Applied Neuropsychology: Adult

ISSN: (Print) (Online) Journal homepage: www.tandfonline.com/journals/hapn21

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To cite this article: Liselotte De Wit, Felicia C. Goldstein & David W. Loring (29 Dec 2022): Clinical value of the Montreal Cognitive Assessment free recall condition alone versus cued recall and recognition conditions to detect true memory impairment, Applied Neuropsychology: Adult, DOI: 10.1080/23279095.2022.2161050

To link to this article: https://doi.org/10.1080/23279095.2022.2161050

APPLIED NEUROPSYCHOLOGY: ADULT
https://doi.org/10.1080/23279095.2022.2161050

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Clinical value of the Montreal Cognitive Assessment free recall condition alone versus cued recall and recognition conditions to detect true memory impairment

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ABSTRACT

The Montreal Cognitive Assessment (MoCA) is widely used as a screener to characterize cognition. Although only the delayed free recall condition is required for administration, performance on the optional cued recall and multiple-choice recognition conditions may improve diagnostic accuracy over free recall alone. Data on 719 individuals with MCI and 601 controls were obtained from the Alzheimer's Disease Neuroimaging Initiative (ADNI) database. The Rey Auditory Verbal Learning Test (AVLT) delayed free recall condition was used as the gold standard of memory status. Participants with *T*-scores $\leq$30 ($\leq$2 *SD*s below the mean) were classified as memory "impaired." Binary logistic regressions assessed if combined MoCA cued recall/recognition predicted impaired delayed recall on the AVLT beyond the contribution of MoCA free recall. Results showed that MoCA free recall predicted AVLT delayed recall, and that the addition of combined MoCA cued recall/recognition improved the ability to detect impaired AVLT recall, with a better overall model fit. The combined MoCA cued recall/recognition score also had higher specificity and likelihood ratios in detecting memory impairment than MoCA free recall, while higher sensitivity values were present for free recall. Thus, the additional administration of the MoCA cued recall and recognition is recommended.

KEYWORDS

Aging; learning; memory; neuropsychology diagnosis; neuropsychology tests

Introduction

The Montreal Cognitive Assessment (MoCA) is widely used as a brief cognitive screening tool that assesses multiple domains including visuoconstructional ability, executive functioning, language, memory, attention, and orientation (Nasreddine et al., 2005). MoCA scores range from 0 to 30 points, with higher scores representing more intact function. The Memory Index Score (MIS) was developed as a supplemental MoCA score that not only includes free recall, but also cued recall during which category cues are provided when words are not freely recalled, and recognition during which a multiple choice format of three answers is provided when cued recall is unsuccessful (Julayanont & Nasreddine, 2017). Results of the study by Julayanont et al. showed that both the MoCA total score and the Memory Index Score were strong predictors of conversion from mild cognitive impairment (MCI) to Alzheimer's disease (AD) over a follow-up of approximately 18 months (Julayanont et al., 2014). However, we are unaware of formal contrasts comparing the traditional 5 item MoCA free recall with the 15 item MIS, and although this MIS was developed to elicit and characterize encoding impairment, any benefit of MIS may simply be related to improved psychometrics associated with a greater behavior sample. For example, while there are multiple task differences between the CERAD memory test and CVLT, the longer CVLT was associated with significantly lower z-scores compared to the CERAD word list in a mixed clinical group of MCI and AD (Beck et al., 2012).

When using the MoCA for cognitive screening, test sensitivity and specificity should be maximized since diagnostic accuracy is important for ensuring appropriate follow-up. Because free recall contributes to the total MoCA score, and administration of cued recall and recognition conditions are optional, the latter are not routinely obtained in many settings despite potential diagnostic advantages in characterizing additional aspects of memory beyond free recall ability. For example, recognition memory helps distinguish encoding from retrieval impairments and may assist in differentiating Alzheimer's disease (AD) from other etiologies. Patients with cognitive impairment due to frontal-subcortical dysfunction (e.g., small vessel disease, Parkinson's disease) tend to exhibit better recognition memory performance than patients with AD (Hildebrandt et al., 2013; Pillon et al., 1993; Tierney et al., 2001; Traykov et al., 2002). In addition, free recall may be negatively influenced by anxiety and depression (Brand et al., 1992; Eysenck, 1979) and can impact free recall to a greater extent than recognition memory, possibly reflecting the effortful demands of search and retrieval processes (Smith et al., 2014).

In the present study, we examined the contribution of the combined MoCA cued recall/recognition score beyond

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free recall alone in predicting memory impairment as determined by performance on the Rey Auditory Verbal Learning Test (AVLT) in individuals with Mild Cognitive Impairment and cognitively unimpaired controls. We also report sensitivity, specificity, and likelihood ratios for MoCA free recall scores and combined MoCA cued recall and recognition scores. We hypothesized that the combined MoCA cued recall/recognition score would significantly predict memory impairment beyond the free recall score and would have better AVLT classification accuracy as reflected by better specificity and higher likelihood ratios when compared to MoCA free recall alone.

Materials and methods

Participants

Data were obtained from the Alzheimer's Disease Neuroimaging Initiative (ADNI) database (adni.loni.usc.edu). ADNI (www.adni-info.org) was launched in 2003 as a public-private partnership, led by Principal Investigator Michael Weiner, MD, with the goal to test whether serial magnetic resonance imaging, positron emission tomography, other biological markers, and clinical and neuropsychological assessment can be combined to measure and predict the progression of MCI and Alzheimer's disease (AD). Criteria for participation include age between 55 and 90 years, at least 6 years of education, fluency in English/Spanish, and Geriatric Depression Scale Short Form (Yesavage & Sheikh, 1986) scores less than 6 points. Additional inclusion/exclusion criteria of ADNI can be found on https://adni.loni.usc.edu/methods/documents/.

Participants were included if they were classified in the ADNI database as cognitively normal or as having MCI. Early cognitive changes are underrecognized in primary care settings (Sabbagh et al., 2020; Stewart, 2012) and therefore the focus was on individuals with MCI, rather than dementia, who might escape detection by their providers. Cognitive status is based on a screening battery that includes the Clinical Dementia Rating (CDR; Morris, 1997) the Mini-Mental State Examination (MMSE; Folstein et al., 1975) and the Logical Memory subtest from the Wechsler Memory Scale-Revised (Wechsler, 1987). Cognitively unimpaired controls have CDR Global Scores of 0, MMSE scores between 24 and 30 and have education adjusted Logical Memory raw scores above specific education-adjusted cutoffs (Delayed Paragraph A only; $\geq$9 story units for 16 or more years of education; $\geq$5 story units for 8–15 years of education; $\geq$3 story units for 7 or fewer years of education), and have intact instrumental activities of daily living. Participants with MCI have subjective memory concerns or concerns noted by their partner, MMSE scores between 24–30, CDR Global Scores of 0.5, and have education adjusted Logical Memory raw scores based on the following cutoffs (Delayed Paragraph A only; $\leq$11 story units for 16 or more years of education; $\leq$9 story units for 8–15 years of education; $\leq$6 story units for 7 or fewer years of education), and relatively intact instrumental activities of daily living such that a diagnosis of dementia cannot be made.

Measures

Rey auditory verbal learning test (AVLT)

The Rey Auditory Verbal Learning Test (AVLT; Rey, 1964) was used as the criterion of impaired memory. The AVLT is a list learning task in which individuals are asked to learn a semantically unrelated word list of 15 words over five trials. After the fifth trial, a new list of 15 words is presented for a single learning trial (List B), followed by free recall of the original 15 items (List A). The delayed free recall score reflects how many items of original List A the individual remembers after ~30 minutes. The AVLT delayed free recall score was used to classify memory as either normal or impaired.

The Mayo Normative Studies (MNS) was used to classify AVLT performance as normal or impaired (Stricker et al., 2021). Based on the MNS norms, AVLT delayed free recall scores were transformed to *T*-scores that were demographically corrected for age, education, and sex.

MoCA memory scores

The MoCA free recall score consists of a maximum of five points, with one point awarded for each of five correctly recalled words. The combined MoCA cued recall/recognition score computed for the current study also consisted of five points to provide a variable with an equal amount of variance as the MoCA free recall variable. One point was given for each word correctly recalled during either free recall, cued recall, or recognition, and zero points was given for a word that was not correctly recalled across the three memory conditions. For example, if a person freely recalled a previously presented word, they were awarded one point for the free recall condition and one point for the cued recall/recognition condition. If they did not freely recall a word, then they were awarded 0 points for the free recall condition and one point if they correctly retrieved that word via cued recall or recognition.

Procedure

Scores from the first baseline ADNI study visit were used for both the MoCA and the AVLT. Both tests were administered during the same visit.

Statistical analyses

Analyses were performed in IBM SPSS Statistics 24 (Armonk, 2007). AVLT delayed free recall was dummy coded to impaired vs. not impaired based on *T*-scores of $\leq$30 (two standard deviations or more below the mean), which is often used in clinical practice (Guilmette et al., 2020). A stepwise binary logistic regression analysis was conducted to examine the MoCA free recall score and combined MoCA cued recall and recognition score as predictors of memory impairment on the AVLT delayed free recall condition. With the first step, MoCA free recall as well as covariates (age, years of education, and sex) were included. With the second step, the combined MoCA cued recall and

recognition was added to the model to assess improvements in model fit.

In a second set of analyses, sensitivity, specificity, and likelihood ratios were calculated for both the MoCA free recall and the combined MoCA cued recall/recognition scores. Likelihood ratios combine sensitivity and specificity scores, and thus help to prevent misinterpretation of scores and to refine clinical judgment (Grimes & Schulz, 2005).

Results

Demographic features and cognitive test scores of the 719 controls and 601 MCI participants are presented in Table 1. A Pearson Chi-square test showed that there were more women among controls and more men among participants with MCI $\chi^2(1)=32.0$), $p<.001$. *T*-tests showed that there were no significant differences between groups in age ($t(1315)=1.0$, $p=0.339$) and that level of education was higher in controls ($t(1317)=4.1$, $p<0.001$). *T*-tests also showed that controls scored significantly higher on MoCA free recall ($t(1177)=14.8$, $p<0.001$) and combined MoCA cued recall and recognition ($t(1195)=13.8$, $p<0.001$) conditions.

Stepwise binary logistic regression analyses showed that, while controlling for age, years of education, and sex, MoCA memory free recall predicted AVLT memory impairment ($b=-1.207$, Wald χ^2 $(1)=128.044$, $p<0.001$). Specifically, for every additional word successfully recalled on MoCA free recall, the likelihood of having impaired AVLT memory decreased by 70% (Odds Ratio (OR)=0.299, 95% CI = [0.243, 0.369]).

The regression analysis' Omnibus Tests of Model Coefficients showed that the addition of the combined MoCA cued recall and recognition score significantly improved the model fit when compared to the model with only MoCA free recall and covariates ($\chi^2(1)=30.616$, $p<.001$). Importantly, while controlling for MoCA free recall as well as other covariates specified above, the combined MoCA cued recall/recognition score also significantly predicted AVLT memory impairment ($b=-0.400$, Wald χ^2 $(1)=29.834$, $p<0.001$), such that for every additional word on combined MoCA cued recall/recognition, the likelihood of being in the AVLT memory impairment group, relative to unimpaired people, decreased by 33% (OR = 0.670, 95% CI = [0. 581, 0.774]).

Table 1. Participant demographics and MoCA Memory Scores.

	Controls ($n=719$)		MCI ($n=601$)	
	Mean	*SD*	Mean	*SD*
Age	71.8	6.3	72.1	7.5
Education	16.7	2.4	16.1	2.6
Sex (*n*, %)	59.2% Female		43.5% Female	
Ethnicity (*n*, %)	5.8% Hispanic/ Latino		3.9% Hispanic/ Latino	
Race (*n*, %)				
American Indian/Alaskan Native	0.3%		0.0%	
Asian	3.2%		1.7%	
Native Hawaiian or other Pacific Islander	0.0%		0.4%	
Black/African American	7.7%		4.5%	
White	86.7%		91.5%	
More than 1 race	2.0%		1.1%	
Unknown	0.2%		0.7%	
MoCA Total Score	26.1	2.7	21.2	4.5
MoCA FR Score	2.5	1.8	1.1	1.5
MoCA CR/Rec. Score	4.6	0.8	3.7	1.4

Note: *SD*: standard; CR/Rec: combined MoCA cued recall/recognition.

Sensitivity, specificity, and likelihood ratios

The likelihood ratios, sensitivity and specificity are presented in Table 2. The sensitivity values overall are higher for the MoCA free recall score compared to combined MoCA cued recall/recognition score. However, both the specificity and the likelihood ratios are higher for combined cued recall/recognition than for free recall.

Other impairment criteria

To assess if the results would differ when using different AVLT delayed free recall cutoffs for what was considered to be impaired vs. not impaired, the analyses were rerun using *T*-scores of ≤40 and of ≤35 (1 standard deviation, and 1.5 standard deviation below the mean, respectively) as cutoffs of AVLT delayed free recall impairment. The pattern of results in terms of regression analyses as well as sensitivity, specificity, and likelihood ratios remained the same using these cutoffs.

Discussion

Cognitive screening is an important component of routine medical evaluation of older adults by identifying individuals needing more detailed evaluation to assist in establishing formal diagnosis and providing the opportunity for appropriate treatment and intervention. The MoCA has been demonstrated to be a valuable screening measure, as it has found to be more sensitive (though less specific) than the Mini Mental State Examination (MMSE; Larner, 2012) and because it provides a more in-depth evaluation of memory. Specifically, the memory component has been expanded when compared to the MMSE, with two learning trials of 5 rather than 3 words. While free recall of the 5 words is included in the total score, optional memory performance measures do not contribute to the overall score and are often not administered as part of routine clinical practice. Results of the current study demonstrated that the combined

Table 2. Likelihood ratio, sensitivity, and specificity values of the MoCA free recall and MoCA Recognition Scores.

	AVLT delayed free recall demographically-adjusted $T\leq 30$		
MoCA	LRs	Sensitivity	Specificity
FR: ≤4	1.1	1.0	0.1
FR: ≤3	1.3	0.9	0.3
FR: ≤2	1.5	0.9	0.4
FR: ≤1	1.9	0.0	1.0
CR/Rec: ≤4	1.6	0.6	0.7
CR/Rec: ≤3	2.4	0.3	0.9
CR/Rec: ≤2	3.6	0.3	0.9
CR/Rec: ≤1	3.1	0.1	1.0

Note: FR: MoCA Free Recall Score; LR: likelihood ratio; MoCA: Montreal Cognitive Assessment; Recog: MoCA Recognition Score; the shaded area displays the MoCA Free Recall Scores, which are part of the MoCA total score.

MoCA cued recall/recognition score improves the ability to detect memory impairment, as shown by a better overall model fit when adding combined the MoCA cued recall/recognition score as a variable. The combined MoCA cued recall/recognition score also had higher specificity and likelihood ratios in detecting memory impairment than the MoCA free recall score, while higher sensitivity values were present for free recall.

The finding of the current study that MoCA free recall significantly predicts AVLT memory impairment provides convergent validation, which is not surprising given that both measures include verbal learning and memory items. However, one of the limitations of MoCA free recall is that it is based upon a limited number of 5 stimulus words, and consequently will be associated with poorer psychometric characteristics than longer measures such as the AVLT, which not only include 15 words, but has five administration trials that permits better learning and encoding (rather than memory) and will have better reliability/validity (Bernstein, 1994). Because there are additional trials associated with optional MoCA memory scores, it is possible that improved memory characterization may result simply from the large item response set. The larger number of items used to assess any construct provides more reliable ability measures, and in the present context, more memory items will provide a more stable estimate of memory performance. This is particularly true for scores surrounding performance threshold used to characterize impaired vs. normal ability.

In addition to greater behavioral sampling, it is also possible that inclusion of recognition memory testing provides a more representative/accurate metric of memory function. Although the distinction between free recall and recognition, the so called "retrieval deficit hypothesis," is sometimes considered to be a marker of disease related memory inefficiency (Higginson et al., 2005; Weintraub et al., 2004), this discrepancy occurs quite frequently in normal aging, particularly after age 65 years (Loring et al., 2022), and by including cued and recognition performance as part of a general memory score, a more stable and accurate estimate of true memory ability is obtained.

The results of the current study indicated that the MoCA cued recall and recognition conditions provide increased precision in classifying AVLT defined memory impairment compared to MoCA free recall alone as reflected by the improved model fit. When examined on an individual classification basis, MoCA cued recall and recognition resulted in better specificity and likelihood ratios than MoCA free recall, while free recall had higher sensitivity values. These results are consistent with previous studies that have highlighted improved diagnostic accuracy of the additional memory scores of the MoCA (Julayanont et al., 2014) and other studies that showed discrepancies between free recall and cued recall or recognition (Pillon et al., 1993; Tierney et al., 2001; Traykov et al., 2002). While results from this study as well as abovementioned studies show an improved ability to detect memory impairment by including cued recall and recognition, this is particularly useful for behavioral classification and staging (e.g., Bruijnen et al., 2021), with future studies addressing whether patterns across the 3 conditions comprising the MIShave potential etiological relevance.

It is not surprising that free recall is associated with high sensitivity to memory impairment since there are multiple factors that can influence performance including all conditions impacting the encoding and retention memory processes (e.g. AD, medial temporal lobe epilepsy) and all conditions impacting retrieval (e.g. conditions impacting the frontal-subcortical, depression, and anxiety; Brand et al., 1992; Eysenck, 1979; Hildebrandt et al., 2013; Pillon et al., 1993; Tierney et al., 2001; Traykov et al., 2002).

When using the MoCA as *a cognitive screening tool*, test sensitivity is important to identify patients needing appropriate management. However, cued recall and recognition memory conditions help distinguish encoding and retention deficits from retrieval deficits, and help distinguish the impact of anxiety and depression which may have greater performance effects during the initial stages of cognitive testing (Brand et al., 1992; Eysenck, 1979). Our findings demonstrate better specificity for MoCA combined cued recall and recognition scores. Thus, while standard MoCA memory testing appears sufficient to identify clinically meaningful memory impairment as established by the AVLT, it will overestimate memory impairment by itself and may suggest the need for further evaluation when that may be unnecessary. The time required for these optional MoCA memory components is minimal, and we suggest that they be included as part of routine clinical administration.

Limitations

A limitation of the database we used is that ADNI participants are screened to have Alzheimer's disease as the likely primary etiology. Therefore, results should be replicated in patients with other etiologies of memory impairment in order to evaluate the potential clinical utility of the supplemental memory conditions in assisting with differential diagnosis. The role of language-related weakness such as word-finding difficulties should also be explored for determining their impact on MoCA combined cued recall recognition conditions as opposed to free recall alone to help distinguish between language-based versus memory-based retrieval difficulties.

Another limitation includes using the AVLT alone as a measure of memory impairment. Future studies should assess if the current findings generalize to impairment on other list learning tasks or contextual memory measures such as story recall. In addition, it is unclear how these results obtained in a large research trial would generalize to a clinical setting where performance anxiety may be higher. Future research should therefore also assess how performance anxiety would impact MoCA combined cued recall recognition conditions as opposed to free recall in both clinical and research settings. However, given the impact of anxiety on free recall performance, we expect that an even stronger benefit of including MoCA combined cued recall recognition conditions will be found in a clinical setting.

Conclusions

MoCA combined cued recall recognition conditions are optional and are not routinely administered across clinical settings. Results of the current study highlight the diagnostic advantages of including these supplemental conditions given their increased accuracy in detecting memory impairment. Future studies should assess if the current results generalize to administration in clinical practice.

Acknowledgments

The grantee organization is the Northern California Institute for Research and Education, and the study is coordinated by the Alzheimer's Therapeutic Research Institute at the University of Southern California. ADNI data are disseminated by the Laboratory for Neuro Imaging at the University of Southern California.

Disclosure statement

No potential conflict of interest was reported by the author(s).

Funding

Data collection and sharing for this project was funded by the Alzheimer's Disease Neuroimaging Initiative (ADNI) (National Institutes of Health Grant U01 AG024904) and DOD ADNI (Department of Defense award number W81XWH-12-2-0012). ADNI is funded by the National Institute on Aging, the National Institute of Biomedical Imaging and Bioengineering, and through generous contributions from the following: AbbVie, Alzheimer's Association; Alzheimer's Drug Discovery Foundation; Araclon Biotech; BioClinica, Inc.; Biogen; Bristol-Myers Squibb Company; CereSpir, Inc.; Cogstate; Eisai Inc.; Elan Pharmaceuticals, Inc.; Eli Lilly and Company; EuroImmun; F. Hoffmann-La Roche Ltd and its affiliated company Genentech, Inc.; Fujirebio; GE Healthcare; IXICO Ltd.; Janssen Alzheimer Immunotherapy Research & Development, LLC.; Johnson & Johnson Pharmaceutical Research & Development LLC.; Lumosity; Lundbeck; Merck & Co., Inc.; Meso Scale Diagnostics, LLC.; NeuroRx Research; Neurotrack Technologies; Novartis Pharmaceuticals Corporation; Pfizer Inc.; Piramal Imaging; Servier; Takeda Pharmaceutical Company; and Transition Therapeutics. The Canadian Institutes of Health Research is providing funds to support ADNI clinical sites in Canada. Private sector contributions are facilitated by the Foundation for the National Institutes of Health (www.fnih.org).

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Data availability statement

Data used in preparation of this article were obtained from the Alzheimer's Disease Neuroimaging Initiative (ADNI) database (adni.loni.usc.edu). As such, the investigators within the ADNI contributed to the design and implementation of ADNI and/or provided data but did not participate in analysis or writing of this report. A complete listing of ADNI investigators can be found at: http://adni.loni.usc.edu/wp-content/uploads/how_to_apply/ADNI_Acknowledgement_List.pdf.

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