of UC San Diego.

Yes/No Recognition Variables

The CVLT is a list-learning test that provides a multitude of verbal learning and memory indices, including immediate recall, free and cued recall over short and long delays, and yes/no recognition. Recall and Yes/No Recognition test items and procedures are essentially identical across the CVLT-II and CVLT-3. Participants in the present study were previously administered the CVLT-II (see above regarding extraction from archival databases) using standard procedures outlined by Delis and colleagues (2000). Given that the target words on the recall trials and the target and distractor items on the Yes/No Recognition trial are identical on the CVLT-II and CVLT-3, CVLT-3 algorithms and norms were applied to existing CVLT-II data to generate and examine raw and scaled scores on CVLT-3 Yes/No Recognition variables. CVLT-3 Yes/No Recognition variables of primary interest were raw and scaled scores on nonparametric Total RD and parametric Total RD (see formulas below). Hits and total FP errors also were examined.

$$\text{Nonparametric Total RD} = [1 - (\text{total FP errors} + \text{total misses}) / 48] \times 100$$
$$\text{Parametric Total RD} = z(\text{hit rate}) - z(\text{FP rate})$$

Data Analysis

Analyses were conducted in the Statistical Package for the Social Sciences (SPSS) Version 25. Prior to conducting primary analyses, 1) analysis of variance and covariance (ANOVA and ANCOVA) assumptions were tested; 2) one-way ANOVA and chi-square tests were conducted to examine group differences on demographic variables (age, gender, education) and DRS/DRS-2 scores; and 3) preliminary ANOVA and ANCOVA tests were conducted to determine which demographic variables were significant predictors of raw scores on Total RD indices.

To address the aims of the study, 1) ANCOVA tests were conducted to examine the effect of group (HD-mild, HD-mod, AD-mild, AD-mod) on raw scores on Yes/No Recognition variables, controlling for demographic factors when appropriate; and 2) ANOVA tests were conducted to examine the effect of group on scaled scores on Yes/No Recognition variables. Post-hoc pairwise comparisons were examined in the context of significant group effects, and an alpha level (α) of .01 was applied to adjust for multiple comparisons. Cohen's *d* effect size values associated with significant group differences on Total RD indices were calculated and reported.

Results

Preliminary Analyses

Data on primary Yes/No Recognition variables of interest were considered to be normally distributed based on examination of skewness (range = −0.69 to 0.32, SE=.17) and kurtosis (range = −1.04 to −0.60, SE=.34) values, histograms (which reflected relatively normal distributions), and boxplots (which indicated absence of outliers). Additionally, Levene's tests revealed equal variances across groups in the context of ANOVA tests examining scaled scores on Yes/No Recognition variables of interest (*p*s>.05) in addition to homogeneity of regression slopes in the context of ANCOVA tests where age was included as a covariate in the examination of group effects on raw scores on Yes/No Recognition variables (*p*s>.05).

Demographic information on study participants is provided in Table 1. One-way ANOVA tests revealed significant group differences on age, $F(3, 103) = 80.90$, $p < .001$, and DRS/DRS-2 scores, $F(3, 103) = 114.35$, $p < .001$, but not education, $F(3, 103) = 1.62$, $p = .19$. As expected, Tukey's post-hoc pairwise comparisons revealed that the HD-mild and HD-mod groups were significantly younger than the AD-mild and AD-mod groups (*p*s < .001). In addition, the HD-mod and AD-mod groups had significantly lower DRS/DRS-2 scores than the HD-mild and AD-mild groups. A chi-square test revealed a significant difference in gender distributions across groups, $\chi^2(3, N = 107) = 8.58$, $p < .05$. Post-hoc tests revealed that there was a higher proportion of women than men in the HD-mild group but a higher proportion of men than women in the AD-mod group (*p*s < .05). Gender proportions were comparable in the HD-mod and AD-mild groups (*p*s > .05).

Preliminary analyses revealed that age was a significant predictor of raw scores on the nonparametric Total RD index, $F(1, 105) = 24.78$, $p < .001$, and the parametric Total RD index, $F(1, 105) = 20.22$, $p < .001$. Thus, age was included as a covariate in the primary analysis involving raw scores on Yes/No Recognition variables. Given that scaled scores correct for age, age was not controlled for in the primary analysis involving scaled scores on Yes/No Recognition variables. Preliminary analyses also revealed that DRS/DRS-2 scores were a significant predictor of raw scores on the nonparametric Total RD index, $F(1, 105) = 20.26$, $p < .001$, and the parametric Total RD index, $F(1, 105) = 25.85$, $p < .001$. However, given that DRS/DRS-2 scores were confounded with group, DRS/DRS-2 scores were not controlled for in primary analyses involving raw or scaled scores on Yes/No Recognition variables. Neither gender nor education were shown to be significant predictors of raw scores on Total RD indices (*p*s > .05); thus, neither of these variables were controlled for in primary analyses of Yes/No Recognition performance.

Primary Analyses

Mean and standard deviation values for raw and scaled scores on CVLT-3 Yes/No Recognition variables in the HD-mild, HD-mod, AD-mild, and AD-mod groups are provided in Table 2. ANCOVA tests revealed a significant effect of group on raw scores on total FP errors, $F(3, 102) = 4.58$, $p < .01$, $\eta_p^2 = .12$, the nonparametric Total RD index, $F(3, 102) = 6.54$, $p < .001$, $\eta_p^2 = .16$, and the parametric Total RD index, $F(3, 102) = 6.48$, $p < .001$, $\eta_p^2 = .16$, but not on hits, $F(3, 102) = 1.24$, $p > .05$, $\eta_p^2 = .04$. Post-hoc pairwise comparisons ($\alpha = .01$) revealed that the HD-mild group had significantly fewer total FP errors than the AD-mild and AD-mod groups ($ps<.001$), and that the HD-mod group had significantly fewer total FP errors than the AD-mod group ($p<.001$). Additionally, on both the nonparametric and parametric Total RD indices, the HD-mild group had significantly higher raw scores than the AD-mild (nonparametric: $p<.001$, $d=1.16$; parametric: $p<.001$, $d=1.13$) and AD-mod (nonparametric: $p<.001$, $d=1.63$; parametric: $p<.001$; $d=1.53$) groups, and the magnitude of these differences was large (see Cohen's *d* values above). Moreover, on the nonparametric Total RD index (but not on the parametric Total RD index), the HD-mod group had significantly higher raw scores than the AD-mod group ($p<.001$), and the magnitude of this difference was large ($d=1.23$). Thus, in the context of raw scores, HD and AD group differences were more robust on the nonparametric Total RD index, and group differences on the nonparametric Total RD index mirrored group differences on total FP errors. No other significant group differences on raw scores were observed.

ANOVA tests revealed a significant effect of group on scaled scores on total FP errors, $F(3, 103) = 5.37$, $p < .01$, $\eta_p^2 = .14$, the nonparametric Total RD index, $F(3, 103) = 5.68$, $p < .01$, $\eta_p^2 = .14$, and the parametric Total RD index, $F(3, 103) = 3.30$, $p < .05$, $\eta_p^2 = .09$, but not on hits, $F(3, 103) = 2.44$, $p > .05$, $\eta_p^2 = .07$. Post-hoc pairwise comparisons ($\alpha = .01$) revealed that the HD-mild group had significantly higher scaled scores on total FP errors (note: in the context of FP errors, higher scaled scores correspond with lower raw scores) than the AD-mild ($p=.007$) and AD-mod ($p=.001$) groups. Additionally, on both the nonparametric and parametric Total RD indices, the HD-mild group had significantly higher scaled scores than the AD-mod group (nonparametric: $p<.001$, $d=0.98$; parametric: $p=.005$, $d=0.69$), and the magnitudes of these differences were medium to large (see Cohen's *d* values above). Moreover, on the nonparametric Total RD index (but not on the parametric Total RD index), the HD-mild group had significantly higher scaled scores than the AD-mild group ($p=.005$), and the magnitude of this difference was medium ($d=0.70$). Thus, as was observed with raw scores, in the context of scaled scores, HD and AD group differences were more robust on the nonparametric Total RD index, and group differences on the nonparametric Total RD index mirrored group differences on total FP errors. No other significant group differences on scaled scores were observed. Descriptive statistics and pairwise comparisons associated with primary analyses of raw and scaled scores on CVLT-3 Yes/No Recognition variables are provided in Table 2.

Discussion

In the present study, we examined and compared the utility of the CVLT-3 nonparametric and parametric Total RD indices in characterizing and distinguishing yes/no recognition

performance in individuals with HD and AD in mild and moderate stages of dementia. In a previous study (Graves et al., 2017), we found that although HD patients had significantly higher raw scores than AD patients on nonparametric and parametric Total RD indices, the HD and AD groups had comparable standardized scores on the CVLT-II parametric Total RD index. At that time, standardized nonparametric Total RD scores could not be generated or examined as CVLT-II norms on a nonparametric Total RD index were not available. The present study expands upon these earlier findings by 1) exploring HD and AD differences on Total RD as a function of dementia severity via categorization of HD and AD patients into mild and moderate subgroups based on DRS/DRS-2 scores, and 2) including an analysis of scaled scores in addition to raw scores on both nonparametric and parametric Total RD indices. It was hypothesized that relative to the parametric Total RD index, the nonparametric Total RD index – in more fully accounting for high FP rates – would be more sensitive to HD and AD differences in yes/no recognition across mild and moderate stages of dementia.

In the present study, analyses of raw and scaled scores on the CVLT-3 nonparametric and parametric Total RD indices provided further evidence that relative to the parametric Total RD index, the nonparametric Total RD index may be more sensitive to HD and AD differences in yes/no recognition. Specifically, on both the nonparametric and parametric Total RD indices, HD patients with mild dementia exhibited significantly higher raw scores than AD patients with mild or moderate dementia. However, HD patients with moderate dementia were shown to perform better than AD patients with moderate dementia on the nonparametric Total RD index, whereas this difference was not observed on the parametric Total RD index. In the context of scaled scores, HD patients with mild dementia exhibited significantly higher scaled scores than AD patients with moderate dementia on both the nonparametric and parametric Total RD indices. However, HD patients with mild dementia also were shown to perform better than AD patients with mild dementia on the nonparametric Total RD index, but not on the parametric Total RD index. Although HD and AD differences appeared less robust in the analysis of scaled scores versus raw scores, this is not surprising given that the correction for age in scaled scores likely impacts HD performance to a greater degree than AD performance given earlier disease onset in HD relative to AD (i.e., many HD patients are compared to cognitively normal middle-aged adults whereas most AD patients are compared to cognitively normal older adults). Taken together, the present findings highlight that relative to the parametric Total RD index, the nonparametric Total RD index may be more sensitive to HD and AD differences in yes/no recognition.

The present study expanded upon our previous work through the examination of HD and AD performance on nonparametric and parametric Total RD as a function of dementia severity. Previously, we found that although HD patients had significantly higher raw scores than AD patients on nonparametric and parametric Total RD indices, the HD and AD groups had comparable standardized scores on the parametric Total RD index (Graves et al., 2017). We hypothesized that for individuals with AD, the impact of high FP rates on Total RD scores may be inadvertently reduced when applying the parametric formula for Total RD (which incorporates FP errors as a rate or probability by way of a *z*-transformed proportion), and that the nonparametric formula (which incorporates FP errors as an absolute proportion or

percentage) may more fully account for significantly elevated FP rates that are often observed in individuals with AD. In the present study, we conducted an exploratory analysis in which we combined (a) the HD-mild and HD-mod groups as well as (b) the AD-mild and AD-mod groups to mirror the sample of HD and AD patients from our previous study (note: there is some overlap between the two study samples, although the present AD sample is substantially larger than the previous AD sample). In this analysis, we found that the HD group exhibited significantly higher raw scores than the AD group on nonparametric and parametric Total RD indices, whereas the HD and AD groups showed comparable scaled scores on both Total RD indices, congruent with the results of our previous study. Notably, results from the primary analysis of raw scores on Total RD indices in particular suggested that, when assessed using the nonparametric method, performance was significantly higher in HD than in AD among individuals in mild and moderate stages of dementia; however, when assessed using the parametric method, HD and AD differences were only observed among individuals in the mild stage of dementia. These findings support our hypothesis that the nonparametric formula for Total RD may more fully account for high FP rates to yield more accurate assessments of Total RD in those who are prone to significantly elevated FP rates, including individuals with AD in the moderate stage of dementia. Moreover, just as FP errors were more strongly correlated with nonparametric Total RD scores than with parametric Total RD scores in the AD group in our previous study, HD and AD group differences on FP errors in the present study more closely corroborated group differences on the nonparametric Total RD index than group differences on the parametric Total RD index (see Table 2). This finding further suggests that relative to the parametric Total RD index, the nonparametric Total RD index may more fully account for high FP rates and, accordingly, be more sensitive to HD and AD differences in yes/no recognition.

Limitations, Future Directions, and Other Considerations

The present study is not without limitations. We acknowledge that a number of demographic and clinical characteristics are typically used to distinguish HD from AD. However, the present findings help to enhance the distinction between the memory disorders associated with HD and AD, and may apply to the assessment of memory disorders associated with other neurodegenerative conditions (such as others involving primarily subcortical-frontal or medial-temporal involvement). Moreover, it may be useful to examine the incremental utility of the nonparametric (versus parametric) Total RD index relative to other CVLT-3 variables in distinguishing between individuals with HD versus AD. Furthermore, while the present study utilized a cross-sectional design and there were no observed group differences between individuals in mild versus moderate stages of dementia among those with HD or those with AD, it may be useful to examine and compare nonparametric and parametric Total RD scores and their correlations with functional status while tracking the course of neurodegenerative processes in HD and AD across the wider spectrum of mild to severe impairment.

The literature suggests that many individuals with HD or AD are affected by depression (Alzheimer’s Association, 2019; Paulsen et al., 2005). The present study was conducted using archival data and we did not have access to information regarding the number or proportion of participants in the sample who carried a diagnosis of a mood disorder.

However, we encourage future studies to examine or account for potential influences of mood on cognition in HD or AD more closely. We also acknowledge that sample size (particularly that of HD participants with moderate dementia) may impact the generalizability of our findings. Additionally, as we compare our present findings to those we reported in our previous work (Graves et al., 2017), it is worth noting that the CVLT-3 scaled scores we examined in the present study corrected for age, whereas the CVLT-II standardized (*z*-) scores examined in our previous study corrected for age and gender (note: controlling for gender would not have significantly impacted results in the present study). Finally, while we must acknowledge that clinical judgments about recognition memory and other aspects of cognitive function are often based on standardized scores, the present findings highlight that examining raw scores (in addition to standardized scores) may provide useful information. We encourage readers to take the issues noted above into consideration when interpreting the present results.

Conclusion

Although the memory profiles of HD and AD have been well characterized, the present findings provide further evidence that the degree to which yes/no recognition is shown to differ between these populations may depend on the manner in which FP errors are incorporated into assessments of yes/no recognition. Of note, the CVLT-3 nonparametric Total RD index – in more fully accounting for high FP rates – may be more sensitive than the parametric Total RD index to HD and AD differences in yes/no recognition across mild and moderate stages of dementia. The present results bolster our previous findings and highlight the utility of examining nonparametric (in addition to parametric) Total RD on the CVLT-3 in assessments and comparisons of yes/no recognition involving clinical populations that are prone to high FP rates.

Acknowledgements and Disclosure of Interest

Dean C. Delis, Ph.D. is a co-author of the CVLT and receives royalties for the test. D.P.S. is a paid consultant for Aptinyx and Takeda Pharmaceuticals. M.W.B. receives royalties from Oxford University Press and is a paid consultant for Eisai, Novartis, and Roche Pharmaceuticals. There are no other conflicts of interest to be declared by any authors. This work was supported, in part, by National Institutes of Health (NIH) grants R01 AG034202 and P30 AG059299 to P.E.G., K24 AG026431 and R01 AG049810 to M.W.B., and P50 AG005131 to the Shiley-Marcos Alzheimer's Disease Research Center, and a Huntington's Disease Society of America Center of Excellence grant to J.C.B.

References

Alzheimer's Association. (2019). Alzheimer's disease facts and figures. Alzheimer's & Dementia, 15(3), 321–387.

Budson AE, & Kowall NW (2013). Handbook of Alzheimer's disease and other dementias. Hoboken, NJ: Wiley-Blackwell.

Butters N, Wolfe J, Martone M, Granholm E, & Cermak LS (1985). Memory disorders associated with Huntington's disease: Verbal recall, verbal recognition, and procedural memory. Neuropsychologia, 23, 729–743. [PubMed: 2934642]

Butters N, Delis DC, & Lucas J (1995). Clinical assessment of memory disorders in amnesia and dementia. Annual Review of Psychology, 46, 493–523.

Delis DC, Kramer JH, Kaplan E, & Ober BA (1987). California Verbal Learning Test. San Antonio, TX: The Psychological Corporation.

Delis DC, Kramer JH, Kaplan E, & Ober BA (2000). California Verbal Learning Test–II, Second Edition. San Antonio, TX: The Psychological Corporation.

Delis DC, Kramer JH, Kaplan E, & Ober BA (2017). California Verbal Learning Test–3, Third Edition. San Antonio, TX: The Psychological Corporation.

Delis DC, Massman PJ, Butters N, Salmon DP, Cermak LS, & Kramer JH (1991). Profiles of demented and amnesic patients on the California Verbal Learning Test: Implications for the assessment of memory disorders. Psychological Assessment: A Journal of Consulting and Clinical Psychology, 3, 19–26.

Delis DC, Wetter SR, Jacobson MW, Peavy G, Hamilton J, Gongvatana A, … & Salmon DP (2005). Recall discriminability: Utility of a new CVLT-II measure in the differential diagnosis of dementia. Journal of the International Neuropsychological Society, 11, 708–715. [PubMed: 16248906]

Fine EM, Delis DC, Wetter SR, Jacobson MW, Hamilton JM, Peavy G, … & Salmon DP (2008). Identifying the “source” of recognition memory deficits in patients with Huntington’s disease or Alzheimer’s disease: Evidence from the CVLT-II. Journal of Clinical and Experimental Neuropsychology, 30(4), 463–470. [PubMed: 18415887]

Graves LV, Holden HM, Woods SP, Delano-Wood L, Bondi M, Salmon DP, … & Gilbert PE (2017). Total recognition discriminability in Huntington’s and Alzheimer’s disease. Journal of Clinical and Experimental Neuropsychology, 39(2), 120–130. [PubMed: 27441951]

Jurica PJ, Leitten S, Mattis S (2001). Dementia Rating Scale-2: Professional manual. Lutz, FL: Psychological Assessment Resources.

Kramer JH, Delis DC, Blusewicz MJ, Brandt J, Ober BA, & Strauss M (1988). Verbal memory errors in Alzheimer’s and Huntington’s dementias. Developmental Neuropsychology, 4, 1–15.

Macmillan NA, & Creelman DC (1991). Detection theory: A user’s guide. New York: Cambridge University Press.

Mattis S (1988). Dementia Rating Scale: Professional manual. Lutz, FL: Psychological Assessment Resources.

McKhann G, Drachman D, Folstein M, Katzman R, Price D & Stadlan M (1984). Clinical diagnosis of Alzheimer’s disease: Report of the NINCD–ADRDA work group. Neurology, 34, 939–944. [PubMed: 6610841]

McKhann GM, Knopman DS, Chertkow H, Hyman BT, Jack CR Jr., Kawas CH, … & Phelps CH (2011). The diagnosis of dementia due to Alzheimer’s disease: Recommendations from the National Institute on Aging – Alzheimer’s Association workgroup. Alzheimer’s & Dementia, 7, 263–269.

Paulsen JS, Nehl C, Ferneyhough Hoth K, Kanz JE, Benjamin M, Conybeare R, … & The Huntington Study Group. (2005). Depression and stages of Huntington’s disease. The Journal of Neuropsychiatry and Clinical Neurosciences, 17(4), 496–592. [PubMed: 16387989]

Salmon DP, & Bondi MW (2009). Neuropsychological assessment of dementia. Annual Review of Psychology, 60, 257–282.

Underwood BJ (1974). The role of the association in recognition memory. Journal of Experimental Psychology Monographs, 102, 917–939.

Table 1.

Frequency, mean (standard deviation), and percentage values on demographic variables and Dementia Rating Scale (DRS)/DRS-2 scores in the Huntington's disease-mild (HD-mild), Huntington's disease-moderate (HD-mod), Alzheimer's disease-mild (AD-mild), and Alzheimer's disease-moderate (AD-mod) groups.

Variable	HD-mild	HD-mod	AD-mild	AD-mod
n	39	16	25	27
Age	49.62 (11.55)	50.00 (12.22)	75.28 (4.84)	78.67 (5.02)
% Female	66.67	56.25	40.00	33.33
Education	14.15 (2.32)	14.19 (2.29)	15.44 (2.89)	15.22 (3.39)
DRS/DRS-2 Total	129.36 (5.29)	113.31 (6.72)	126.88 (3.79)	112.70 (4.11)

Table 2.

Descriptive [mean (standard deviation)] statistics and pairwise comparisons on raw and scaled scores on CVLT-3 Yes/No Recognition variables in the Huntington's disease-mild (HD-mild), Huntington's disease-moderate (HD-mod), Alzheimer's disease-mild (AD-mild), and Alzheimer's disease-moderate (AD-mod) groups.

Variable	HD-mild	HD-mod	AD-mild	AD-mod	Pairwise comparisons
Raw Scores					
Hits	12.28 (3.04)	10.63 (3.74)	11.64 (3.09)	11.11 (2.99)	N/A
Total FP errors	7.13 (6.17)	8.00 (5.93)	13.68 (6.81)	15.59 (6.17)	HD-mild > AD-mild, AD-mod; HD-mod > AD-mod
Nonparametric Total RD	77.46 (12.85)	72.13 (12.25)	62.40 (13.01)	57.33 (11.80)	HD-mild > AD-mild, AD-mod; HD-mod > AD-mod
Parametric Total RD	1.77 (0.82)	1.30 (0.77)	0.92 (0.67)	0.64 (0.65)	HD-mild > AD-mild, AD-mod
Scaled Scores					
Hits	6.62 (3.18)	5.13 (2.60)	7.68 (3.31)	7.19 (2.98)	N/A
Total FP errors	6.97 (3.09)	6.56 (3.01)	4.92 (2.72)	4.37 (2.79)	HD-mild > AD-mild, AD-mod
Nonparametric Total RD	6.15 (2.84)	4.94 (2.41)	4.28 (2.53)	3.70 (2.11)	HD-mild > AD-mild, AD-mod
Parametric Total RD	5.77 (2.59)	4.37 (2.06)	4.52 (2.20)	4.11 (2.21)	HD-mild > AD-mod

Note: ">" signifies better performance.