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Determining a Short Form Montreal Cognitive Assessment (s-MoCA) Czech Version: Validity in Mild Cognitive Impairment Parkinson's Disease and Cross-Cultural Comparison

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Abstract

The Montreal Cognitive Assessment (MoCA) is one of the most common screening instruments for mild cognitive impairment. However, the standard MoCA is approximately two times longer to administer than the Mini-Mental State Examination. A total of 699 Czech and 175 American participants received the standard MoCA Czech and English versions and in the clinical part, a sample of 102 nondemented patients with Parkinson's disease (PD). We created a validated Czech short version (s-MoCA-CZ) from the original using item response theory. As expected, s-MoCA-CZ scores were highly correlated with the standard version (Pearson $r = .94$, $p < .001$). s-MoCA-CZ also had 80% classification accuracy in the differentiation of PD mild cognitive impairment from PD without impairment. The s-MoCA-CZ, a brief screening tool, is shorter to administer than the standard MoCA. It provides high-classification accuracy for PD mild cognitive impairment and is equivalent to that of the standard MoCA-CZ.

Keywords

s-MoCA-CZ; s-MoCA; MoCA; MMSE; cognitive screening; test equating

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Parkinson's disease (PD) is a chronic, progressive neurodegenerative disorder. Worldwide, more than four million individuals over the age of 50 years are affected by PD, and this number will grow significantly during the next 25 years (Dorsey et al., 2007). Motor symptoms are the primary clinical feature of PD, however, nonmotor symptoms, including cognitive impairment, are quite prevalent (Jankovic, 2008; Williams-Gray et al., 2013; Williams-Gray, Foltynie, Brayne, Robbins, & Barker, 2007). Cognitive impairment in PD is characterized according to International Parkinson and Movement Disorder Society (IPMDS) along with a spectrum ranging from mild cognitive impairment (PD-MCI) to dementia syndrome (PD-D; Dubois et al., 2007; Emre et al., 2007; Litvan et al., 2012). Overall, the prevalence of PD-MCI is high and ranges from 24% to 31% in PD (Litvan et al., 2012). Moreover, two authoritative studies found that from 78% to 100% of individuals with PD-MCI were likely to develop dementia over the next 5 to 8 years (Aarsland, Andersen, Larsen, Lolk, & Kragh-Sorensen, 2003; Pigott et al., 2015), thus PD-MCI conferring a significant risk for PD-D.

Reliable detection of MCI is clinically relevant as it is associated with a higher risk of developing dementia, which negatively affects patient well-being and instrumental activities of daily living (Pirogovsky et al., 2014) while increasing caregiver burden (Aarsland, Larsen, Karlsen, Lim, & Tandberg, 1999), depressive symptoms, and health care costs (Schrag, Jahanshahi, & Quinn, 2000; Vossius, arsen, Janvin, & Aarsland, 2011). Detailed neuropsychological assessment plays an essential role in the detection of PD-MCI. However, it is time consuming and not well-suited for the routine clinical management of PD patients. It is, therefore, necessary to have validated appropriate brief screening instruments for busy clinicians that help detect cognitive impairment in patients with PD (Fengler et al., 2016; Roalf et al., 2016).

Screening tests such as Montreal Cognitive Assessment (MoCA; Nasreddine et al., 2005) and Mini-Mental State Examination (MMSE; Folstein, Folstein, & McHugh, 1975) are efficient clinimetric tools for the detection of cognitive impairment. Several studies have shown that MoCA is more informative than MMSE due to its higher sensitivity and specificity in the detection of PD-MCI (Bezdicek, Michalec, et al., 2014; Dalrymple-Alford et al., 2010; Fengler et al., 2016; Hoops et al., 2009; Nazem et al., 2009; Zadikoff et al., 2008). While the MMSE is the most widely used brief cognitive screening test, the MoCA is likely to supplant the MMSE given its superior psychometrics (Horton et al., 2015; Roalf et al., 2013; Roalf et al., 2016). The MoCA consists of 13 items and includes screening questions from multiple cognitive domains, including visuospatial, executive, naming, attention, language, abstraction, memory, and orientation. As PD is known to result in deficits of a visuospatial and executive function early in the clinical course (Dirnberger & Jahanshahi, 2013; Gill, Freshman, Blender, & Ravina, 2008; Owen et al., 1992), the MoCA is likely to prove useful in screening for initial cognitive impairment. However, administration time is considered a disadvantage of the MoCA (Gill et al., 2008; Roalf et al., 2016; Zadikoff et al., 2008). The standard MoCA takes about 10 to 15 minutes to administer even in the healthy population (Henderson et al., 2016; Kopecek et al., 2017; Roalf et al., 2016) and is approximately two times longer than the administration time of the MMSE (Stepankova et al., 2015). However, recent work has created validated short forms of the

MoCA (s-MoCA; Horton et al., 2015; Panenková, Kopeček, & Lukavský, 2016; Roalf et al., 2016). Roalf et al. (2016) introduced an eight-item s-MoCA, which is characterized by better psychometric characteristics than the standard MoCA to detect cognitive impairment in a broad spectrum of diseases. The items empirically selected for the s-MoCA are in agreement with other psychometric studies of the MoCA (Horton et al., 2015; Panenková et al., 2016). But most important, the s-MoCA administration time is on average 5 minutes (Roalf et al., 2016).

It is also important to consider whether the English s-MoCA is psychometrically equivalent in item structure when the items are translated to form the s-MoCA Czech version (s-MoCA-CZ). This is critical for generalizability and has been partially addressed in previous normative research on the Czech version of the standard MoCA, which showed differential item functioning and reduced generalizability (Kopecek et al., 2017; Rossetti, Lacritz, Cullum, & Weiner, 2011). Thus, item response theory (IRT) provides a promising approach to identify the most discriminative items, while removing items that may bias the test due to language or sociocultural differences (Embretson & Reise, 2000; Lord, 1980; van de Vijver & Tanzer, 2004).

Here, using data from healthy older adults individuals, we aim to (a) compare the cross-cultural validity of the MoCA (Nasreddine et al., 2005) and s-MoCA (Roalf et al., 2016) in a sample of healthy older adults—699 from the Czech Republic and 175 from the United States; (b) create an s-MoCA-CZ for brief clinimetric screening; (c) compare the s-MoCA-CZ with the English version (s-MoCA-US); and (d) test its validity in a sample of 102 PD patients from the Czech population.

Method

Participants and Methods

Czech Sample.—Healthy participants (normal cognition [NC]; $n = 699$; mean age [$M \pm SD$] 71.27 ± 14.24 and education 13.09 ± 3.46 years; Table 1) were recruited through flyers and advertisements from the general community. NC was included if there was no history of head trauma with loss of consciousness, no cerebrovascular accident, no abuse of alcohol or other psychoactive substances, no neurological or psychiatric disease (e.g., epilepsy, multiple sclerosis, schizophrenia), not currently undergoing radio or chemotherapy and free from uncompensated sensory deficits. Participants meeting the above criteria were then tested for manifestations of depression and instrumental activities of daily living. In order to prevent the inclusion of participants at risk of developing neurodegenerative disease, limits for enrollment were set on two or more of the following neuropsychological tests not having a score 2 *SD*s below the sample mean: a composite score on Trial 1 to 5 and Trial 9 in 12-word Philadelphia Verbal Learning Test (czP(r) VLT-12; Bezdicek, Libon, et al., 2014); Trail Making Test, Part B (TMT-B; Bezdicek et al., 2012); a composite score on tests of verbal fluency (three letters and animal stimuli; Benton, Hamsher, & Sivan, 1994; Nikolai et al., 2015); the Beck Depression Inventory (BDI-II) at a score of <13 or the shortened version of the Geriatric Depression Scale (GDS-15) <10, and the Functional Activities Questionnaire (FAQ) at ≤10 points (Bezdicek, Stepankova, Martinec Novakova, & Kopecek, 2016).

Demographic characteristics of the cohort and their basic functional characteristics are presented in Table 1.

The clinical sample consisted of patients with PD (n = 102). All participants were recruited from the Movement Disorders Center, Department of Neurology, First Faculty of Medicine and General University Hospital in Prague (Prague, Czech Republic). All PD patients were examined by a neurologist specialized in movement disorders and met the U.K. PD Society Brain Bank criteria (Hughes, Daniel, Kilford, & Lees, 1992). Exclusion criteria were as follows: PD-D according to IPMDS criteria (Emre et al., 2007); atypical or secondary parkinsonism; severe or unstable depression; the presence of psychotic manifestations (hallucinations or delusions) based on a psychiatric interview; anticholinergic medications; and other medical or neurological conditions potentially resulting in cognitive impairment (e.g., seizure, stroke, or head trauma). Total levodopa equivalent daily dose for each patient was calculated (Table 2). All PD patients (n = 102; Table 2) were examined in the ON motor state. All participants (PD patients and paired NC; n = 74; Table 2) underwent a comprehensive clinical evaluation that included medical history, evaluation of functional abilities, medication status, motor status by the UPDRS-III (Unified Parkinson's Disease Rating Scale–Part III), and standard MDS Level II neuropsychological assessment for the diagnosis of PD-MCI (Supplemental Table 7).

The MoCA was administered before neuropsychological testing. The standard Czech version of MoCA (www.mocatest.org) was used which was approved by the author of the original, Dr. Z. Nasreddine (Reban, 2006). Neuropsychological testing was conducted by trained psychologists at Level II (comprehensive assessment), which consisted of 10 tests in five cognitive domains (see supplemental material [All supplementary materials are available in online version of the article.]). First, we classified PD sample into PD-MCI (n = 42) and PD-NC (n = 60, i.e., PD without cognitive impairment, see Table 3) based on our previous normative data study (Bezdicek, Nikolai et al., 2017; Bezdicek, Sulc et al., 2017) at Level II. PD-MCI classification: We normalized the raw scores of the PD group from each of the 10 measures in the battery and transformed them to z scores using the Rankit formula (rankits of a set of data are the expected values of the order statistics of a sample from the standard normal distribution; Solomon & Sawilowsky, 2009). On Level II, patients that scored 2.0 SDs below the average z score derived from the normative sample were classified as PD-MCI. These participants satisfied impairment criteria on at least two neuropsychological tests, represented by either two impaired tests in one cognitive domain or one impaired test in two different cognitive domains (Litvan et al., 2012). The classification was used for the determination of the discriminative potential of the s-MoCA-CZ based on the ROC analysis to prevent circularity in our diagnostic decision making. Afterward, we compared PD-NC and PD-MCI samples with demographically matched NC (n = 74) selected from the normative study (n = 699). The MoCA-CZ was administered to all participants but was not used during clinical evaluation to prevent circularity in diagnostic decision making.

The study was approved by the local ethics committees (General University Hospital, National Institute of Mental Health) and all participants provided signed informed consent.

American Sample.—Data from 175 healthy older American adults (age 71.96 ± 9.34 and education 16.03 ± 2.71 years) were included as a cross-cultural comparison cohort (Table 1). These data were previously published, and full details are described (Roalf et al., 2016). Briefly, all healthy older adults were recruited from the Penn Memory Center and Clinical Core of the University of Pennsylvania's Alzheimer's Disease Center at the University of Pennsylvania. A healthy consensus diagnosis was established using standardized clinical criteria on the basis of history, physical, and neurologic examinations conducted by experienced clinicians, including a review of neuroimaging, neuropsychological (including MMSE), and laboratory data. The MoCA was not used during consensus. The institutional review board at the University of Pennsylvania's participating approved the study and written informed consent was obtained from participants prior to study participation.

Statistical Analyses.—All analyses were performed using R (R Core Team, 2016), SPSS (v. 22.0; IBM Corp, Armonk, NY), and Stata (StataCorp, 2017). Continuous variables are expressed as *M, SD*, and range, categorical variables as percentages, and ordinal variables as medians. Normality was evaluated by visual inspection of Q–Q plots and the Shapiro–Wilk test. The homogeneity of variances was measured using the Levene's test. The Spearman correlation coefficient was used to evaluate the relationship between different ordinal test measures and the Pearson correlation coefficient for different continuous test measures. For between-groups differences, one-way analysis of variance was used. Effect size statistic was based on eta square. The level of significance was set at $\alpha = .05$.

Item Calibration and Computerized Adaptive Test Simulation.—Item selection for the short form of the Czech version of the MoCA was completed using a previously published method (Moore et al., 2015; Roalf et al., 2016). All individuals ($n = 801$; young, old, and PD) with Czech MoCA scores were used to derive the short form. Briefly, items were calibrated using IRT (Embretson & Reise, 2000; Lord, 1980)—specifically, the graded response model (Samejima, 1969). The resulting estimated item parameters were then inputted to Firestar (Choi, 2009), a computerized adaptive test (Wainer et al., 2000) simulation program. This program simulated what would have happened if the full sample had been administered an adaptive version of the MoCA (stopping rule: standard error of measurement [SEM] < 0.63), and the usefulness of the items was judged based on how often they were administered in said simulations. Specifically, items were classified as "useful" and "not useful" based on *k*-means clustering with two centroids (Steinhaus, 1956) of their administration frequencies. This resulted in an administration percentage cutoff of approximately 85% in the Czech sample. The stopping rule of SEM < 0.63 was determined by calculating the SEM equivalent of a minimum acceptable value of Lambda2 (Guttman, 1945), which is 0.60; thus, the SEM was the square root of (1 – 0.6), which is 0.63. Scores on the resulting short form were then compared with (a) the full MoCA and (b) the English language short form (Roalf et al., 2016).

Results

Cross-Cultural Comparison

Mean age distributions were similar across the Czech and American samples. However, the Czech sample included more individuals in both tails (under 50 years old and older than age 80). In addition, the American sample included a higher proportion of women χ^2 (degrees of freedom [*df*] = 1, $n = 874$) = 8.77, $p = .003$, $\varphi = .103$ and, on average, had higher education $t(874) = -10.45$, $p < .001$, (Table 1). Thus, to better compare performance across cultures a demographically matched sample Czech ($n = 174$; age 71.88 ± 9.50 and education 14.26 ± 2.64 years) and American ($n = 175$; age 71.96 ± 9.34 and education 16.03 ± 2.71 years) was generated using only a subsample of the Czech data (Table 4). This subsample did not differ from the American sample in age, sex, or education.

Comparison of the Standard MoCA Between Czech and American Sample

On average, Czech adults (25.93 ± 2.43; $n = 174$) scored significantly lower on the MoCA than American adults (27.24 ± 1.90; $n = 175$), $t(347) = -5.62$,$p < .001$, even though both groups were demographically matched according to age, education, and sex (Table 2). Similarly, Czech adults (12.63 ± 2.11; $n = 174$) had significantly lower s-MoCA-US scores (Roalf et al., 2016) as compared with American adults (13.53 ± 1.87; $n = 175$), $t(347) = -4.24$, $p < .001$. As expected, there was a significant relationship between age and performance on the MoCA-US ($r = -.17$, $n = 175$, $p = .029$) and s-MoCA-US ($r = -.17$, $n = 175$, $p = .026$); however, the age-performance relationship was stronger when the Czech versions were used: MoCA-CZ ($r = -.33$, $n = 174$, $p < .001$); s-MoCA-CZ ($r = -.23$, $n = 174$, $p = .002$). Thus, a culturally specific s-MoCA-CZ including normative data is warranted.

Derivation of the Czech s-MoCA

Item analysis and computerized adaptive test of the MoCA-CZ across a large sample ($n = 699$) including identified eight items with high discriminations and sufficiently variable difficulties to discriminate between cognitively impaired and unimpaired individuals (Table 5). Selected items included the following: Trail Making, Clock Draw, Digit Span Backwards, Serial Subtraction, Language Repetition (Cat), Language Fluency, Abstraction (Watch), and Recall. Using only these items, an s-MoCA-CZ was constructed with a score range from 0 to 16. Notably, six of the eight items overlapped with items on the recently published s-MoCA-US (Roalf et al., 2016) indicating the utility of a Czech version. The items of difference between the two versions were (Naming Rhinoceros and Orientation Place; see Table 5 and Supplemental table 9).

Within the Czech sample the convergent validity was high as the correlation between MoCA-CZ and s-MoCA-CZ in healthy individuals ($n = 699$) was Pearson $r = .937$ (95% confidence interval [.925, .947]; $p < .001$). These associations remained the same after z transform of the data, and these associations were similar to the previously reported by Roalf et al. (2016).

Clinimetric Screening Using s-MoCA-CZ in PD Patients

Discriminative Validity.—Based on an independent samples *t* test ($M = 12.16$, $SD = 2.51$, $n = 102$), PD patients scored lower on the s-MoCA-CZ as compared with NC ($M = 13.18$, $SD = 1.90$, $n = 74$); $t(174) = -2.93$, $p = .004$. The magnitude of the differences in the means using eta square was small to moderate ($\eta^2 = .047$).

An analogous nonparametric analysis based on Mann–Whitney *U* test $U = 2916$, $z = -2.59$, $p = .009$, $r = .19$ corroborated the results (Table 2).

One-way between-groups analysis of variance was used to explore compare cognitive performance, as measured by the MoCA-CZ and s-MoCA-CZ in subgroups of PD with (PD-MCI) and without cognitive impairment (PD-NC). MoCA-CZ and s-MoCA-CZ scores were used to compare PD-NC and PD-MCI and to determine their diagnostic accuracy (Tables 2 and 3). Levene's test for homogeneity of variances did not indicate a violation of the homogeneity of variance assumption for the s-MoCA-CZ ($p > .05$), but this was not the case for the MoCA-CZ ($p < .01$). Scores on both the MoCA-CZ and s-MoCA-CZ differentiated all three groups, NC from PD-NC and PD-MCI, $F(2,173) = 33.9$, $p < .001$ and $F(2,173) = 25.2$, $p < .001$. The effect size, calculated using eta square for MoCA-CZ and s-MoCA-CZ was large to medium ($\eta^2 = .28$ and .23), respectively. Post hoc comparisons using the Tukey's HSD (honest significant difference) test indicated significant differences between PD-NC versus PD-MCI (both $p < .001$) for MoCA-CZ and s-MoCA-CZ.

Again, a nonparametric analysis provided analogous results (taking into account the violation of homogeneity of variances in the case of MoCA-CZ).

Detection Potential of the MoCA-CZ/s-MoCA-CZ for Mild Cognitive Impairment in PD.—Within the complete PD sample ($n = 102$), there was a significant association between MoCA-CZ and s-MoCA-CZ ($r = .922$, $p < .001$). The AUC of the s-MoCA-CZ comparing PD-MCI with PD-NC was good (80%), but was lower than the standard MoCA-CZ (82%; Table 3). The optimal cutoff score of the s-MoCA-CZ was ≤12 (Table 3). We examined the difference between ROC curves using DeLong test (DeLong, DeLong, & Clarke-Pearson, 1988) and did not find any significant differences: PD-NC versus PD-MCI $\chi^2(df = 1, n = 102) = 1.16$, $p = .281$ (Supplemental Table 8).

The Equipercentile Equivalent Scores on the MMSE and s-MoCA-CZ—The correlation of the MoCA-CZ and s-MoCA-CZ with MMSE was ($r = .484$ and .404, respectively, $n = 582$, $p < .001$). To facilitate the use of the s-MoCA-CZ, we report corresponding test scores and percentile ranks to allow for the conversion of s-MoCA-CZ scores to MMSE scores. The equipercentile matched MMSE and s-MoCA-CZ scores are based on 582 healthy participants because only those had both MMSE and MoCA (Table 6). For example, a score of 8 on the s-MoCA-CZ is equivalent to a score of 26 on the MMSE, as both of these scores fall at the 20th percentile. Age and education could affect this conversion. Thus, we included age- and education-adjusted equivalency tables (Supplemental Tables 10 and 11; 13 and 14).

Cross-Cultural Differences Between s-MoCA and s-MoCA-CZ—To quantify the potential contribution of different languages to the MoCA, regression analysis on MoCA/MoCA-CZ total score and s-MoCA/s-MoCA-CZ, respectively, was performed. Following previously used regression methods (Testa, Winicki, Pearlson, Gordon, & Schretlen, 2009), a model that included age, education, sex, and handedness accounted for 12.7% of the variance in MoCA performance, for 10.1% of the variance in s-MoCA performance, and for 12.0% of the variance in s-MoCA-CZ performance, respectively. Overall, the first block of variables (handedness, gender, age, and education) explained significant variance for each test version (all $p < .001$). Adding a term for language improved the model significantly for the English language versions with a 5.1% of the variance explained for the MoCA ($p < .001$), and 2.6% more variance explained for the s-MoCA ($p = .003$). Astonishingly, language accounted for an additional 26.1% of the variance of the model for performance on the s-MoCA-CZ ($p < .001$; see Supplemental Table 12).

Discussion

The rationale behind the present study was to satisfy the need for an adequate, yet quick to administer, screening measure of cognitive function in routine clinical settings (Brayne, Fox, & Boustani, 2007; Roalf et al., 2016; Roalf et al., 2017). Based on our previous research on the normative data for the standard MoCA and MMSE Czech version, we aimed at abbreviating the standard MoCA to shorten the administration time, as this is the greatest disadvantage of standard MoCA to MMSE. The MoCA-CZ takes on average 12 minutes to administer, which is more than two times longer than the MMSE; however, we aimed at preserving the discriminative validity of the MoCA-CZ (Kopecek, Bezdicek, Sulc, Lukavsky, & Stepankova, 2016; Kopecek et al., 2017; Panenková et al., 2016; Stepankova et al., 2015). Here, we provide a comparison of MoCA performance across Czech and U.S. cultures, calculate an abbreviated version of the MoCA (s-MoCA-CZ) for use in the Czech population, and investigate the utility of the MoCA-CZ and s-MoCA-CZ to differentiate mild cognitive impairment in PD.

We have shown that a culturally specific s-MoCA-CZ is needed based on American and Czech matched samples comparisons using IRT. This discordant result in the specific items included is not unexpected regarding previous findings of differing results in comparisons of the same version of tests from different cultural backgrounds (Bezdicek, Moták et al., 2016; Fernandez & Marcopulos, 2008; Ostrosky-Solis et al., 1985). Using IRT, we created a culturally adequate eight-item s-MoCA-CZ which has slightly different items than the English version (Roalf et al., 2016). Not surprisingly, s-MoCA-CZ scores were also in general lower in Czech NC sample in comparison with American data. This difference may be explained by a pronounced word-length effect in the MoCA-CZ and s-MoCA-CZ (Memory subscale in the MoCA-CZ is based on a word-by-word translation, and while the original MoCA-Memory subscale contains 7 syllables, the Czech version has 12; Kopecek et al., 2017). Moreover, MoCA-CZ delayed recall has by far strongest correlation with MoCA-CZ total score (.75) and as a polytomous item loads one sixth of the total test score (Panenková et al., 2016). Our current results are highly consistent with that of Panenková et al. (2016), where it was shown that the most discriminative item pairs (e.g., dyads) on the MoCA includes the delayed recall questions. In fact, the most discriminative dyad (AUC

≥ .847) for the detection of low cognitive performance included delayed recall and trail making, both of which are items selected for inclusion in the s-MoCA-CZ. Moreover, our results were supported by the regression analyses in which after accounting for the influence of age, education, sex, and handedness, the term for language explained an astonishing 26.1% of the variability in the s-MoCA-CZ (but only 2.6% in the original s-MoCA). We argue that these results indicated the need for a cross-culturally adapted diagnostic instruments, especially, when verbal memory is included as a domain.

The North American normative studies available also differ significantly in the mean MoCA scores (Nasreddine et al., 2005; Rossetti et al., 2011). In conclusion, the resulting s-MoCA-CZ is not only nonequivalent in the mean score to the s-MoCA-US but it also has a different item structure. However, a culturally adapted s-MoCA-CZ is clinically useful because it provides normative values for participants aged from 19 to 97 years and can also be transformed to standard MMSE percentile equivalents to enhance its clinical applicability (Roalf et al., 2013; Roalf et al., 2017).

To evaluate the classification accuracy and discriminative validity of the s-MoCA-CZ, we administered the test to PD patients diagnosed according to the standard IPMDS criteria at Level II and classified them as PD-NC and PD-MCI. Afterward, we used ROC analysis (Bezdicek et al., 2017; Florkowski, 2008; Litvan et al., 2012). Both the standard MoCA-CZ and the s-MoCA-CZ highly differentiated PD-NC from PD-MCI (both $p < .001$) and had comparable AUC ≥ 80%. This is a very good result regarding PD-MCI as a predementia state with only milder cognitive deficits present (Aarsland et al., 2017). However, the sensitivity of the s-MoCA-CZ was unsatisfactory and lower than in the standard MoCA-CZ (.67 < .73). On the other hand, s-MoCA-CZ had higher specificity than MoCA-CZ (.81 > .76), that is, s-MoCA-CZ classifies with higher accuracy a percentage of PD-NC (has higher true negative rate). Both levels are higher than in the previous study by Roalf et al. (2016). However, those comparisons by Roalf et al. (2016) were based on PD versus HC and PD-D versus PD.

Slightly different were the results in PD-MCI versus NC comparisons when s-MoCA-CZ had higher sensitivity than MoCA-CZ (.84 > .82). However, both standard and abbreviated versions had similar levels of unsatisfactory specificity (.62). Taken together, these results are supportive of s-MoCA-CZ as an abbreviated but valid and discriminative tool in comparison with standard MoCA-CZ for the differentiation of PD-MCI (Horton et al., 2015; Roalf et al., 2016). In case of PD-MCI differentiation from NC, s-MoCA-CZ had high detection potential, that is, if the test result is negative (≥13 points cutoff), then we can be nearly certain that they do not have MCI (high sensitivity); however, if the test is positive (<13 cutoff), then we cannot be nearly certain that they actually have the disease (unsatisfactory specificity).

Overall, both results may be viewed favorable because in clinical settings (PD-NC vs. PD-MCI differentiation), we need high specificity (being almost sure that the patients are not MCI when they really are not); however, in population screening we need high sensitivity (being almost sure that the person does have MCI when it is actually the case; Fawcett, 2006). Of note is that classification accuracies reported for s-MoCA-CZ are comparable to

the most authoritative study on the standard MoCA versus MMSE in PD-MCI and PD-D (Hoops et al., 2009). More important, both ROC curves of s-MoCA-CZ and original MoCA-CZ are equivalent based on DeLong test; that is, there is no reliable difference in the classification accuracy of both instruments.

The current study is not without limitations and these need to be stated. First, the sample size of our PD sample was modest, that is, more precise cutoff values could be achieved with larger samples. Second, the present classification accuracies cannot be generalized to other neurodegenerative diseases, for example, Alzheimer's disease. Third, our s-MoCA-CZ is not equivalent to the s-MoCA-US due to differing item structure, and future normative data sets cannot be directly compared. Fourth, the MoCA, administered before neuropsychological assessment, may have therefore some practice effect on the subsequent neuropsychological testing. Fifth, any adjustments needed for age and education regarding equipercentile equating of the s-MoCA and MMSE could not be taken into account as there is limited sampling from the younger range. As a result, these converted scores may be helpful only as approximations in clinical practice.

In conclusion, the aim of the present investigation was to shorten the standard MoCA-CZ to abbreviated s-MoCA-CZ and provide normative data in the Czech population and compare patients with PD with a healthy matched comparison sample. Early detection of cognitive impairment is an important step in the screening of predementia states, such as MCI, and is essential for enhancing patient's cognitive performance by early medical interventions (Emre et al., 2004), for lowering caregiver burden and reducing long-term health care costs (Schrag et al., 2000; Vossius et al., 2011). The s-MoCA-CZ is not only two times shorter, thus reducing time costs substantially, but it also has equivalent diagnostic accuracy for the differentiation of PD-MCI from PD-NC as the standard MoCA-CZ and can be readily transformed to MMSE score using equipercentiles.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Table 1.

Participant Characteristics of the Czech (n = 699) and American (n = 175) Samples.

	Czech		American	
	Count	**Percentage**	**Count**	**Percentage**
Sex				
Male	325	46.5	59	33.7
Female	374	53.5	116	66.3
Age, years				
19-29	21	3.0	0	0.0
30-39	10	1.4	0	0.0
40-49	17	2.4	0	0.0
50-59	21	3.0	17	9.7
60-64	110	15.7	28	16.0
65-69	99	14.2	26	14.9
70-74	111	15.9	31	17.7
75-79	92	13.2	34	19.4
80-84	101	14.4	19	10.9
85-89	80	11.4	17	9.7
90-97	37	5.3	3	1.7
Education				
Lower	202	28.9	3	1.7
Higher	496	71.1	172	98.3

Note. Education: higher = number of years at school ≥ 12 years; lower = number of years at school < 12 years.

Table 2.

Demographic, Clinical, and Neuropsychological (Level II) Characteristics of PD Patients (n = 102) and NC (n = 74).

	PD (PD-NC + PD-MCI)	NC	*P*
Age, years, *M* (*SD*), *Mdn*	60.47 (8.54), 63	61.38 (10.07), 63	.436
Education, years, *M* (*SD*), *Mdn*	13.94 (2.96), 13	14.30 (2.53), 13	.156
Gender (% male)	67	47	.016[a]
Ethnicity (% Caucasian)	100	100	*ns*
Language (% Czech)	100	100	*ns*
Duration of PD, years, *M (SD), Mdn*	11.06 (5.45), 11	—	—
UPDRS-III (ON), *M (SD), Mdn*	13.82 (10.26), 13.50	—	—
Hoehn/Yahr stage, *M (SD), Mdn*	2.04 (0.64), 2	—	—
Medication (LEDD), *M (SD), Mdn*	1275.40 (582.93), 1172.50	—	—
MoCA-CZ, *M (SD), Mdn*	25.12 (3.18), 26	26.59 (2.29), 27	.001 (.004)
s-MoCA-CZ, *M (SD), Mdn*	12.16 (2.51), 12	13.18 (1.90), 13	.004 (.009)

Note. LEDD = levodopa equivalent daily doses; UPDRS = Unified Parkinson's Disease Rating Scale; MMSE = Mini-Mental State Examination Czech version; PD = Parkinson's disease; PD-NC = Parkinson's disease with normal cognition; *ns* = nonsignificant result; MoCA = Montreal Cognitive Assessment; MoCA-CZ = Montreal Cognitive Assessment Czech version; s-MoCA-CZ = short version MoCA-CZ; IPMDS = International Parkinson and Movement Disorder Society; PD-MCI = Parkinson's disease with mild cognitive impairment, *p* Value is based on Mann-Whitney *U* test due to nonnormal distribution (or on independent samples *t* test in parenthesis). Data represent means or percentages, standard deviations, and medians. IPMDS PD-MCI battery domains, raw scores for the neuropsychological tests are provided.

[a] χ^2 test for independence (with Yates Continuity Correction).

Table 3.

Comparison of the Diagnostic Accuracy of MoCA-CZ and s-MoCA-CZ in PD-MCI, PD-NC, and NC.

	Cutoff	Sensitivity	Specificity	AUC	Lower 95% CI	Upper 95% CI
PD-MCI (n = 42) vs. PD-NC (n = 60)						
MoCA-CZ	25.50	.733	.762	.815	.727	.903
s-MoCA-CZ	12.50	.667	.810	.796	.705	.887
PD-MCI (n = 42) vs. NC (n = 74)						
MoCA-CZ	24.50	.824	.619	.804	.720	.889
s-MoCA-CZ	12.50	.838	.620	.786	.697	.876
PD-NC (n = 60) vs. NC (n = 74)						
MoCA-CZ	—	—	—	.501	.403	.599
s-MoCA-CZ	—	—	—	.493	.394	.591

Note. MoCA = Montreal Cognitive Assessment; MoCA-CZ = MoCA Czech version; s-MoCA-CZ = short version MoCA-CZ; PD = Parkinson's disease; CI = confidence interval; AUC = area under the curve; Cutoff = optimal diagnostic cutoffs (cutoffs with maximum combined sensitivity and specificity); PD-NC = Parkinson's disease with normal cognition; PD-MCI = Parkinson's disease with mild cognitive impairment.

Table 4.

Participant Characteristics of the Demographically Matched Czech (n = 174) and American (n = 175) Samples.

	Czech		American	
	Count	**Percentage**	**Count**	**Percentage**
Sex				
Male	58	33.3	59	33.7
Female	116	66.7	116	66.3
Age, years				
50-59	16	9.2	17	9.7
60-64	28	16.1	28	16.0
65-69	26	14.9	26	14.9
70-74	31	17.8	31	17.7
75-79	34	19.5	34	19.4
80-84	19	10.9	19	10.9
85-89	17	9.8	17	9.7
90-97	3	1.7	3	1.7
Education				
Lower	3	1.7	3	1.7
Higher	171	98.3	172	98.3

Note. Education: higher = number of years at school ≥ 12 years; lower = number of years at school < 12 years.

Table 5.

Items Selected in the CAT for the s-MoCA-CZ: A Comparison With the s-MoCA-US Is Provided (Roalf et al., 2016).

Item	Name	% Administered Czech version	Include in Czech version	% Administered English version	Include in English version
1	Trail Making	99.7	Y	80.0	Y
2	Cube Copy	69.2	—	71.0	—
3	Clock Draw[a]	100.0	Y	100.0	Y
4	Naming Lion	52.4	—	50.0	—
5	Naming Rhinoceros	57.8	—	83.0	Y
6	Naming Camel	55.9	—	54.0	—
7	Attention Digit Forward	60.2	—	51.0	—
8	Attention Digit Backwards	100.0	Y	55.0	—
9	Attention Letters	63.4	—	72.0	—
10	Attention Subtraction[a]	100.0	Y	100.0	Y
11	Language Repeatjohn	75.8	—	63.0	—
12	Language RepeatCat	98.8	Y	59.0	—
13	Language Fluency	90.0	Y	76.0	Y
14	Abstraction Train	63.4	—	65.0	—
15	Abstraction Watch	85.2	Y	86.0	Y
16	Recall[a]	95.0	Y	90.0	Y
17	Orientation Month	51.6	—	64.0	—
18	Orientation Year	53.4	—	56.0	—
19	Orientation Day	51.7	—	72.0	—
20	Orientation Place	54.4	—	98.0	Y
21	Orientation City	51.6	—	52.0	—

Note. CAT = computerized adaptive test; s-MoCA-CZ = short eight-item Montreal Cognitive Assessment Czech version; s-MoCA-US = short eight-item Montreal Cognitive Assessment American version. "% Administered" indicates the percentage of examinees who received that item during simulated adaptive test administration. Overlapping items are highlighted in green; nonoverlapping items are indicated in red.

[a]Polytomous items (i.e., items that have more than two possible scores).

Table 6.

Equipercentile Rank Equating of the MoCA-CZ, s-MoCA-CZ, and MMSE.

s-MoCA-CZ (*n* = 699)	MMSE (*n* = 582[a])	MoCA-CZ (*n* = 699)
15-16	30	30
14	30	30
14	30	30
14	30	30
13	30	29
12	29	28
12	29	27
11	28	26
11	28	26
10	27	25
9	27	24
8	26	23
7	25	21
7	24	20
6	23	19
5	22	18

Note. s-MoCA-CZ = short eight-item form Montreal Cognitive Assessment Czech version (range 0-16 points/raw score); MMSE = Mini-Mental State Examination (Czech version); MoCA-CZ = the standard Montreal Cognitive Assessment Czech version (range 0-30 points/ raw score). Equipercentile equating of the s-MoCA-CZ and MMSE and MoCA-CZ corresponding test scores and percentile ranks allow for conversion of s-MoCA-CZ scores to MMSE and MoCA-CZ scores. For example, an s-MoCA-CZ score of 11 (50th percentile) is equivalent to an MMSE score of 28 (50th percentile).

[a]Due to changes in the study protocol and technical problems, 117 (16.7%) participants were missing MMSE test score.