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Reading the Mind in the Eyes: A Population-Based Study of Social Cognition in Older Adults

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Abstract

Background—Social cognition indicates the cognitive processes involved in perceiving, interpreting, and processing social information. Although it is one of the six core DSM-5 cognitive domains for diagnosing neurocognitive disorders, it is not routinely assessed in older adults. The

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AUTHOR CONTRIBUTIONS

Soyoung Lee made substantial contributions to the analysis, and interpretation of data for the work; drafting the work and revising it critically for important intellectual content; and gave final approval of the version to be published. She agrees to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. **Erin P. Jacobsen** made substantial contributions to the acquisition, analysis, and interpretation of data for the work; revising it critically for important intellectual content; and gave final approval of the version to be published. She agrees to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. **Yichen Jia** made substantial contributions to the analysis, and interpretation of data for the work; revising the work critically for important intellectual content; and gave final approval of the version to be published. She agrees to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. **Beth E. Snitz** made substantial contributions to the analysis, and interpretation of data for the work; revising it critically for important intellectual content; and gave final approval of the version to be published. She agrees to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. **Chung-Chou H. Chang** made substantial contributions to the analysis, and interpretation of data for the work; revising it critically for important intellectual content; and gave final approval of the version to be published. She agrees to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. **Mary Ganguli** made substantial contributions to the conception and design of the work, the acquisition, analysis, and interpretation of data for the work; revising it critically for important intellectual content; and gave final approval of the version to be published. She agrees to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

DISCLOSURE/CONFLICT OF INTEREST

Dr. Ganguli reports grants from National Institute on Aging during the conduct of the study. Dr. Chang reports grants from National Institute of Health during the conduct of the study. Dr. Lee, Ms. Jia, Ms. Jacobsen, and Dr. Snitz report no conflicts with any product mentioned or concept discussed in this article.

Reading the Mind in the Eyes Test assesses Theory of Mind, the social cognition mechanism which forms the root of empathy.

Objectives—To describe the distribution of, and factors associated with, scores on a 10-item version of Reading the Mind in the Eyes Test [RMET-10] in older adults.

Design—Population-based cross-sectional study.

Setting—Small-town communities in Pennsylvania.

Participants—Adults aged 66 to 105 years (N=902, mean age=76.6).

Measurements—The assessment included RMET-10, demographics, cognitive screening, literacy, depression symptoms, anxiety symptoms, cognitive composites derived from a neuropsychological test battery, Social Norms Questionnaire, and Clinical Dementia Rating [CDR].

Results—RMET-10 score was normally distributed in our overall study sample. Normative RMET-10 scores among those rated as CDR=0 were calculated by age, sex, and education. RMET-10 score was significantly higher with younger age, higher education, white race, higher cognitive screening scores, literacy, social norms scores, higher scores in all five domains in cognitive composites, and lower CDR. RMET-10 score was also significantly higher with fewer depression and anxiety symptoms after adjusting for demographics.

Conclusions—The Reading the Mind in the Eyes Test is a potentially useful measure of social cognition for use in the research assessment of older adults. With appropriate calibration it should also have utility in the clinical setting.

Keywords

aging; Theory of Mind; Reading the Mind in the Eyes Test; community-based; epidemiology; Cognitive empathy

INTRODUCTION

Social cognition indicates the cognitive processes involved in perceiving, interpreting, and processing social information. It integrates perceived social cues with acquired social knowledge and higher-order reasoning to infer the cognitive and emotional status of others, resulting in empathy and ‘Theory of Mind (TOM).’ Social cognition allows individuals to respond to social information appropriately, which is critical to maintain interpersonal relationships, participate in social interactions, and function within society. (1, 2)

Impairment in social cognition can be found in nearly all brain disorders. It is especially recognized in both neurodevelopmental and neurodegenerative disorders with frontal lobe dysfunction, such as autism and frontotemporal dementia, and, increasingly, in other neurocognitive disorders. (3–7) Most studies in social cognition have focused on these disorders; less is known about the integrity of social cognition in normal aging. (2, 4)

However, unlike other cognitive domains, social cognition is not routinely measured in geriatric evaluations. While a number of objective assessment tools are available to index

social cognition, little information is available regarding the performance and utility of those tests in older adults. Further, some social cognition tests that measure social judgment and behavior, such as the Social Norms Questionnaire and the Test of Practical Judgment, are difficult to validate across generational and national/ethnic subgroups because perceptions of normative or appropriate social behavior are heavily based on prevailing culture. (8, 9)

The Reading the Mind in the Eyes Test [RMET] (10) is a popular measure of individual differences in TOM, the most representative mechanism of social cognition, which refers to "cognitive empathy," i.e., the ability to discern the mental states of others. In this assessment, participants are presented with images of only the eye regions of single individuals and are asked to choose which of four words best describes each target's mental state. The relevance of this cognitive function in everyday life has been brought into sharp focus by the global SARS-CoV-2 (COVID-19) pandemic. Near-universal mask-wearing is requiring individuals to ascertain the emotional states and responses of others by looking only at their eyes.

The RMET has been widely used and is one of few TOM tests that have been validated in older adults. (11) Another strength of the test is various abbreviated versions are available (11, 12); brevity is particularly important in the clinical assessment of older patients as well as in large population-based studies, where assessment fatigue is a concern.

The present study aims a) to describe the distribution of the RMET scores in a representative population sample of older adults using an abbreviated 10-item version of the RMET [RMET-10], b) to describe population-based norms on the RMET-10, and c) to examine the associations of RMET-10 scores with age, sex, race/ethnicity, education, literacy, a cognitive screen, clinical dementia rating, individual domains in cognitive composites derived from a neuropsychiatric battery, anxiety and depression screens, and a test of social norms recognition.

METHODS

Participants

Participants were from the Monongahela-Youghiogheny Healthy Aging Team (MYHAT) study which is focused on the epidemiology of mild cognitive impairment and dementia. The MYHAT cohort was accrued by age-stratified random selection from the voter registration list an economically distressed, post-industrial region of southwestern Pennsylvania, USA. Participants were initially enrolled in the original MYHAT cohort between 2006–2008 if they met the eligibility criteria of being 65 years and older, lived within select geographically defined areas, and resided independently in the community at the time of recruitment. Individuals were excluded if they met the above criteria but were too ill to participate, had vision or hearing impairment severe enough to preclude neuropsychological testing, or had decisional incapacity. (13, 14) Of 2036 individuals who qualified, the full evaluation described below was administered to 1982 without substantial cognitive impairment, defined as age-education corrected Mini Mental State Exam (15, 16) scores ≥ 21. A new sub-cohort of 709 participants meeting the same criteria, aged of 65–74 during 2016–2019, was enrolled to replenish the original cohort; of these, 703 underwent the

full assessment. All participants were invited to undergo annual reassessment, which took place in overlapping data collection cycles.

RMET-10 (10, 12) was added to the MYHAT protocol for all participants in 2017 when the new sub- cohort was beginning its second assessment cycle. Thus, different participants were in different annual cycles when they first completed the RMET-10. All procedures were approved by the University of Pittsburgh Institutional Review Board, and all participants provided written informed consent.

RMET-10 is an abbreviated version of the full RMET, an advanced test of TOM, originally developed in children with autism, later revised for adults, with shorter versions validated in different populations. (10, 12) The test stimuli consist of 10 grey-scale photos of people that were originally taken from magazines. The photos were cropped and rescaled so that only the area around the eyes is visible. Each photo is surrounded by four words each describing a state of mind, one of which has been predetermined to correctly represent the emotion of the individual in the photo. The participant is asked to select, within 20 seconds, the word which best describes what the person in the photo is thinking or feeling. During pilot testing, we identified five words provided on the test (despondent, contemplative, tentative, imploring, pensive) with which our participants were unfamiliar. For these five words, we found substitutes in the RMET glossary(10) and/or thesaurus (hopeless, reflective, cautious, pleading, thoughtful).

Relevant to this report, the annual MYHAT assessment also included the following items:

Demographics: age, sex, race (white/ non-white), level of education

Cognitive screen: Mini-Mental State Examination [MMSE](15)

Literacy: Wechsler Test of Adult Reading [WTAR] (17)

Depression symptoms: modified Center for Epidemiological Studies- Depression scale [mCES- D] (18, 19)

Anxiety symptoms: Generalized Anxiety Disorder brief scale [GAD-7] (20)

Cognitive Composites: composite scores derived for the domains of attention, memory, language, visuospatial function, and executive function, derived from our neuropsychological test battery. (21) A composite score for each domain was calculated for each participant as the average of z- transformed tests in domain. (14)

Social Norms: Social Norms Questionnaire [SNQ-22], (22) measuring a different aspect of social cognition, a test which asks individuals about the appropriateness of specific behaviors in hypothetical scenarios, errors being related either to breaking with norms or to over-adhering to perceived norms.

Dementia Rating: Clinical Dementia Rating [CDR®] Staging Instrument, (23) as previously detailed.(14) On the CDR, ratings of 0, 0.5, and >1 indicate normal cognition, mild cognitive impairment or very mild dementia, and at least mild dementia.

Statistical Analyses.—To visually examine the distribution of scores on RMET-10, we plotted scores on the test among the whole cohort (N=902) and those with CDR scores of 0 (N=756). To generate norms on the test we calculated the mean (SD), median (50th %ile), and 5th %ile RMET scores by age, sex, and educational level (less than or equal to high school [HS] graduate, more than HS graduate) among those with CDR=0. For comparison, we calculated the same values among those with CDR=0.5. We also calculated the Kuder-Richardson coefficient of internal consistency on RMET-10. (24)

In the entire sample, we then calculated mean scores on the RMET among the subgroups determined by each of the following variables: age (65–74, 75–84, ≥85), sex (men, women), education (<HS, HS, >HS), race (white, non-white), MMSE (≤17, 18–23, 24–27, ≥28), WTAR (≤99, 100–108, 109–117, ≥118), SNQ22 (≤19, 20, 21, 22), GAD-7 (0, 1–5, 6–18, ≥11), mCES-D (0, 1–4, ≥5), and CDR (0, 0.5, ≥1). We modeled RMET-10 score as a continuous variable on each of these above-mentioned covariates and cognitive composites domain scores, first in simple linear regression (unadjusted) models and then in multiple linear regression models adjusting for age, sex, and education.

RESULTS

A total of 902 older adults were administered RMET-10. Their ages ranged from 66 to 105 years, with a mean (SD) age of 76.6 (8.06) years; 62.4% were women; 38.9% had high school or less education; 61% had more than high school education; and 93.7% were of European descent.

The RMET-10 scores were roughly normally distributed in our overall study sample [Figure 1.A] with a range of 0–10, a median score of 7, and a mean (SD) score of 6.5 (1.9), and also among those with CDR=0 [Fig 1.B], with range 0–10, median 7 and mean (SD) 6.64 (1.8).

Normative RMET-10 scores among those with CDR=0, and, for comparison, scores among those with CDR=0.5, are shown as mean (SD), median, and 5th %ile scores by age, sex, and education [Table 1].

Mean (SD) RMET-10 scores were calculated for each of the categories in age, sex, education, race, MMSE, WTAR, SNQ-22, GAD-7, mCES-D, and CDR [Table 2]. Distribution of RMET-10 scores were statistically significantly different between categories of age, education, race, MMSE, WTAR, and CDR. The Kuder-Richardson coefficient for the RMET-10 was 0.449, which is not unexpected for a short scale where the emphasis is on brevity and content validity.(25)

In unadjusted linear regression models, the RMET-10 score was estimated to be significantly higher among those with younger age, higher education, white race, lower CDR, higher MMSE, WTAR, SNQ-22 scores, and higher cognitive scores in all five domains. [Table 2] Women performed significantly better than men only in the age group 65–74 years, with mean (SD) scores of 7.18 (1.79) vs. 6.72 (1.66), by two-sample t-test, 2.6385, df= 428, P=0.009.

In multivariable regression models adjusted for age, sex, and education, all the above associations remained statistically significant. RMET-10 score was also significantly higher in those with fewer anxiety and depression symptoms after adjusting for demographics. [Table 2]

DISCUSSION

Social cognition is a relatively under-investigated area in geriatric psychiatry despite its being listed in the fifth edition of Diagnostic and Statistical Manual of Mental Disorders (DSM-5) (26) as one of the cognitive domains to be assessed in the diagnosis of neurocognitive disorders. Measurement of social cognition would complement conventional approaches to the study of cognitive aging, and shine a light on the deficits underlying behaviors like disinhibition and loss of empathy that are major sources of distress for patients and families. An effective tool to assess social cognition could also be key to early detection of neurocognitive disorders in subgroups of patients where memory loss is not the first deficit to appear. However, before a measure can be used effectively for diagnosis, it should be evaluated in the appropriate populations, so that effects of normal aging can be described and distinguished from disease effects. Using a large, population-based sample of older adults, we described the distribution of a 10-item version of the RMET in relation to demographics, measures of other cognitive functions, depression and anxiety, and awareness of social norms.

We found that RMET performance was negatively associated with age in this cross-sectional analysis, in line with existing evidence from the literature that overall social cognition, including TOM ability, declines with aging. (27–29) Several previous studies focused on the aging effect on the RMET also reported a decline of the RMET performance with aging. (30–32) While those studies compared older versus younger adult participants, we were able to show that RMET is negatively associated with greater age even within an older cohort. Continued follow-up of the MYHAT cohort will determine whether we observe further decline in RMET scores over time.

A previous study compared older and younger groups on their performance on 3 social cognition tasks involved in “mentalizing,” while recording their brain activity on fMRI. It showed poor performance and a decrease in neural activation in the dorsomedial prefrontal cortex in older adults, suggesting that social cognitive deficits involve specific regions of the default network and are associated with aging. (33) Another study that examined the difference in brain activity in younger and older participants completing the RMET reported no difference in RMET scores between young and old groups. However, the two groups had different patterns of brain activity; both groups activated structures in the default mode network, but older adults showed more bilateral activation of frontal areas and stronger involvement of the linguistic components of the mirror neuron system, suggesting functional compensation among successfully aging older individuals with preserved TOM ability. (34, 35)

Age-related decline of TOM ability is prominent in neurocognitive disorders, such as MCI and dementia due to Alzheimer’s Disease, frontotemporal lobar degeneration, Lewy Body

disease, and vascular cognitive impairment.(3–7, 36) The significant negative associations between RMET and CDR, MMSE, WTAR, education and all cognitive domain scores observed here reflect strong relevance to cognitive status and abilities. TOM is a highly complicated mental process that is not restricted to circumscribed brain regions or circuits that represent specific functions. (37) It might be viewed as an independent function from general cognition in aging, but more evidence indicates that some characteristics of social cognition are reliant on other cognitive functions i.e. processing speed, executive function, and working memory. (27, 35) Therefore, aging in social cognition should be assessed in the context of other relevant cognitive functions that are also vulnerable to aging. Longitudinal studies will provide critical information regarding how RMET scores may decline along with cognitive status; whether RMET effectively screens cases of pathologic neurodegenerative or cerebrovascular processes in early stages; and whether RMET predicts the trajectory of cognitive decline.

It has been previously described that depression is related to poor TOM ability including on RMET performance. (38) In our multiple regression models, RMET performance was worse with depressive symptoms as expected, and as well as with anxiety symptoms. While this association with GAD rating appears to diverge from a study reporting better TOM performance associated with worry among individuals with GAD, worry and anxiety are not the same. (39) Depression and anxiety in some but not all older adults may represent underlying neurodegeneration. (13, 40, 41)

The previously reported association between sex and the RMET performance (i.e. female superiority)(10) was not evident in our study except in the age group 65–74 years. Sex differences were also absent in a previous study among adults with autism. (42)

Also, a significant correlation with race was found in our study. A potential explanation is the so-called Other-Race Effect, which has been described in multiple kinds of literature; people consistently display worse recognition memory for other-race faces compared to same-race faces. (43, 44) A more recent study found evidence for both behavioral and neural differences in same-versus other-race mentalizing. (45) Thus, the RMET should be used judiciously in diverse populations. Adapted versions of the RMET test consisting of faces from different races and ethnic groups (i.e. Black RMET (46)) may generate different results.

Our group previously reported the distribution of SNQ-22 in the population-based cohort from the MYHAT study. The RMET score was significantly associated with the SNQ-22, although the two tests examine different components of social cognition. Potentially, a composite of the two measures might serve as a broader representation of social cognition in future studies.

It is increasingly recognized that social cognition is impaired in mild and major neurocognitive disorders due to neurodegenerative conditions such as Alzheimer’s disease and Lewy Body disease, as well as vascular cognitive impairment.(3–7, 26, 36) As the world’s population ages and the prevalence of neurocognitive disorders rises accordingly, early diagnosis is important to provide better support for these patients. Our population-

based norms on the RMET could prove useful to clinicians and other researchers in calibrating the scale for their own patients and study participants. Using the scale as a continuous measure, clinicians can assess their patients' social cognition bearing in mind that test scores will be influenced by age, sex, race, and education, as well as by anxiety and depression. To identify appropriate screening cutoff scores in a given population or setting, the test should be normed and calibrated in that population or setting.

Our study cohort was relatively large, providing sufficient statistical power, and population-based, minimizing selection bias. All data were obtained directly from participants; we had no access to their medical records or neuroimaging data. As only 6% of our cohort was not of European descent, our findings should be replicated in other cohorts with greater minority representation. As with any vision-dependent test, the RMET is not suitable for administration to individuals with severely impaired vision. This was a cross-sectional study and thus no inferences may be drawn regarding the directions of the associations; prospective follow-up of the cohort will allow us to determine whether RMET scores, alone or in combination with SNQ22 scores, predict the incidence of various neurocognitive disorders.

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HIGHLIGHTS

What is the primary question addressed by this study?

The distribution in older adults of scores on the 10-item version of Reading the Mind in the Eyes Test of social cognition (Theory of Mind).

What is the main finding of this study?

The test score is normally distributed and associated with age, education, race, cognitive screening scores, literacy, dementia rating, depression symptoms, anxiety symptoms, cognitive function measured by neuropsychiatric battery, and awareness of social norms measured by Social Norms Questionnaire.

What is the meaning of the finding?

The Reading the Mind in the Eyes Test is a potentially useful measure of social cognition for use in the research assessment of cognitive decline and dementia. With appropriate calibration it should have utility in the clinical setting.

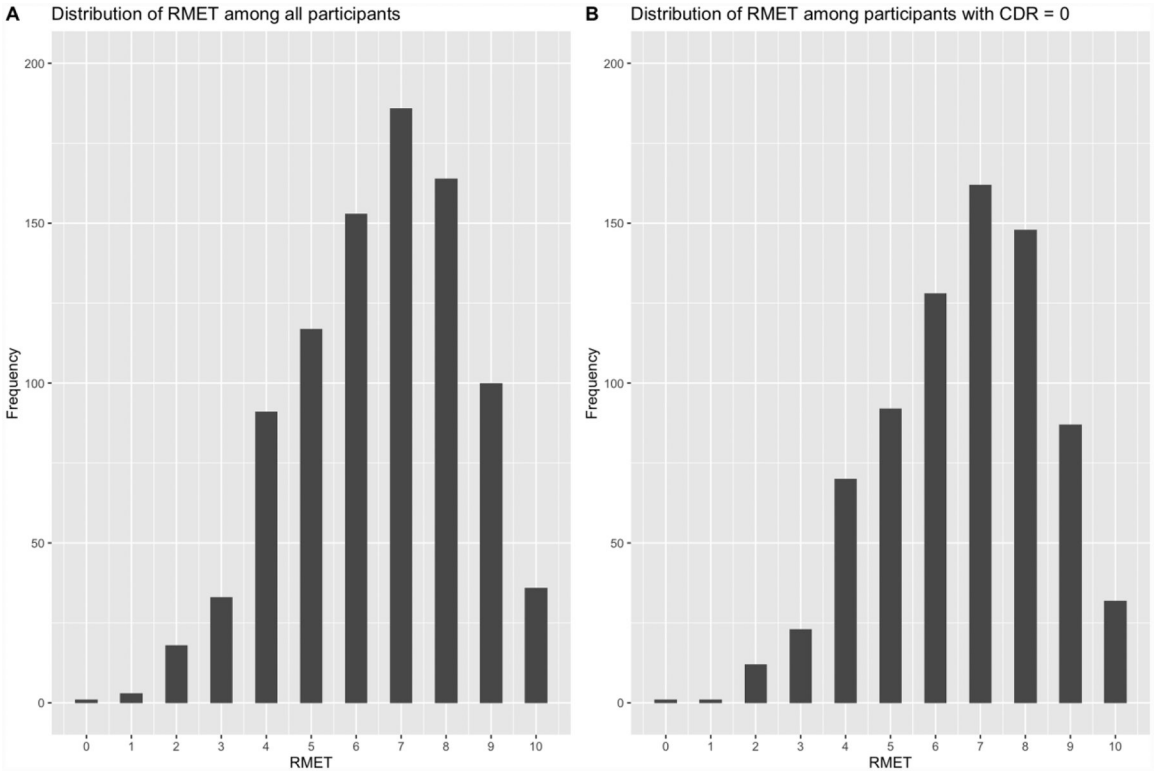

Figure 1.

A. RMET-10 scores of overall study sample (N=902) were roughly normally distributed. The median score was 7, and the mean (SD) score was 6.5 (1.9). B. RMET-10 scores among those rated as CDR=0 (N=756), who are free of dementia, were also roughly normally distributed. The median was 7, and the mean (SD) was 6.644 (1.844).

Table 1.

Reading the Mind in the Eyes Test (RMET) scores among MYHAT study participants free of dementia

Age in years	Gender	Education Level	N	Mean score	SD	Median score (50th %ile)	5th %ile score
Clinical Dementia Rating = 0 (Norms) N=756							
65–74	Male	≤ HS	45	6.49	1.87	7	3
		> HS	115	6.94	1.46	7	4
	Female	≤ HS	62	7.21	1.82	7	4.05
		> HS	153	7.24	1.71	8	4
75–84	Male	≤ HS	26	6.23	1.63	6	4
		> HS	60	6.38	1.87	6.5	3
	Female	≤ HS	81	6.38	1.82	7	4
		> HS	92	6.85	1.71	7	4
85+	Male	≤ HS	15	5.13	1.73	5	3.1
		> HS	25	5.64	2.18	5	2.2
	Female	≤ HS	48	5.81	1.93	6	3
		> HS	34	5.59	2.18	5	2
Clinical Dementia Rating = 0.5 N=134							
65–74	Male	≤ HS	7	5.43	2.7	6	1.9
		> HS	13	6.46	1.61	7	4
	Female	≤ HS	17	6.71	2.17	7	3.8
		> HS	16	7.12	2.09	7.5	4.25
75–84	Male	≤ HS	9	6	2.18	6	3
		> HS	7	7.43	1.9	8	5
	Female	≤ HS	14	5.07	1.86	5	2
		> HS	9	6.22	2.11	7	3.4
85+	Male	≤ HS	4	5	1.83	5	3.15
		> HS	10	5.2	1.87	5	3
	Female	≤ HS	15	4.73	1.67	5	2
		> HS	3	5.77	1.3	6	4

HS = High school graduate, SD = standard deviation, %ile = percentile

Table 2.

Factors associated with RMET scores (N = 902)

Participant Characteristics		N (%)	RMET Score Mean *(SD)*	Multiple linear regression models of RMET score[#]			
				Unadjusted		Adjusted for Demographics[*]	
				Coeff *(CI)*	*P*	Coeff *(CI)*	*P*
Age	65–74	430 *(47.7)*	6.99 *(1.75)*	−0.73 *(−0.88, −0.57)*	<0.001	Multiple Values[**]	
	75–84	298 *(33.0)*	6.46 *(1.83)*				
	85+	174 *(19.3)*	5.45 *(1.94)*				
Sex	Male	339 *(37.6)*	6.39 *(1.83)*	*Ref.*	0.115		
	Female	563 *(62.4)*	6.60 *(1.94)*	0.21 *(−0.05, 0.46)*			
Education	≤ HS	351 *(38.9)*	6.22 *(1.96)*	*Ref*	<0.001		
	> HS	551 *(61.1)*	6.71 *(1.84)*	0.49 *(0.24, 0.75)*			
Race	Non-White	57 *(6.32)*	5.60 *(2.21)*	*Ref*	<0.001	1.12 *(0.64, 1.60)*	<0.001
	White	845 (93.68)	6.58 (1.86)	0.98 *(0.48, 1.49)*			
Clinical Dementia Rating (CDR)	0	756 *(83.8)*	6.64 *(1.84)*	*Ref.*			
	0.5	134 *(14.9)*	5.98 *(2.04)*	−0.67 *(−1.01, −0.32)*	<0.001	−0.41 *(−0.74, −0.07)*	0.017
	≥ 1	12 *(1.3)*	4.58 *(1.83)*	−2.06 *(−3.13, −0.99)*	<0.001	−1.30 *(−2.34, −0.26)*	0.015
Mini-Mental State Exam (MMSE)	≤ 17	5 *(0.6)*	5.20 *(0.84)*	0.21 *(0.16, 0.27)*	<0.001	0.16 *(0.11, 0.21)*	<0.001
	18–23	53 *(5.9)*	5.55 *(2.33)*				
	24–27	287 *(31.8)*	6.07 *(1.90)*				
	≥ 28	557 *(61.8)*	6.85 *(1.78)*				
Weschler Test of Adult Reading (WTAR)	≤ 99	255 *(28.6)*	5.69 *(1.84)*	0.05 *(0.04, 0.06)*	<0.001	0.05 *(0.04, 0.06)*	<0.001
	100–108	209 *(23.5)*	6.59 *(1.81)*				
	109–117	241 *(27.0)*	6.77 *(1.78)*				
	≥ 118	186 *(20.9)*	7.35 *(1.74)*				
Social Norms Questionnaire (SNQ-22)	≤ 19	304 *(34.5)*	6.34 *(1.93)*	0.13 *(0.06, 0.21)*	0.001	0.10 *(0.03, 0.18)*	0.007
	20	246 *(28.0)*	6.66 *(1.73)*				
	21	209 *(23.8)*	6.70 *(2.00)*				
	22	121 *(13.8)*	6.52 *(1.85)*				
Generalized Anxiety Disorder scale (GAD-7)	0	361 *(48.0)*	6.53 *(1.89)*	−0.04 *(−0.08, 0.00)*	0.081	−0.05 *(−0.09, −0.01)*	0.013
	1–5	290 *(38.6)*	6.64 *(1.89)*				
	6–10	74 *(9.8)*	6.41 *(2.01)*				
	≥ 11	27 *(3.6)*	5.81 *(1.66)*				
Modified Center for Epidemiologic Studies - Depression Scale (mCES-D)	0	605 *(67.5)*	6.62 *(1.89)*	−0.04 *(−0.09, 0.02)*	0.172	−0.07 *(−0.12, −0.02)*	0.008
	1–4	220 *(24.6)*	6.36 *(1.92)*				
	≥ 5	71 *(7.9)*	6.18 *(1.82)*				
Attention Domain Score		N/A		0.58 *(0.44, 0.73)*	<0.001	0.40 *(0.25, 0.55)*	<0.001

Participant Characteristics	N (%)	RMET Score Mean *(SD)*	Multiple linear regression models of RMET score[#]			
			Unadjusted		Adjusted for Demographics[*]	
			Coeff *(CI)*	*P*	Coeff *(CI)*	*P*
Executive Domain Score			0.96 *(0.81, 1.11)*	<0.001	0.78 *(0.62, 0.94)*	<0.001
Language Domain Score			1.02 *(0.86, 1.17)*	<0.001	0.83 *(0.65, 1.01)*	<0.001
Memory Domain Score			0.50 *(0.38, 0.63)*	<0.001	0.37 *(0.25, 0.49)*	<0.001
Visuospatial Domain Score			0.60 *(0.46, 0.73)*	<0.001	0.50 *(0.37, 0.64)*	<0.001

Coeff: coefficient; CI: 95% confidence interval

The p-values are derived from t test, and the df = N - # of tests, where N is the total sample size of each variables (N varies as some variables have missingness). The Bonferroni-corrected alpha level is 0.05/16 =0.003.

#: In the multiple linear regression model, age, MMSE, WTAR, SNQ-22, GAD-7, and mCES-D are in their continuous format.

Columns5–6

**:* The adjusted model is in the form of RMET~Age+Sex+Education+Covariate (participant characteristic). The base model only contains demographics; each covariate was added to the base model separately in a separate model.

**** The coefficients for demographics in the adjusted models are not shown in the table since there is one coefficient for each demographic in each model.