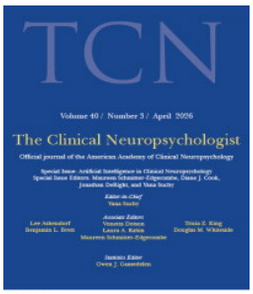
Article:
Kjaergaard, D., Delgado-Álvarez, A., Waldemar, G. et al. (2026) Diagnostic accuracy of the Multicultural Cognitive Examination (MCE) for detection of MCI and dementia in a diverse international cohort. The Clinical Neuropsychologist. ISSN: 1385-4046

https://doi.org/10.1080/13854046.2026.2652032



The Clinical Neuropsychologist

ISSN: 1385-4046 (Print) 1744-4144 (Online) Journal homepage: www.tandfonline.com/journals/ntcn20

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To cite this article: Daniel Kjaergaard, Alfonso Delgado-Álvarez, Gunhild Waldemar, Ulrike Beinhoff, Peter Bekkhus-Wetterberg, Sanne Franzen, Caitlin H. Illingworth, Jerson Laks, Alvaro Lozano-Ruiz, Andreas Lueschow, Jordi A. Matias-Guiu, Simone Pomati, Kurt Segers, Rozita Torkpoor, Jørgen Wagle & T. Rune Nielsen (10 Apr 2026): Diagnostic accuracy of the Multicultural Cognitive Examination (MCE) for detection of MCI and dementia in a diverse international cohort, The Clinical Neuropsychologist, DOI: 10.1080/13854046.2026.2652032

To link to this article: https://doi.org/10.1080/13854046.2026.2652032

THE CLINICAL NEUROPSYCHOLOGIST
https://doi.org/10.1080/13854046.2026.2652032

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Diagnostic accuracy of the Multicultural Cognitive Examination (MCE) for detection of MCI and dementia in a diverse international cohort

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ABSTRACT

Objective: Accurate cognitive screening tests for culturally, linguistically, and educationally diverse populations remain scarce, contributing to diagnostic inequities. To address this, we examined the cross-cultural properties and diagnostic accuracy of the Multicultural Cognitive Examination (MCE) in classifying mild cognitive impairment (MCI), dementia, Alzheimer's disease (AD) dementia, and non-AD dementia in participants with diverse backgrounds. Method: In this retrospective cross-sectional study, we aggregated data from 1,449 participants across 11 countries. Multiple linear regression models were used to determine the influence of demographic variables on MCE scores, which informed the creation of regression-based normative data. Diagnostic accuracies were examined using Receiver Operating Characteristics (ROC) curves. Results: The cohort consisted of 1001 cognitively intact participants, 140 patients with MCI, and 308 patients with dementia. 54.2% had immigrant backgrounds and originated from 63 different countries. MCE scores were significantly influenced by education and age,

ARTICLE HISTORY
Received 27 November 2025
Accepted 23 March 2026
Published online 09 April 2026

KEYWORDS
Alzheimer's disease; cognitive tests; dementia; ethnic groups; culture; cross-cultural comparison; education; mild cognitive impairment; minority groups; neuropsychological tests

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Supplemental data for this article can be accessed online at https://doi.org/10.1080/13854046.2026.2652032.

but not by sex or immigrant status. The MCE demonstrated high accuracy in differentiating cognitively intact participants from patients with dementia (AUC: .95) and MCI (AUC: .84). The MCE was both accurate for classifying AD dementia (AUC: .97) and non-AD dementia (AUC: .94). Conclusions: This study supports the clinical utility of the MCE as a culturally robust and highly accurate cognitive screening test. Future studies should examine the ability of the MCE to monitor cognitive decline.

Introduction

Global immigration is at an all-time high, with an estimated 3.6% of the world population being migrants in 2024 (McAuliffe & Oucho, 2024). This increase is also found in memory clinics across the world as the number of patients with immigrant backgrounds referred for diagnostic assessment is increasing (Nichols et al., 2022; Nielsen et al., 2011; Segers et al., 2013; Van Mol & de Valk, 2016). However, clinicians frequently encounter barriers when examining patients with immigrant backgrounds because of cultural and linguistic differences (Nielsen, 2022; Nielsen et al., 2024; Nielsen & Kjaergaard, 2024). Such barriers include difficulty communicating medical history, biases in cognitive testing, and the inappropriateness of diagnostic criteria (Franzen et al., 2021; Mazzeo et al., 2024; Nielsen & Kjaergaard, 2024). To address these challenges, several initiatives, including the European Consortium of Cross-cultural Neuropsychology (ECCroN), promote knowledge and develop tools for fair assessment of people with diverse cultural, linguistic, and educational backgrounds (Ardila, 2020; Franzen et al., 2020; 2021; 2022).

The most widely used cognitive screening tests in memory clinic settings are prone to cultural and linguistic biases (Nielsen, 2022). These include the Mini-Mental Status Examination (MMSE), Montreal Cognitive Assessment (MoCA), and the Addenbrooke's Cognitive Examination (ACE) (Tsoi et al., 2015). Examples of bias include confrontation naming of black-and-white drawings in the MoCA and ACE, which disfavors individuals with lower levels of education and require specific cultural knowledge of objects and animals, that may be specific to certain parts of the world (Franzen et al., 2020; Nielsen, 2022; Reis et al., 2006). In addition, literacy and school dependent skills influence most aspects of the MMSE, including reading, writing, copying, orientation, subtractions, and repetitions (Brucki & Nitrini, 2010; Mandyla & Kosmidis, 2023; Milman et al., 2018). Solely translating the tests into different languages would be unfeasible in clinical practice, as comprehensive cultural adaptations and validations would be required for each language and cultural context (Franzen et al., 2020; Nielsen, 2022). Therefore, there is a pressing need for accurate and easy-to-use cross-cultural cognitive screening tests in memory clinics. Such tests already exist, including the Rowland Universal Dementia Assessment Scale (RUDAS) (Storey et al., 2004), the Cross-Cultural Dementia screening (CCD) (Goudsmit et al., 2017), the Multicultural Cognitive Examination (MCE) (Nielsen et al., 2019; Torkpoor et al., 2024), and the European Cross-cultural Neuropsychological Test Battery (CNTB) (Nielsen et al., 2018; 2019). However, cross-cultural cognitive tests, such as these, are so far not widely implemented (Nielsen et al., 2019; 2024; 2025). In particular, the MCE may be one of the

most accurate cross-cultural cognitive tests for identifying cognitive impairment. Additionally, the MCE can be administered across languages without changing the content, includes visual stimuli, low verbal load, fit for interpreter-mediated administration, and has little influence of education (Chithiramohan et al., 2024; Matias-Guiu & Delgado-Álvarez, 2023). In head-to-head comparisons, the MCE demonstrated superior diagnostic properties in multicultural populations compared to other screening tests, including the MMSE, RUDAS, CCD, and the Category Cued Memory Test (CCMT), and showed comparable performance to the Brief Assessment of Impaired Cognition (BASIC), although these findings are based on smaller samples (Delgado-Álvarez et al., 2026; Nielsen et al., 2025). Furthermore, the MCE can potentially also inform clinicians about cognitive profiles as it makes a broad assessment of several cognitive functions. Cross-cultural cognitive tests that reliably identify MCI and dementia across diverse populations, and for which clear evidence of their clinical applicability exists, are essential especially given the rising global prevalence of dementia and increasing diversity of world populations (McAuliffe & Oucho, 2024; Nichols et al., 2022; Nielsen et al., 2011; Segers et al., 2013; Van Mol & de Valk, 2016).

This paper extends prior research on the MCE conducted in smaller samples (Kjaergaard et al., 2025; Nielsen et al., 2019; 2025; Torkpoor et al., 2024), by examining the MCE on a large scale across sites in multiple countries with a culturally, linguistically, and educationally diverse cohort with mild cognitive impairment (MCI) and dementia. To support the cross-cultural properties and clinical applicability of the MCE, this study aimed to: (a) determine the influence of demographic variables on the MCE, (b) create normative data for the MCE, (c) determine the diagnostic accuracy of the MCE for differentiating cognitively intact participants from patients with MCI and dementia, and (d) examine the ability of the MCE to distinguish cognitively intact participants from patients with AD dementia and non-AD dementia.

Materials and methods

Study design and participants

We conducted a retrospective cross-sectional study, in which we aggregated existing participant data from sites in 11 countries. Participant data was obtained from published and ongoing studies across Belgium, Brazil, Denmark, France, Germany, Italy, the Netherlands, Norway, Spain, Sweden, and the United Kingdom (Araujo et al., 2020; Delgado-Álvarez et al., 2023; 2023; Nielsen et al., 2018; 2019; Nielsen et al., 2025; Torkpoor et al., 2024). Anonymized participant data was pooled and analyzed at the Danish Dementia Research Center. See participant characteristics stratified by country of inclusion in Supplementary Table 1.

Study participants included cognitively intact participants consisting of healthy controls (HC) and memory clinic patients with subjective cognitive decline (SCD). The cognitively impaired patients were memory clinic patients diagnosed with MCI or dementia. Participants were eligible for inclusion if they had available data on the MCE, demographic information (age, sex, education, country of birth), and syndrome diagnosis (HC, SCD, MCI, dementia). Patients' syndrome diagnosis was determined using different clinical criteria for MCI (Albert et al., 2011; American Psychiatric

Association, 2013; Winblad et al., 2004; World Health Organization, 1993) and dementia (American Psychiatric Association, 1994; 2000; 2013; McKhann et al., 2011; World Health Organization, 1993) across the participating sites (see Supplementary Table 2 for specifications). Across sites, diagnostic criteria required evidence of objective cognitive impairment, preserved functional independence in MCI, and functional decline in dementia. Differences primarily concerned terminology (for example major cognitive disorder vs. dementia) and emphasis on biomarker evidence. Diagnoses in memory clinics were set by multidisciplinary teams following comprehensive assessments. HC and SCD participants were pooled in this study, forming a cognitively intact group. Participants were excluded if they had significant physical, motor, neurological, vision, hearing, or psychiatric conditions that could interfere with cognitive testing. Furthermore, participants with missing data on more than one subtest of the MCE were excluded.

All memory clinic patients had undergone a comprehensive clinical examination, and the diagnoses were determined by a multidisciplinary team. The clinical assessment generally included a patient and informant interview, physical, neurological, cognitive, and psychiatric evaluation, standard laboratory blood tests, and structural brain imaging (computerized tomography or magnetic resonance imaging). At most sites, cerebrospinal fluid biomarkers, positron emission tomography, and neuropsychological or psychiatric evaluation were included when needed. The MCE was not part of the diagnostic evaluation, except for some patients included in the Netherlands ($N = 111$), where it was administered as part of an extensive culture-sensitive neuropsychological test battery (the TULIPA battery (Franzen et al., 2023)). HC participants were recruited from local districts, population registries, relatives of patients in memory clinics, senior centers, voluntary organizations, social networks of bilingual researchers, and advertisements in local newspapers.

Participants born in a different country than their country of examination were classified as having immigrant backgrounds, while participants born in their country of examination were classified as native-born.

The multicultural cognitive examination

The MCE consists of four subtests (Table 1): RUDAS (Storey et al., 2004), Recall of Pictures Test (RPT) (Nielsen et al., 2012), Supermarket Fluency Test (SFT) (Strauss et al., 2007), and Clock Reading Test (CRT) (Schmidtke & Olbrich, 2007). The total MCE score ranges from 0 to 100 points.

Table 1. The multicultural cognitive examination.

Cognitive test	Cognitive domain	Score range
MCE	General cognitive function	0–100
RUDAS	General cognitive function	0–30
RPT immediate recall	Episodic memory	0–10
RPT delayed recall	Episodic memory	0–10
RPT recognition	Episodic memory	0–10
SFT	Language function Executive function	0–28
CRT	Visuospatial function	0–12

Abbreviations: CRT = Clock Reading Test, MCE = Multicultural Cognitive Examination, RPT = Recall of Pictures Test, RUDAS = Rowland Universal Dementia Assessment Scale, SFT = Supermarket Fluency Test.

RUDAS is a brief cognitive screening test assessing orientation, praxis, drawing, judgment, memory, and language (Storey et al., 2004). The RUDAS ranges from 0 to 30 points. RPT is a measure of episodic memory with immediate- and delayed recall, and recognition of ten colored pictures (Nielsen et al., 2012). In the immediate recall, the ten pictures are learned over three trials, while the delayed recall task is performed after distraction interval. The recognition task requires the participant to correctly identify the original ten pictures among a set consisting of ten previously learned and ten new pictures. The three RPT subtests each have a score range from 0 to 10 points. The whole RPT ranges from 0 to 30 points. SFT is a measure of semantic fluency, requiring participants to name as many different things as possible that can be bought in a supermarket within one minute (Strauss et al., 2007). The SFT score was capped at 28 points, resulting in a score range of 0 to 28. CRT is a measure of visuospatial function which requires participants to correctly read the time on 12 clock faces without numbering (Schmidtke & Olbrich, 2007). The CRT score ranges from 0 to 12 points. In the current study, at the Dutch site, supermarket fluency was replaced by food fluency ($N = 111$).

Data analysis

The aggregated data was checked for errors and accuracy by checking distributions and outliers. Missing data were dealt with by creating imputed values using multiple imputations by chained equations (MICE) applying predictive mean matching, based on age, education and the other MCE subtests when maximum one subtest was missing. The primary outcome was the syndrome diagnosis of the participants (HC/SCD, MCI, dementia), while a secondary outcome was the clinical etiological diagnosis of AD dementia and non-AD dementia. Overall group differences were determined by the Kruskal-Wallis rank sum test for non-normally distributed continuous variables and by the Chi-squared test for categorical variables. Pairwise comparisons were examined using the Mann-Whitney U test for non-normally distributed continuous variables and Fisher's exact test for categorical variables. Rank-biserial correlations were used for effect sizes (very small < .10, small .10-.29, moderate .30-.49, large ≥ .50.

A multiple linear regression model in cognitively intact participants was used to estimate and quantify the influence of the following predictors on MCE scores: Years of education, age, sex, and immigrant background. Regression-based normative data for the MCE were calculated based on significant predictors and presented as percentile scores (50^{th}, 25^{th}, 10^{th}, 5^{th}, 2^{nd} percentile). The percentiles were calculated using the predicted mean MCE score and the residual standard deviation (subtracting the actual MCE score from the predicted score). The median ages (24, 34, 44, 54, 64, 74, 85) and median years of education (2, 6, 10, 12) were used to calculate the percentile scores in the summarized groups.

Receiver Operating Characteristic (ROC) analyses were utilized to compare the Area Under the ROC Curve (AUC) of the MCE and RUDAS using the consensus diagnosis established by the multidisciplinary team as reference standard. Significant differences were determined using DeLong's method. Accuracy, sensitivity, specificity, and likelihood ratios were estimated based on the original MCE cutoff, Youden's J statistic, and the 25^{th}, 10^{th}, 5^{th}, and 2^{nd} percentile cutoffs from the generated normative data.

Participants younger than 65 years old were excluded from all accuracy analyses as younger participants were highly under-represented among memory clinic patients.

All analyses were conducted using the statistical software R (version 4.4.1). The R code used is available on GitHub (https://github.com/dkja0031/MCE/blob/main/Accuracy). $p < .05$ (two-tailed) was considered significant.

Results

Participant characteristics

Data from 1,449 participants were included in the study. The participants were born in 63 different countries ($n = 640$ from Europe, $n = 414$ from South America, $n = 370$ from the Middle East and North Africa, $n = 14$ from South, East, and Southeast Asia, and $n = 11$ from Sub-Saharan Africa), 54.2% had immigrant backgrounds (Supplementary Table 3). In the cognitively intact group, participants with immigrant backgrounds were younger ($p < .001$), less likely to be female ($p < .001$), had fewer years of education ($p = .004$), and higher scores on RUDAS ($p = .002$) but not on MCE ($p = .084$) (Supplementary Table 4). Of the 308 participants with dementia, 188 were diagnosed with Alzheimer's disease (AD), 42 with mixed AD with vascular pathology, 28 with vascular dementia (VaD), 11 with behavioral variant frontotemporal dementia, 8 with dementia with Lewy bodies or Parkinson's disease dementia, 21 with unspecified dementia, and 10 with other specified dementias (3 normal pressure hydrocephalus, 2 semantic dementia, 1 HIV-associated neurocognitive disorder, 1 other organic dementia, 1 Gerstmann-Sträussler-Scheinker disease, 1 post traumatic dementia, and 1 multifactorial decline). Across inclusion sites, 1,434 participants had complete data on all subscales of the MCE. A total of 15 participants were missing data for one MCE subtest, which was handled by creating imputed values. Participant characteristics are presented in Table 2.

Impact of demographic variables

A linear regression model measuring the effect of age, sex, education, and immigrant background on the MCE score in cognitively intact participants showed significant effects of education ($p < .001$, $R^2 = .20$) and age ($p < .001$, $R^2 = .16$), but not sex ($p = .10$) or having immigrant background ($p = .63$) (Table 3, Figure 1).

All MCE subtests were significantly affected by age and education ($p < .001$), however the RPT subtests were less influenced by education (R^2 range = .6%-2.2%) compared to RUDAS, CRT and SFT (R^2 range = 11.4%-15.5%). The RPT recognition subtests was least affected by age ($R^2 = 2.0\%$) followed by CRT, SFT, and the other RPT subtests (R^2 range = 4.7%-9.3%) and lastly by the RUDAS ($R^2 = 17.5\%$).

Normative data

Normative data were based on the 1001 cognitively intact participants. The MCE showed a slightly negatively skewed normal distribution and had a low ceiling effect (scoring max points on the MCE) of 1.1%. The above multiple linear regression

Table 2. Cohort characteristics.

	Cognitively intact	Cognitively intact *(≥ 65 years old)*	MCI	Dementia	P-value
N	1001	364	140	308	–
Age, years	59.0 [47.0, 69.0]	73.0 [68.0, 78.0]	72.0 [65.0, 77.0]	77.0 [73.0, 82.0]	< .001[c,d]
Female sex (%)	593 (59.2%)	224 (61.5%)	68 (48.6%)	171 (55.5%)	.025[b]
Education, years	12.0 [6.0, 15.0]	10.0 [5.0, 14.0]	9.0 [6.0, 12.0]	7.5 [4.0, 11.0]	< .001[c,d]
No formal education (%)	60 (6.0%)	38 (10.5%)	4 (3.0%)	25 (8.4%)	.03 [b,d]
Immigrant status (%)	610 (60.9%)	150 (41.2%)	63 (45.0%)	113 (36.7%)	.20
MCE score	89.0 [81.0, 94.0]	82.0 [79.0, 89.0]	67.0 [60.0, 76.5]	51.0 [43.0, 61.0]	< .001[a]
RUDAS score	28.0 [27.0, 30.0]	27.0 [26.0, 28.0]	24.0 [22.0, 26.0]	20.0 [17.0, 23.0]	< .001[a]
RPT immediate recall	8.0 [7.0, 9.0]	7.0 [6.0, 8.0]	5.0 [4.0, 7.0]	4.0 [2.5, 5.0]	< .001[a]
RPT delayed recall	9.0 [7.0, 10.0]	8.0 [6.0, 9.0]	5.0 [3.0, 6.0]	2.0 [0.0, 4.0]	< .001[a]
RPT recogniton	10.0 [10.0, 10.0]	10.0 [10.0, 10.0]	10.0 [8.0, 10.0]	8.0 [6.0, 10.0]	< .001[a]
CRT	12.0 [11.0, 12.0]	11.0 [10.0, 12.0]	11.0 [9.0, 12.0]	8.0 [4.0, 10.0]	< .001[c,d]
SFT	23.0 [18.0, 27.0]	19.0 [15.0, 24.0]	15.0 [12.0, 19.0]	10.0 [7.0, 14.0]	< .001[a]

Note: Continuous variables presented as median [Q1, Q3]; categorical variables are presented as n (%). Overall p-values are determined by Kruskal-Wallis rank sum test for continuous variables and by Chi-squared test for categorical variables. Pairwise comparisons were determined by Mann-Whitney U test and Fisher's exact test. Pairwise comparisons used Benjamini–Hochberg adjusted $p < .05$ (a = All are significantly different from each other, b = cognitively intact/MCI, c = cognitively intact/dementia, d = MCI/dementia).

Abbreviations: MCI = Mild Cognitive Impairment, MCE = Multicultural Cognitive Examination, RPT = Recall of Pictures Test, RUDAS = Rowland Universal Dementia Assessment Scale, SFT = Supermarket Fluency Test.

Table 3. Linear regression.

	Beta	95% CI	SE	P-value	R^2
Education	.80	.70, .90	.05	< .001	.20
Age	−0.21	−0.25, −0.18	.02	< .001	.16
Immigrant status	.26	−0.78, 1.3	.53	.63	< .01
Female sex	.81	−0.16, 1.8	.49	.10	< .01

Note: N = 1,001.

Abbreviations: CI = Confidence interval, SE = Standard Error.

identified age and education as significant predictors of the MCE score and these were therefore used to calculate the normative data. Age^2 was included in the regression model as it significantly improved the model fit as age and MCE score did not follow a strict linear relationship (R^2: .40 to .45, Akaike Information Criterion (AIC): 6903 to 6818, $p < .001$). The best model fit was therefore: Predicted MCE score = MCE score intercept + .504(Age) − .007(Age^2) + .791(Years of education). Model assumptions were checked and were not violated including linearity, homoscedasticity, normality of residuals, and multicollinearity. The normative data are presented as 50th, 25th, 10th, 5th, and 2nd percentiles in Supplementary Table 5.

Classification accuracy

ROC curves showed that the raw MCE was highly accurate in differentiating cognitively intact participants from patients with dementia (AUC .95, 95% CI .94-.97) and MCI

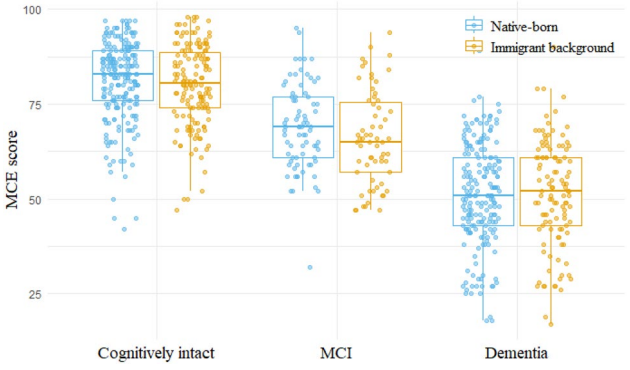

Figure 1. MCE scores stratified by syndrome diagnosis and immigrant background.
Note: Orange = Participants with immigrant backgrounds, Blue = Native-born participants. Cognitively intact participants are ≥ 65 years old. N = 812.
Abbreviations: MCE = Multicultural Cognitive Examination, MCI = Mild Cognitive Impairment.

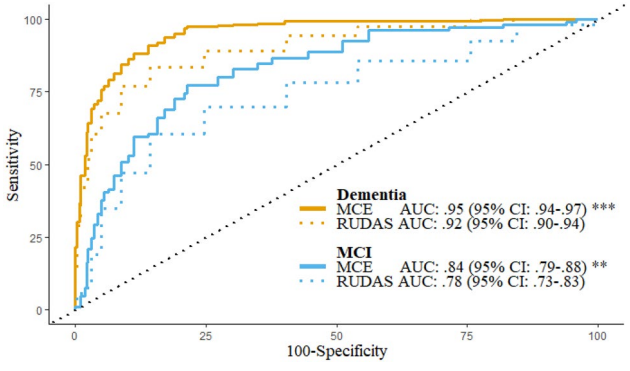

Figure 2. Classification accuracy of dementia and MCI using the MCE or RUDAS.
Note: * = P < .05, ** = P < .01, *** = P < .001. All participants are ≥ 65 years old. N = 755.
Abbreviations: AUC = Area under the Receiver Operating Characteristics curve, CI = Confidence Interval, MCE = Multicultural Cognitive Examination, MCI = Mild Cognitive Impairment, RUDAS = Rowland Universal Dementia Assessment Scale.

(AUC .84, 95% CI .79-.88). The MCE was significantly more accurate using DeLong's test compared to the RUDAS for dementia (AUC .95 vs. .92, $p < .001$) and MCI (AUC .84 vs. .78, $p = .01$) (Figure 2). Sub-analyses revealed no differences in AUCs when stratifying by immigrant/native-born backgrounds (AUC .92 vs .93, $p = .50$).

In the present sample, Youden's index cutoff for separating cognitively intact participants from patients with dementia was 68/69 (sensitivity .91, specificity .86), and for MCI 73/74 (sensitivity .78, specificity .79) (Table 4). The original MCE cutoff to differentiate dementia from cognitively intact participants was 70/71 (sensitivity .94, specificity .83) (Nielsen et al., 2019). Utilizing the generated normative data cutoffs at 25th, 10th, 5th, and 2nd percentiles, generally changed the weighing of sensitivity and specificity. For example, the 5th percentile specificity for MCI was .90 compared to .79 at Youden's cutoff.

The MCE was equally accurate in differentiating cognitively intact participants from AD dementia (AUC .97, 95% CI .95-.98) and non-AD dementia (AUC .94, 95% CI .91-.96, $p = .06$). Additionally, the MCE was significantly more accurate than the RUDAS

Table 4. Diagnostic accuracy of the MCE in differentiating dementia and MCI from no cognitive impairment.

Dementia						
Cutoff	Original (Nielsen et al., 2019) 70/71	Youden 68/69	25th percentile	10th percentile	5th percentile	2nd percentile
Accuracy	.88	.88	.83	.89	.89	.88
Sensitivity	.94	.91	.96	.92	.87	.82
Specificity	.83	.86	.73	.86	.90	.93
LR+	5.51	6.49	3.57	6.71	8.82	11.5
LR-	.08	.11	.05	.09	.14	.20
MCI						
Cutoff	Original (Nielsen et al., 2019) 70/71	Youden *73/74*	25th percentile	10th percentile	5th percentile	2nd percentile
Accuracy	.80	.78	.75	.82	.82	.82
Sensitivity	.70	.78	.81	.65	.52	.43
Specificity	.83	.79	.73	.86	.90	.93
LR+	4.05	3.62	3.01	4.75	5.24	6.11
LR-	.38	.29	.26	.40	.53	.61

Note: All included participants were ≥ 65 years old. $N = 755$.
Abbreviations: LR = Likelihood ratio, MCI = Mild Cognitive Impairment, MCE = Multicultural Cognitive Examination.

Table 5. MCE subtests by AD dementia and non-AD dementia.

	AD dementia	Non-AD dementia	p-value	Rank-biserial correlation
N	177	48	–	–
Age, years	78.0 [74.0, 83.0]	77.5 [74.5, 81.5]	.50	.07
Education, years	6.0 [4.0, 11.0]	8.0 [5.0, 12.0]	.20	−0.12
RUDAS score	20.0 [17.0, 23.0]	21.5 [18.0, 24.0]	.03	−0.21
RPT immediate recall	3.0 [2.0, 5.0]	4.0 [3.0, 5.0]	.01	−0.23
RPT delayed recall	1.0 [0.0, 3.0]	4.0 [2.0, 5.5]	<.001	−0.46
RPT recognition	8.0 [6.0, 10.0]	9.0 [8.0, 10.0]	.001	−0.30
CRT	7.0 [4.0, 10.0]	8.0 [6.0, 10.0]	.04	−0.20
SFT	11.0 [8.0, 14.0]	10.0 [6.5, 14.5]	.50	.07

Note: Continuous variables presented as median [Q1, Q3]. P-values are determined by Mann-Whitney U test. Rank-biserial correlation reported as the effect size. The non-AD dementia disorders were Vascular dementia ($N = 24$), Lewy Body Dementia/Parkinsons Disease dementia ($N = 8$), Frontotemporal dementia ($N = 9$), Normal Pressure Hydrocephalus ($N = 3$), Semantic dementia ($N = 2$), Other organic dementia ($N = 1$), Multifactorial decline ($N = 1$).
Abbreviations: AD = Alzheimer's disease, CRT = Clock Reading Test, RPT = Recall of Pictures Test, RUDAS = Rowland Universal Dementia Assessment Scale, SFT = Supermarket Fluency Test.

in differentiating cognitively intact participants from AD (AUC .92, 95% CI .90-.95, $p < .001$) and non-AD dementia (AUC .89, 95% CI .84-.93, $p = .01$). Across MCE subtests, RPT delayed recall was the subtest that best distinguished between AD and non-AD dementia being the only variable with a moderate effect size (rank-biserial

correlation = −0.46, $p < .001$) (Table 5). Among dementia patients scoring ≤ 1 on RPT delayed recall, 57.1% had AD (101/177) compared to 20.8% of the non-AD patients (10/48). Whereas of the patients scoring 2 or above, 42.9% had AD (76/177) and 79.2% had non-AD (38/48).

Discussion

We examined the cross-cultural properties and diagnostic accuracy of the MCE in a large international sample of 1,449 participants originating from 63 different countries. We found that the MCE was influenced by education and age, but not by sex or having immigrant background, suggesting that it is relatively unaffected by participant's cultural and linguistic backgrounds. Next, we created regression-based normative data for the MCE to provide clinicians with a better method for interpreting the performance of individual patients. Comparable to previous studies (Nielsen et al., 2019; 2025; Torkpoor et al., 2024), we found that the MCE was highly accurate in differentiating patients with dementia (AUC .95) and MCI (AUC .84) from cognitively intact participants, also when using the original MCE cutoff (Nielsen et al., 2019). By applying regression-based normative data we could slightly improve overall diagnostic accuracy metrics, giving clinicians a better possibility to evaluate the cognitive performance of memory clinic patients depending on the specific context. Lastly, we found that the MCE was equally accurate for differentiating cognitively intact participants from AD dementia and non-AD dementia indicating that the MCE is not only relevant for AD but also for other dementia disorders. Although scoring 1 or below on RPT delayed recall was indicative of AD dementia, but further assessment would be encouraged. To our knowledge, this is the largest study to examine a cross-cultural cognitive test for memory clinic settings.

Distinguishing individuals with MCI from cognitively intact individuals with brief cognitive screening tests has long been a challenge in research and clinical settings, particularly in culturally diverse populations. We found an AUC of .84 for identifying MCI, which was significantly higher compared to the RUDAS with an AUC of .78 ($p = .01$). These results are comparable to the upper estimates of a meta-analysis of cognitive screening tests such as MMSE, MoCA, and ACE that found AUCs ranging from .758 to .847 in identifying MCI (Breton et al., 2019). In contrast to these cognitive screening tests, the MCE was evaluated in a culturally, linguistically, and educationally diverse cohort while retaining high diagnostic accuracy. Although education significantly influenced MCE performance in the present study, evidence from the broader literature indicates that educational bias may be less pronounced for the MCE than for commonly used screening instruments such as the MMSE and MoCA (Chithiramohan et al., 2024; Goudsmit et al., 2018; Steis & Schrauf, 2009). Compared with other cross-cultural cognitive tests such as the CCD and CNTB, the MCE shows comparable or superior diagnostic accuracy for MCI (AUC: 0.72–0.82 vs. .84) and dementia (AUC: 0.80–0.99 vs. .95) (Delgado-Álvarez et al., 2022; Nielsen et al., 2019). The combination of strong cross-cultural validity, multidomain cognitive assessment, and brief administration time makes the MCE well suited for both research and clinical settings where populations are culturally, linguistically, and educationally diverse. Altogether, these results suggest that the MCE is a highly accurate cognitive test that is appropriate for culturally, linguistically, and educationally diverse

populations. Our results encourage clinicians to consider implementing the MCE, particularly in culturally, linguistically, and educationally diverse populations, as it is less culturally biased while retaining high accuracy.

This large multicultural study represents participants originating from Europe, the Middle East, North Africa, South Asia, and South America, supporting the generalizability of the results. However, other major geographic regions are less represented including Oceania, Southeast- and East Asia, and Sub-Saharan Africa encouraging future studies to include participants from these regions. Other limitations of this study should be considered. While the clinical evaluations included a comprehensive assessment and consensus diagnosis, the adopted clinical criteria differed between sites (see Supplementary Table 2), which may have affected the classification of specific cognitive disorders. In addition, linguistic and cultural differences between inclusion sites may have influenced how the same diagnostic criteria were interpreted and implemented (Mazzeo et al., 2024; Nielsen & Kjaergaard, 2024). Immigrant status does not directly capture differences in language fluency, bi/multilingualism, acculturation, and quality of education, but it served as a proxy for these in the current study. Patients' immigrant background reflects the complex interplay between these factors, but future studies are needed to reflect the direct influences on the cross-cultural cognitive tests as acknowledged by ECCroN (Franzen et al., 2022). Each inclusion site represents unique characteristics, reflecting its local cultural, economic, educational, linguistic, and geographic context. These differences include differences in educational quality, structure, and curricular content, which may have led to over- or underestimation of the influence of education on the MCE. Although this reflects the clinical reality where large differences are present across countries, our study generalized results across multiple sites where certain country-specific aspects would be clinically relevant to consider. For example, the Brazilian inclusion site is unique as all participants were born in Brazil, but also had few years of schooling in general. However, a post-hoc sensitivity analysis where we excluded participants from the Brazilian site in a multiple linear regression found similar beta-coefficients as the original regression model (Supplementary Table 6). Pooling HC participants and patients with SCD in a cognitively intact group may influence outcomes by reducing diagnostic accuracy, as some patients with SCD may represent preclinical stages of neurodegenerative disease. However, inclusion of SCD reflects a more realistic memory clinic population. Sensitivity analyses excluding patients with SCD revealed results consistent with the primary analyses (Supplementary Tables 7–9).

In conclusion, as the world is becoming increasingly more culturally and linguistically diverse, diagnostic tools must be accurate and unbiased to fight health disparities and diagnostic inequities. Our study suggests that the MCE is highly accurate in identifying MCI and dementia in culturally, linguistically, and educationally diverse populations. Future studies should explore the ability of the MCE to monitor cognitive decline longitudinally and to capture effects of interventions.

Acknowledgments

The authors express our sincere gratitude to the participants and clinics staff involved. We would like to acknowledge the important contributions with participant inclusion by Esther van den

Berg, Lize Jiskoot, and Judy van Hemmen (all Erasmus MC University Medical Center), Lotte van de Wiel (Maasstad Ziekenhuis), Naaheed Mukadam (University College London), Juliette Palisson (Avicenne University Hospital), Nieves Méndez and Marina Gavilán (University of Granada), and the Israac Sheffield Somali community champions: Muse Jama and Sahra Abdi, and Sheffield Biomedical Research Centre. Furthermore, we would like to thank research assistants and students at relevant sites for their contributions to data collection.

Consent statement

The study was approved by the Danish Data Protection Agency (p-2024-15786).

Disclosure statement

No potential conflict of interest was reported by the authors.

Funding

The study was supported by the Innovation Fund Denmark [grant number 1099-00022B], under the frame of ERA PerMed [reference number: ERAPERMED2021-184] and the Instituto de Salud Carlos III (PI19/01260). JAMG is supported by Instituto de Salud Carlos III through the project INT20/00079 and INT23/00017 (co-funded by European Regional Development Fund "A way to make Europe"). SF is supported by ZonMW (#73305095007, #10510032120004) and Health Holland, Topsector Life Sciences & Health (PPP-allowance; #LSHM20106). Data collected from the University of Sheffield is independent research funded by the NIHR i4i NIHR202911/CognoSpeak: a Cognitive Health Assessment Tool (CcHAT). The views expressed are those of the author(s) and not necessarily those of the NIHR i4i, the NIHR or the Department of Health and Social Care. The Memory Clinic at Skåne University Hospital was supported by the Swedish federal government under the ALF agreement, and by the Kockska foundation and Vinnova (grant No. 583 2021–02680). The funding sources had no involvement in the design or reporting of the study.

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Data availability statement

The data that support the findings of this study originate from multiple centers who each hold the ownership of their data. Data can be made available upon reasonable request and consent from the respective centers.

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