

Assessment of age-related differences in functional capacity using the Virtual Reality Functional Capacity Assessment Tool (VRFCAT)

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BACKGROUND

Reliable evaluation of cognitive performance and functional capacity is critical to the effective assessment of mental health in aging individuals. The Virtual Reality Functional Capacity Assessment Tool (VRFCAT) was developed as a direct performance-based assessment of functional capacity that is sensitive to changes in function across multiple populations.

Using a realistic virtual reality environment, the VRFCAT assesses a subject's ability to complete instrumental activities associated with a shopping trip, including searching the pantry at home, making a list, taking the correct bus, shopping in a store, paying for the purchases, and returning home. The VRFCAT includes multiple forms, to allow for repeated testing with minimal practice effects. In previous studies, the VRFCAT has demonstrated high test-retest reliability and has shown sensitivity to functional impairment (Ruse et al., 2014).

The primary aims of the present study were to (1) assess the sensitivity of the VRFCAT to functional declines associated with normal aging, (2) examine the relationship between VRFCAT performance and cognitive function in both young and older adults, and (3) to examine age differences in the relationship between functional and cognitive measures.

VRFCAT SCREENSHOTS



METHODS

SUBJECTS

- Participants included 44 healthy Young Adults (YA) ages 18-30 (24 male, 20 female), and 41 healthy Older Adults (OA) ages 55-70 (17 male, 24 female).
- Subjects were recruited from the University of California- San Diego, the University of Miami Miller School of Medicine, and the University of South Carolina.
- Participants provided detailed information regarding computer use and experience.
 - 100% of YAs and 90% of OAs indicated a high level of familiarity and comfort with computers.

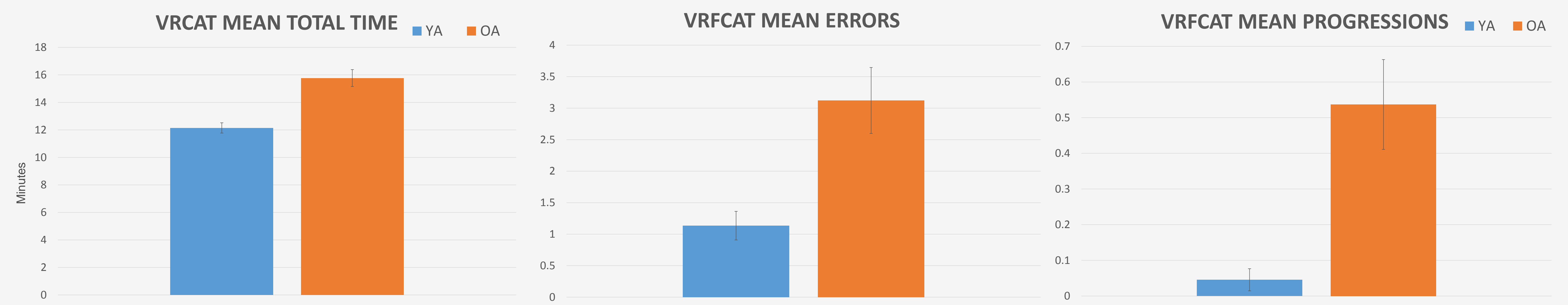
PROCEDURE

- Functional capacity was assessed with both the VRFCAT and the UPSA-2-VIM, which is a standard rater-administered performance-based measure of functional capacity utilizing physical props and materials.
- Randomized alternate forms of the VRFCAT were administered at Visit 1 and Visit 2.
- Cognitive performance was assessed using the MATRICS Consensus Cognitive Battery (MCCB) which assesses speed of processing, attention, working memory, verbal learning, visual learning, reasoning and problem solving, and social cognition.
- Key outcome measures for the VRFCAT included (1) Total Time to complete all objectives, (2) Errors, and (3) Forced Progressions, which occur following repeated failure at a given task.
- Analyses examined age differences in performance as well as correlations between functional and cognitive outcomes.

	YA (N = 44)	OA (N = 41)	p value	Cohen's d
Age, Mean (SD)	25.8 (3.47)	60.81 (4.38)	< 0.001	-
UPSA-2-VIM, Mean (SD)	84.4 (8.63)	83.2 (8.88)	NS	0.1
VRFCAT Total Time in minutes, Mean (SD)	12.1 (2.47)	15.8 (3.93)	< 0.001	1.1
VRFCAT Total Errors	1.1 (1.50)	3.1 (3.35)	< 0.001	0.8
VRFCAT Total Progressions	0.0 (0.21)	0.5 (0.81)	< 0.001	0.9

NOTE: Age-normalized MNCB composite T scores were 44.9 (12.17) and 43.1 (13.62) for YA and OA, respectively.

RESULTS



EFFECTS OF AGING ON MEASURES FUNCTIONAL CAPACITY

- VRFCAT demonstrated strong age-related differences in performance on total completion time, total errors, and total forced progressions ($p < .001$ for all).
- UPSA total score was not sensitive to differences between age groups ($p > .1$).
- UPSA total score was strongly correlated with VRFCAT Total Time in both groups ($r = -.72$ for YA, $r = -.81$ for OA, $p < .0001$ for both), suggesting the measures assess similar constructs.

RELATIONSHIP TO COGNITIVE FUNCTION

- VRFCAT demonstrated strong correlations with cognitive performance across both age groups.
 - Negative correlation between verbal working memory (Letter Number Span) and both VRFCAT Total Time and VRFCAT Errors in both YAs and OAs ($p < .001$ for all).
- In OAs, declines in verbal learning (HVLt total learning) and visual learning (BVMT total learning) were associated with an increase in the number of reminders required during the VRFCAT assessment (i.e. checking the bus schedule).

VRFCAT RELIABILITY AND PRACTICE EFFECTS

- VRFCAT Total Time demonstrated strong test retest reliability, $ICC = .78$ for OAs and $ICC = .62$ in YAs.
- VRFCAT demonstrated small, insignificant practice effects in both OAs and YAs.
- UPSA Total Score demonstrated large practice effects in both OAs and YAs, suggesting this measure may not be suitable for repeat testing in these healthy subject groups.

PEARSON CORRELATION COEFFICIENTS BETWEEN THE VRFCAT, UPSA-2-VIM & MCCB Subtests

	VRFCAT Time	VRFCAT Errors	VRFCAT Progressions	UPSA-2-VIM	TMT	BACSSC	HVLt	WMSIII	LNS	NAB	BVMT	Fluency	MSCEIT	CPT	MCCB
VRFCAT Time		0.84	0.55	-0.72	-0.18	-0.37	-0.54	-0.5	-0.52	-0.43	-0.46	-0.44	-0.73	-0.61	-0.79
VRFCAT Errors	0.9		0.64	-0.59	-0.09	-0.4	-0.5	-0.38	-0.46	-0.35	-0.45	-0.25	-0.59	-0.47	-0.67
VRFCAT Progressions	0.86	0.86		-0.35	-0.12	-0.21	-0.26	-0.21	-0.24	-0.08	-0.28	-0.18	-0.33	-0.37	-0.37
UPSA-2-VIM	-0.6	-0.58	-0.62		0.17	0.39	0.66	0.46	0.59	0.48	0.58	0.49	0.53	0.54	0.79
TMT	-0.46	-0.45	-0.39	0.5		0.24	-0.02	0.32	0.13	0.39	0.05	-0.01	0.16	0.2	0.31
BACSSC	-0.48	-0.45	-0.44	0.61	0.45		0.31	0.45	0.39	0.27	0.52	0.2	0.3	0.63	0.66
HVLt	-0.48	-0.39	-0.35	0.43	0.35	0.35		0.21	0.3	0.18	0.49	0.62	0.37	0.27	0.6
WMSIII	-0.5	-0.53	-0.4	0.64	0.39	0.53	0.35		0.47	0.42	0.39	0.2	0.28	0.47	0.62
LNS	-0.63	-0.59	-0.57	0.57	0.59	0.51	0.54	0.59		0.15	0.43	0.18	0.38	0.58	0.61
NAB	-0.47	-0.43	-0.33	0.43	0.61	0.51	0.38	0.48	0.43		0.27	0.32	0.41	0.36	0.6
BVMT	-0.49	-0.46	-0.43	0.58	0.44	0.64	0.63	0.58	0.59	0.5		0.43	0.5	0.59	0.77
Fluency	-0.34	-0.22	-0.24	0.3	0.41	0.34	0.57	0.35	0.52	0.46	0.51		0.28	0.35	0.55
MSCEIT	-0.29	-0.1	-0.21	0.41	0.2	0.33	0.06	0.33	0.22	0.16	0.22	0.2		0.55	0.74
CPT	-0.45	-0.34	-0.39	0.6	0.42	0.43	0.56	0.63	0.51	0.35	0.43	0.39	0.41		0.81
MCCB Composite	-0.66	-0.55	-0.53	0.73	0.64	0.71	0.71	0.75	0.76	0.68	0.81	0.66	0.48	0.75	

- Correlations highlighted below the diagonal are for the OAs; those above the diagonal are for the YAs; $p < .001$ for all $r > .48$
 - Color coding indicates correlations that differed significantly by Age Group using a Fisher z comparison, $p < .05$.
 - One extreme outlier (an OA) was removed due to a Total Time value that was > 3 SD above the group mean.

NOTE: MCCB Subtests include: Trail Making Test, Part A (TMT); Brief Assessment of Cognition Symbol Coding (BACSSC); Hopkins Verbal Learning Test-Revised (HVLt); Wechsler Memory Scale-III (WMSIII); Letter Number Span (LNS); Neuropsychological Assessment Battery Mazes (NAB); Brief Visuospatial Memory Test - Revised (BVMT); Mayer-Salovey-Caruso Emotional Intelligence Test (MSCEIT); Continuous Performance test-Identical Pairs (CPT).

TEST-RETEST RELIABILITY & PRACTICE EFFECTS FOR THE VRFCAT & UPSA-2-VIM FOR YAs (blue) and OAs (white)

Assessment	Visit 1 Mean (SD)		Visit 2 Mean (SD)		Difference Mean (SD)		Paired t-test p-value		Cohen's d		ICC	
VRFCAT Total Time	12.1 (2.48)	15.3 (3.16)	11.7 (2.45)	15.0 (4.33)	0.4 (1.63)	0.3 (3.32)	NS	NS	0.2	0.2	0.78	0.62
VRFCAT Errors	1.1 (1.46)	2.80 (3.04)	0.9 (1.28)	2.8 (4.65)	0.2 (1.43)	0 (4.19)	NS	NS	0.1	0.07	0.46	0.44
VRFCAT Progressions	0.0 (0.22)	0.5 (0.72)	0.0 (0.22)	0.4 (0.93)	0.0 (0.22)	0.1 (0.82)	NS	NS	0	0.1	0.48	0.52
UPSA-2-VIM	84.8 (8.45)	83.4 (8.98)	87.6 (8.21)	86.2 (9.56)	-2.7 (5.76)	-2.7 (6.58)	$p < .01$	$p < .05$	0.4	0.3	0.72	0.72

- Due to missed visits, sample sizes for test-retest analyses were 42 and 39 for Young Adults and Older Adults, respectively.

CONCLUSIONS

- Assessment of functional capacity in primary prevention and preclinical/prodromal AD trials requires measures with improved sensitivity to changes in non-demented individuals.
- Many studies rely on partner-reported measures that require the availability of a competent informant and lack sensitivity to subtle functional deficits in this population; performance based measures represent a viable alternative.
- The VRFCAT is a reliable performance-based measure with sensitivity to age-related differences in functional capacity.
- 90% of OAs indicated a high degree of familiarity and comfort with computers, indicating computerized testing is appropriate in this population.
- Findings provide preliminary support for the VRFCAT as a sensitive and reliable co-primary measure of functional capacity in primary prevention and prodromal AD trials.

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