Routledge
Taylor & Francis Group

Applied Neuropsychology: Adult

ISSN: 2327-9095 (Print) 2327-9109 (Online) Journal homepage: http://www.tandfonline.com/loi/hapn21

Montreal Cognitive Assessment (MoCA): Normative Data for Old and Very Old Czech Adults

Miloslav Kopecek, Hana Stepankova, Jiri Lukavsky, Daniela Ripova, Tomas Nikolai & Ondrej Bezdicek

http://dx.doi.org/10.1080/23279095.2015.1065261

Montreal Cognitive Assessment (MoCA): Normative Data for Old and Very Old Czech Adults

Miloslav Kopecek[a], Hana Stepankova[a], Jiri Lukavsky[a], Daniela Ripova[a], Tomas Nikolai[b] and Ondrej Bezdicek[a,b]

[a]National Institute of Mental Health, Klecany, Czech Republic; [b]Department of Neurology and Centre of Clinical Neuroscience, First Faculty of Medicine and General University Hospital in Prague, Charles University in Prague, Prague, Czech Republic

ABSTRACT
The principal aim of our study was to present norms for old and very old Czech adults on the Czech version of the Montreal Cognitive Assessment (MoCA) and investigate the influence of social and demographic factors on MoCA performance. We analyzed 540 adults aged ≥ 60 years (5-year age categories; nationally representative sample in terms of sex and educational level), who met strict inclusion criteria for the absence of neurodegenerative disorders and performed within normal range in neuropsychological assessment. Using multiple regression model, we found that MoCA performance was affected by age and education (both $p < .001$) but not sex. The study provides normed percentile estimates for MoCA performance stratified by age (60–74 years; ≥ 75 years) and education (lower versus higher). We also present percentile equivalents for the MoCA and Mini-Mental State Examination (MMSE) for use in clinical practice. We found age- and education-related effects on MoCA performance which support the use of culturally adapted normative data.

KEYWORDS
Ageing; cognition; Mini-Mental State Examination; Montreal Cognitive Assessment; normative data; screening

Dementia is one of the most common mental disorders in older adults and is a major cause of disability and mortality (Wittchen et al., 2011). A thorough neuropsychological assessment is an important component of the medical evaluation of patients with cognitive disorders including dementia, but due to time pressure this is not always possible and there is therefore a need for brief screening tools. There are many cognitive screening tests but Mini-Mental State Examination (MMSE) is one of the most popular and widely used (Folstein, Folstein, & McHugh, 1975). It has however been criticized because it is rather insensitive to mild dementia or mild cognitive impairment (MCI) (Nasreddine et al., 2005). The Montreal Cognitive Assessment (MoCA) is also a valid method for early dementia screening (Freitas, Simoes, Alves, & Santana, 2011; Freitas, Simoes, Maroco, Alves, & Santana, 2012; Hoops et al., 2009; Nasreddine et al., 2005) and there have been several published reports of national norms (for Portugal, United States of America, Japan and Ireland (Freitas et al., 2011; Kenny et al., 2013; Narazaki et al., 2013; Rossetti, Lacritz, Cullum, & Weiner, 2011) since the MoCA was introduced. The International Working Group (IWG) for New Research Criteria for the Diagnosis of Alzheimer's Disease (AD) and the U.S. National Institute on Aging-Alzheimer's Association (Albert et al., 2011; Dubois et al., 2014) recommend that data from individual patients should be compared with norms for age- and education-matched peers on culturally appropriate cognitive tests. We decided to obtain normative data for the Czech version of the MoCA in old and very old people from the Czech Republic and investigate the influence of social and demographic factors on MoCA performance. Furthermore, our aim was to publish percentile equivalents for MoCA and MMSE, which could be used in clinical practice. Normative data for the Czech MMSE in an older population are already available (Štěpánková et al., 2015).

Method

Participants

The current report is a part of a longitudinal 4-year project, the National Normative Study of Cognitive Determinants of Healthy Aging (NANOK). This analysis focuses on information obtained in baseline assessments conducted in the first year of the study. We recruited a convenience sample of independent elderly volunteers through advertisements on the institutional web site and in post offices, public libraries, and general practitioners' clinics. We recruited participants using non-random quota sampling in 12 of the 14 regions in the Czech Republic. The numbers recruited in each

CONTACT Ondrej Bezdicek, PhD ondrej.bezdicek@gmail.com Department of Neurology and Centre of Clinical Neuroscience, Charles University in Prague, 1st Faculty of Medicine and General University Hospital in Prague, Katerinska 30, 128 21, Praha 2, Czech Republic.

sociodemographic category were based on previous normative studies in older adults (5-year age categories; representative in terms of sex and level of education; (Crum, Anthony, Bassett, & Folstein, 1993; Huppert, Cabelli, Matthews, & MRC Cognitive Function and Ageing Study [MRC CFAS], 2005; Ivnik et al., 1990; Wechsler, 1997). Two educational categories were used, lower and higher education level (see Table 1). We recruited a predefined number of participants in each subgroup (equal numbers of men and women and in the two educational categories). The inclusion criterion was age ≥60 years; the exclusion criteria were any neurodegenerative disease; previous head trauma resulting in unconsciousness; stroke; a history of alcohol or substance abuse; undergoing radiotherapy or chemotherapy; epilepsy; major depression or other major psychiatric disorder; unstable medical illness; and uncorrected visual or hearing impairment. We enrolled 568 participants (age range: 60–98 years) who met the criteria and provided informed consent. To avoid the inclusion of individuals with emerging dementia or depressive disorder we applied an additional exclusion criterion, having a score 2 SDs below the sample mean on two or more of the following neuropsychological tests: a composite score on trial 1–5 and trial 9 in Twelve-Word Philadelphia Verbal Learning Test (czP(r)VLT-12; (Bezdicek et al., 2014); (score <19 words in 60–74 years old persons or <16 words in ≥75 years old persons)); Trail Making Test, Part B (TMT-B; (Bezdicek et al., 2012)); (time >295 s in younger or time >360 s in older group); a composite score on tests of verbal fluency (three letters and animal stimuli); (Benton, Hamsher, & Silvan, 1994); (score <23 words in younger and <15 words in older group); the Functional Activities Questionnaire (FAQ >10); (Bezdicek, Stepankova, Martinec, Novakova, & Kopecek, 2016; Pfeffer, Kurosaki, Harrah, Chance, & Filos, 1982) and the Geriatric Depression Scale (GDS-15 >10); (Sheikh & Yesavage, 1986)). We chose czP(r)VLT-12, TMT-B and verbal fluency tests to cover three different cognitive domains that are impaired in patients with dementia and should be normal in healthy participants. czP(r)VLT-12 covers memory domain, TMT-B covers executive function domain and verbal fluency tests cover language domain (Backman et al., 2005). We use 2 SDs below the overall sample mean for FAQ and GDS-15 rather than exact cut off because in very old population in Czech Republic we lack the validaty study for GDS-15 and FAQ respectively. The final sample consisted of 540 older adults (Table 1).

Table 1. Descriptive statistics of the sample.

Age	N (%)	Mean ± SD
60–64 years	81 (15.0)	62.00 ± 1.52
65–69 years	77 (14.3)	67.05 ± 1.52
70–74 years	91 (16.9)	72.39 ± 1.28
75–79 years	84 (15.6)	77.17 ± 1.33
80–84 years	98 (18.1)	81.89 ± 1.59
85 + years	109 (20.2)	88.10 ± 2.88
Whole sample	540	75.59 ± 9.12
Sex		
Men	248 (45.9)	
Women	292 (54.1)	
Education		
Lower (<12 years)	254 (47.0)	10.18 ± 2.01
Higher (≥12 years)	286 (53.0)	14.94 ± 2.97
Whole sample	540	12.70 ± 3.5

Note. *N* = number of subjects in each group.

Procedure

The team of assessors consisted of 25 psychologists and other health professionals including two authors of this paper (HS; MK). Each assessor was trained to administer and evaluate the cognitive tests in order to ensure adequate inter-rater reliability. All participants were assessed individually in an office or at home, according to their preference. Every assessor ensured the same standardized testing environment at home as in the office. The assessment protocol consisted of two blocks: the MoCA block and the MMSE block, named after the first test used in the block. We used the Czech version of MoCA (www.mocatest.org; (Reban, 2006)) after discussions with members of the original MoCA team. We did not use the educational correction in calculating totals scores on the MoCA. The MoCA block comprised the following tests and questionnaires: Wechsler Adult Intelligence Scale, Third Revision (WAIS-III) Digit Span subtest and Digit Symbol Substitution Test (Wechsler, 2010); Wechsler Memory Scale, Third Revision (WMS-III) Logical Memory (Wechsler, 2011); semantic verbal fluency (the categories were animals, plants, hand tools, and vegetables; (Nikolai et al., 2015)); TMT-A and -B (Bezdicek et al., 2012); and the Boston Naming Test-30 item version (Mack, Freed, Williams, & Henderson, 1992). The MMSE block comprised the following tests and questionnaires: czP(r)VLT-12 (Bezdicek et al., 2014); the Prague Stroop Test (PST; (Bezdicek et al., 2015); letter verbal fluency (Benton et al., 1994; Nikolai et al., 2015); FAQ (Bezdicek et al., 2011); GDS-15 (Sheikh & Yesavage, 1986); Geriatric Anxiety Inventory (GAI; (Pachana et al., 2007)); and the Everyday Memory Questionnaire revised 13-item scale (EMQ-R; (Royle & Lincoln, 2008)). We measured the time taken to administer the MoCA using a wrist-watch. The test duration is one of the important characteristic of screening test and previous information about it was based more on estimate rather than on exact measurement. The study protocol was approved by the Institutional Ethical Review Board of the Czech National Institute of Mental Health.

Statistical analysis

Analyses were performed using statistical software R (2014). Multiple regression was used to analyze associations between total MoCA score and age, education, and sex. ANOVA with post-hoc tests was used to evaluate the classification into six age groups (based on nonrandom quota sampling). The correlation between scores on the MoCA and the MMSE were evaluated using Spearman's coefficient of correlation. Our mapping of MoCA and MMSE scores was based on equipercentile equating and log-linear smoothing functions from the *equate* library in R (Albano, 2014). All tests were two-sided and a significance level of .05 was adopted.

Results

Order effects and influence of age, education, and sex on the MoCA

There was no detectable effect of block order on the MoCA score ($t(537.4) = 1.41$, $p = .158$), so we combined data from both blocks. Associations between MoCA total score and age (continuous factor), education (2 levels) and sex (2 levels) were assessed with multiple regression model without interactions (adjusted R2 = .187; p < .001). We found that MoCA total score was associated with age (regression coefficient b = −.095; 95% confidence interval (CI): [−0.119; −0.071]; p < .001). The mean score of participants in the higher education category was 1.81 point higher than that of participants in the lower education category (95% CI [1.37; 2.25]; p < .001). We found no effect of sex (woman: b = .11; 95% CI [−0.33; 0.55]; p = .629). An alternative model with included interactions did not provide significantly better fit ($\chi2(4) = 54.28$; p = .084). Because the MoCA results are correlated with age, it is convenient to split the sample into several age groups for the normative purposes. First, we tested the differences based on 6 five-year groups used for our sampling. We performed an ANOVA with age (6 five-year categories) as the independent variable and it showed a main effect of age (F (5, 534) = 11.02; p < 0.001). However, none of the post-hoc pairwise comparisons of neighboring groups were significant and we decided not to use five-year groups for normative data stratification. The largest–and still non-significant–difference was between the 70–74 years and 75–79 years groups (mean and SD: 25.19 years ±2.75, 24.13 years ±2.30, respectively); the boundary between these groups was therefore a convenient boundary for splitting the sample into two age groups in order to provide separate norms for elderly and very elderly subgroups. We find this separation point convenient, because it splits our data into two groups of similar size and it also corresponds with the traditional distinction between young-old and old-old (Neugarten, 1974). Table 2 shows descriptive statistics for the MoCA scores based on two educational categories and two age groups (60–74 years and ≥75 years). Table 3 presents estimated percentile boundaries for each of the MoCA raw scores stratified by age and education.

Table 3. Age and education adjusted normative data of the MoCA Czech version.

	MoCA score			
	Age 60–74 y		Age ≥75 y	
Percentile	Edu <12 y	Edu ≥12 y	Edu <12 y	Edu ≥12 y
95	28	30	28	28
90	28	29	26	28
85	27	29	26	27
80	27	28	25	27
75	27	28	25	27
70	26	28	24	26
65	26	28	24	26
60	26	28	24	26
55	25	27	23	25
50	25	27	23	25
45	25	27	23	25
40	24	26	22	24
35	24	26	22	24
30	23	25	21	24
25	23	25	21	23
20	22	24	21	23
15	22	24	20	22
10	21	23	20	22
5	20	22	19	21
2	18	21	18	20

Note. Edu = education (number of years at school); SD = standard deviation; y = years. MoCA percentile scores were rounded to an integer.

Table 2. Descriptive statistics for the MoCA and the MMSE scores by age and education.

			MoCA		MMSE	
Age	Education	N	Mean ± SD	Median (IQR)	Mean ± SD	Median (IQR)
60–74 years	<12 years	117	24.62 ± 2.66	25 (23–27)	27.53 ± 1.91	28 (26–29)
60–74 years	≥12 years	132	26.43 ± 2.37	27 (25–28)	28.23 ± 1.42	28 (27–29)
>74 years	<12 years	137	22.98 ± 2.88	23 (21–25)	26.39 ± 2.13	27 (25–28)
>74 years	≥12 years	154	24.79 ± 2.47	25 (23–27)	27.39 ± 2.00	28 (26–29)
60–96 years	5–28 years	540	24.69 ± 2.86	25 (23–27)	27.37 ± 2.00	28 (26–29)

Note. IQR = interquartile ratio, *M* = mean; MMSE = Mini-Mental State Examination; MoCA = Montreal Cognitive Assessment; *N* = number of subjects in each group; SD = standard deviation.

Table 4. Conversion table for the MMSE and the MoCA based on equipercentile equating in 540 healthy seniors.

MoCA raw score	MMSE equivalents
29–30	30
27–28	29
25–26	28
23–24	27
22	26
20–21	25
18–19	24
17	23
15–16	22
14	21

Note. MMSE = Mini-Mental State Examination; MoCA = Montreal Cognitive Assessment; percentile scores were rounded to an integer.

MoCA completion time

Reliable data on the time taken to administer the MoCA were available for 523 participants (97% of the original sample). On average the MoCA test took about 14 minutes to complete (mean = 13.55, *SD* = 5.4, median = 12). The distribution of test completion time was positively skewed: 25% of participants completed the MoCA in less than 10 minutes; 75% in less than 15 minutes and 95% of participants in less than 24 minutes. Completion time was positively correlated with age (Spearman $\rho = .396$, $p < .001$). We found a small effect of education (Wilcoxon W = 39822.5, $p < .001$, Cohen $d = .12$) and no effect of sex (W = 35526, $p = .380$, $d = .08$). Test duration was negatively correlated with performance (Spearman $\rho = -.288$, $p < .001$).

Association between the MoCA and the MMSE: Estimation of percentile equivalents

We found a significant association between scores on the MoCA and the MMSE (Spearman $\rho = 0.439$, $p < .001$). Percentile equivalents for the MoCA and the MMSE were constructed (see Table 4).

Discussion

We have presented normative data for the Czech version of the MoCA in old and very old Czech adults. Our data are in accordance with previous research showing that total MoCA score is associated with age and educational level but not sex (Freitas et al., 2011; Kenny et al., 2013; Narazaki et al., 2013; Oren et al., 2015; Rossetti et al., 2011). In summary, the difference between old (60–74 years) and very old participants (≥75 years) was two points in total MoCA score (see median in Table 3) as well as two points difference between less and higher educated participants. The authors of the original MoCA recommend adjusting scores by one point in participants with less than 12 years of education but they do not suggest any age adjustment (Nasreddine et al., 2005). Most validation studies have not detected any association between age and total MoCA score (Bartos, Orlikova, Raisova, & Ripova, 2014; Bezdicek et al., 2010; Bezdicek et al., 2013; Cumming, Churilov, Linden, & Bernhardt, 2013; Goldstein et al., 2014; Hoops et al., 2009; Kaya et al., 2014; Nasreddine et al., 2005) but other studies revealed a significant relation between age and the MoCA and adapted appropriately their normative data (Freitas et al., 2011; Oren et al., 2015; Rossetti et al., 2011). We presume these differences are related to differences in study design and sample size. Validation studies do not use age stratification and therefore cannot assess age effects directly. We suggest that the best method of taking age effects into account when using the test is to provide norms for two age groups corresponding to the common division into young elderly people and old elderly people cohorts in studies of healthy aging (Neugarten, 1974; Oren et al., 2015; Tombaugh, McDowell, Kristjansson, & Hubley, 1996).

We found that 50% of our sample fell below the standard cutoff, 26 points, for cognitive disorders (Table 2) suggested in the original study (Nasreddine et al., 2005). This proportion is comparable to that found in other normative studies, e.g., 66% (Rossetti et al., 2011) or lower 82.6% (Narazaki et al., 2013) but still higher than would be expected given the prevalence of MCI and dementia (Lopez-Anton et al., 2015; Matthews et al., 2013). There are several variables that could explain this inconsistency; we consider language bias to be the most important factor. To understand this consider an example: the official Czech version of the MoCA is based on a word-by-word translation and whilst the original MoCA-Memory subscale contains 7 syllables the Czech version has 12, resulting a more pronounced word-length effect and therefore greater item difficulty (Crocker & Algina, 2008). Overall, we agree with Dubois et al.'s (2014) statement about the need for culturally adapted tests and normative data: "The challenge of prescribing cutoff points lies in the variations in the tests used and in the adjustments across populations for age and education" (p. 616).

We did not find an order effect during the assessment, which started either with the MoCA, or with the MMSE block. This is encouraging for researchers or clinical neuropsychologists who may need to administer a complex neuropsychological battery and cannot rely on a single neuropsychological test. We detected some variability of MoCA test duration that could be explained by total score and age. This issue is important theoretically and could be linked with processing-speed theory of adult age differences (Salthouse, 1996), one of the major contemporary theories of healthy aging. Processing-speed theory presumes that cognitive deficits reflect a general reduction in the speed of cognitive processes due to age-related decline (Salthouse, 1996). Administration of the MoCA took 10–15 minutes in 75% of study participants, which seems a little high for a screening test, which should not normally take more than 10 minutes to administer. Busy clinicians would probably welcome the development of a shorter version (Appels & Scherder, 2010; Velayudhan et al., 2014; Roalf et al., 2016).

We found only a weak correlation between scores on the MoCA and MMSE. This might be because our sample was limited to healthy adults where the ceiling effect of the MoCA and MMSE might play a role. The MoCA is intended to assess executive functions and visuo-spatial abilities (Freitas et al., 2012), which are not included in the MMSE (Folstein et al., 1975; Štěpánková et al., 2015).

The percentile equivalents for the MoCA and the MMSE that we have presented may be helpful, at least as approximations, in clinical practice when the clinicians do not have enough time to administer both tests. Especially the results from the MMSE are often requested in the Czech Republic by insurance companies for the prescription of acetylcholinesterase inhibitors or in the cases, when the patient was tested a week ago with the MMSE and a robust practice effect can be expected by repeated administration. Our results are similar to previously published studies giving MMSE equivalents (Roalf et al., 2013; Solomon et al., 2014).

We are aware of the limitations of our study. Although our exclusion criteria were carefully formulated to minimize the chance of including individuals with pathological aging, our research sample did not undergo a thorough medical/neurological evaluation, including structural brain imaging, to exclude individuals with incipient or borderline brain atrophy. We use a conservative approach for a definition of normative healthy group (-2 SD exclusion criteria) because i) many cases of dementia are unrecognised in incipient phases and ii) we rely on personal history of subjects that is not always exactly clarified. Conservative approach reduced possibility that a person with dementia influences normative results. We excluded subjects that were impaired at least in two of the three cognitive domains. We used three different neuropsychological tests (czP(r)VLT, TMT-B and verbal fluency tests) that represent different cognitive domains impaired in patients with dementia (Backman et al., 2005). The combination of two domains reduced possibility to exclude cognitively healthy subjects and inflate impairment rates among healthy adults. We excluded 2.5% (14/568) subjects by use of -2 SD criteria. Moreover, according to some studies neuropsychological assessment is the best predictor of cognitive decline (Richard, Schmand, Eikelenboom, & Gool, 2013). Because effects related to the amount of effort research participants put into performing well on a test are always a concern we used the forced choice section of the czP(r)VLT-12 (Bezdicek et al., 2014) to assess effort levels; all participants demonstrated acceptable levels of effort. All participants in our study were Caucasian and so the generalizability of the results to other ethnic groups is clearly open to question. Longitudinal research with the same sample would be interesting as this would give us the opportunity to assess age-related decrements in total MoCA score at individual level and construct a reliable change index to be used when follow-up assessments are required to assess progressive disorders of cognitive function.

These limitations notwithstanding, these normative data for the Czech version of the MoCA, based on a large, representative sample of elderly and very elderly Czech adults, reveal a consistent decline in cognitive performance with age and show that education has a protective effect. We suggest that caution must be exercised when using cutoff scores derived from studies of samples with a different cultural background (Rossetti et al., 2011) and on this basis we have presented age- and education-adjusted norms for the Czech population to support clinical decision-making. We have also provided estimated percentile equivalents for the MoCA and MMSE for use in clinical practice.

Acknowledgments

The authors thank all the assessors (Eva Biedermannova, Pavla Davidova, Lenka Freharova, Marketa Holubova, Karolina Horakova, Adela Jencova, Olga Kozicka, Lenka Malkova, Jiri Michalec, Barbora Mnukova, Vlasta Novotna, Erika Panenkova, Klara Patlichova, Jana Pecinkova, Lucie Prazakova, Ilona Sedmidubska, Lenka Sreibrova, Nina Sterbova, Tomas Vacha, Martin Vaverka, Zuzana Velkoborska, Michaela Viktorinova, and Tomas Vilimovsky).

Funding

The study was conducted in the Czech Republic. This study was supported by grants from the Internal Grant Agency of Ministry of Health of the Czech Republic under grant number NT 13145-4/2012 and by the project "National Institute of Mental Health (NIMH-CZ)", under grant number ED2.1.00/03.0078, and the European Regional Development Fund.

References

Albano, A. (2014). *Equate: Observed-score linking and equating. R package version 2.0–3*. Retrieved from http://CRAN.R-project.org/package=equate

Albert, M. S., DeKosky, S. T., Dickson, D., Dubois, B., Feldman, H. H., Fox, N. C., … Phelps, C. H. (2011). The diagnosis of mild cognitive impairment due to Alzheimer's disease: Recommendations from the national institute on Aging-Alzheimer's Association Workgroups on diagnostic guidelines for Alzheimer's disease. *Alzheimer's & Dementia*, *7*(3), 270–279. doi:10.1016/j.jalz.2011.03.008

Appels, B. A., & Scherder, E. (2010). Review: The diagnostic accuracy of dementia-screening instruments with an administration time of 10 to 45 minutes for use in secondary care: A systematic review. *American Journal of Alzheimer's Disease and Other Dementias*, *25*(4), 301–316. doi:10.1177/1533317510367485

Backman, L., Jones, S., Berger, A. K., Laukka, E. J., & Small, B. J. (2005). Cognitive impairment in preclinical Alzheimer's disease: A meta-analysis. Neuropsychology, *19*(4), 520–531.

Bartos, A., Orlikova, H., Raisova, M., & Ripova, D. (2014). Czech training version of the Montreal cognitive assessment (moca-cz1) for early identification of Alzheimer disease. *Czech and Slovak Neurology and Neurosurgery*, *77*(5), 587–595.

Benton, A. L., Hamsher de, K. S., & Sivan, A. B. (1994). *Multilingual aphasia examination* (3rd ed.). San Antonio, TX: The Psychological Corporation.

Bezdicek, O., Balabanova, P., Havrankova, P., Stochl, J., Roth, J., & Ruzicka, E. (2010). A comparison of the Czech version of the Montreal Cognitive Assessment Test with the Mini Mental State Examination in identifying cognitive deficits in Parkinson's disease. *Czech and Slovak Neurology and Neurosurgery*, *73*(2), 150–156.

Bezdicek, O., Libon, D. J., Stepankova, H., Panenkova, E., Lukavsky, J., Garrett, K. D., … Kopecek, M. (2014). Development, validity, and normative data study for the 12-word Philadelphia verbal learning test [czP(r)VLT-12] among older and very old Czech adults. *Clinical Neuropsychologist*, *28*(7), 1162–1181. doi:10.1080/13854046.2014.952666

Bezdicek, O., Lukavsky, J., Stepankova, H., Nikolai, T., Axelrod, B. N., Michalec, J.,… Kopecek, M. (2015). The Prague Stroop Test: Normative standards in older Czech adults and discriminative validity for mild cognitive impairment in Parkinson's disease. *Journal of Clinical and Experimental Neuropsychology*, *37*(8), 794–807. doi: 10.1080/13803395.2015.1057106

Bezdicek, O., Stepankova, H., Martinec Novakova, L., & Kopecek, M. (2016). Toward the processing speed theory of activities of daily living in healthy aging: Normative data of the Functional Activities Questionnaire. *Aging Clinical and Experimental Research*, *28*(2), 239–247. doi: 10.1007/s40520-015-0413-5

Bezdicek, O., Majerova, V., Novak, M., Nikolai, T., Ruzicka, E., & Roth, J. (2013). Validity of the Montreal cognitive assessment in the detection of cognitive dysfunction in Huntington's disease. *Applied Neuropsychology-Adult*, *20*(1), 33–40. doi:10.1080/09084282.2012.670158

Bezdicek, O., Motak, L., Axelrod, B. N., Preiss, M., Nikolai, T., Vyhnalek, M., … Ruzicka, E. (2012). Czech version of the trail making test: Normative data and clinical utility. *Archives of Clinical Neuropsychology*, *27*(8), 906–914. doi:10.1093/arclin/acs084

Crocker, L., & Algina, J. (2008). *Introduction to classical and modern test theory*. Mason, OH: Cengage Learning.

Crum, R. M., Anthony, J. C., Bassett, S. S., & Folstein, M. F. (1993). Population-based norms for the mini-mental state examination by age and educational level. *The Journal of the American Medical Association*, *269*(18), 2386–2391. doi:10.1001/jama.269.18.2386

Cumming, T. B., Churilov, L., Linden, T., & Bernhardt, J. (2013). Montreal cognitive assessment and mini-mental state examination are both valid cognitive tools in stroke. *Acta Neurologica Scandinavica*, *128*(2), 122–129. doi:10.1111/Ane.12084

Dubois, B., Feldman, H. H., Jacova, C., Hampel, H., Molinuevo, J. L., Blennow, K., … Cummings, J. L. (2014). Advancing research diagnostic criteria for Alzheimer's disease: The IWG-2 criteria. *Lancet Neurology*, *13*(6), 614–629. doi:10.1016/S1474-4422(14)70090–0

Folstein, M. F., Folstein, S. E., & McHugh, P. R. (1975). "Mini-mental state." A practical method for grading the cognitive state of patients for the clinician. *Journal of Psychiatric Research*, *12*(3), 189–198.

Freitas, S., Simoes, M. R., Alves, L., & Santana, I. (2011). Montreal cognitive assessment (MoCA): Normative study for the Portuguese population. *Journal of Clinical and Experimental Neuropsychology*, *33*(9), 989–996. doi:10.1080/13803395.2011.589374

Freitas, S., Simoes, M. R., Maroco, J., Alves, L., & Santana, I. (2012). Construct validity of the Montreal cognitive assessment (MoCA). *Journal of the International Neuropsychological Society*, *18*(2), 242–250. doi:10.1017/S1355617711001573

Goldstein, F. C., Ashley, A. V., Miller, E., Alexeeva, O., Zanders, L., & King, V. (2014). Validity of the Montreal cognitive assessment as a screen for mild cognitive impairment and dementia in African Americans. *Journal of Geriatric Psychiatry and Neurology*, *27*(3), 199–203. doi:10.1177/0891988714524630

Hoops, S., Nazem, S., Siderowf, A. D., Duda, J. E., Xie, S. X., Stern, M. B., & Weintraub, D. (2009). Validity of the MoCA and MMSE in the detection of MCI and dementia in Parkinson disease. *Neurology*, *73*(21), 1738–1745. doi:10.1212/WNL.0b013e3181c34b47

Huppert, F. A., Cabelli, S. T., Matthews, F. E. & the MRC Cognitive Function, and Ageing Study (MRC CFAS). (2005). Brief cognitive assessment in a UK population sample – Distributional properties and the relationship between the MMSE and an extended mental state examination. *BMC Geriatrics*, *5*, 7. doi:10.1186/1471-2318-5-7

Ivnik, R. J., Malec, J. F., Tangalos, E. G., Petersen, R. C., Kokmen, E., & Kurland, L. T. (1990). The auditory-verbal learning test (AVLT): Norms for ages 55 years and older. *Psychological Assessment: A Journal of Consulting and Clinical Psychology*, *2*(3), 304–312. doi:10.1037//1040-3590.2.3.304

Kaya, Y., Aki, O. E., Can, U. A., Derle, E., Kibaroglu, S., & Barak, A. (2014). Validation of Montreal cognitive assessment and discriminant power of Montreal cognitive assessment subtests in patients with mild cognitive impairment and Alzheimer dementia in Turkish population. *Journal of Geriatric Psychiatry and Neurology*, *27*(2), 103–109. doi:10.1177/0891988714522701

Kenny, R. A., Coen, R. F., Frewen, J., Donoghue, O. A., Cronin, H., & Savva, G. M. (2013). Normative values of cognitive and physical function in older adults: Findings from the Irish longitudinal study on ageing. *Journal of the American Geriatrics Society*, *61*, S279–S290. doi:10.1111/Jgs.12195

Lopez-Anton, R., Santabarbara, J., De-la-Camara, C., Gracia-Garcia, P., Lobo, E., Marcos, G., … Lobo, A. (2015). Mild cognitive impairment diagnosed with the new DSM-5 criteria: Prevalence and associations with non-cognitive psychopathology. *Acta Psychiatrica Scandinavica*, *131*(1), 29–39. doi:10.1111/Acps.12297

Mack, W. J., Freed, D. M., Williams, B. W., & Henderson, V. W. (1992). Boston naming test – Shortened versions for use in Alzheimer's-disease. *Journals of Gerontology*, *47*(3), P154–P158. doi:10.1093/geronj/47.3.p154

Matthews, F. E., Arthur, A., Barnes, L. E., Bond, J., Jagger, C., Robinson, L., Brayne, C. & Medical Research Council Cognitive Function, and Ageing Collaboration.. (2013). A two-decade comparison of prevalence of dementia in individuals aged 65 years and older from three geographical areas of England: Results of the cognitive function and ageing study I and II. *Lancet*, *382*(9902), 1405–1412. doi:10.1016/S0140-6736(13)61570-6

Narazaki, K., Nofuji, Y., Honda, T., Matsuo, E., Yonemoto, K., & Kumagai, S. (2013). Normative data for the Montreal cognitive assessment in a Japanese community-dwelling older population. *Neuroepidemiology*, *40*(1), 23–29. doi:10.1159/000339753

Nasreddine, Z. S., Phillips, N. A., Bedirian, V., Charbonneau, S., Whitehead, V., Collin, I.,…Chertkow, H. (2005). The Montreal cognitive assessment, MoCA: A brief screening tool for mild cognitive impairment. *Journal of the American Geriatric Society*, *53*(4), 695–699. doi:10.1111/j.1532-5415.2005.53221.x

Neugarten, B. L. (1974). Age groups in American society and the rise of the young-old. *Annals of the American Academy of Political and Social Sciences*, *415*(1), 187–198. doi:10.1177/000271627441500114

Nikolai, T., Michalec, J., Bezdíček, O., Štěpánková, H., Marková, H., & Kopeček, M. (2015). Normative data on verbal fluency in very old Czech adults. *Czech and Slovak Neurology and Neurosurgery*, *78*(3), 292–299.

Oren, N., Yogev-Seligmann, G., Ash, E., Hendler, T., Giladi, N., & Lerner, Y. (2015). The Montreal cognitive assessment in lognitively-intact elderly: A case for age-adjusted cutoffs. *Journal of Alzheimer's Disease*, *43*(1), 19–22.

Pachana, N. A., Byrne, G. J., Siddle, H., Koloski, N., Harley, E., & Arnold, E. (2007). Development and validation of the geriatric anxiety inventory. *Intenational Psychogeriatrics*, *19*(1), 103–114. doi:10.1017/S1041610206003504

Pfeffer, R. I., Kurosaki, T. T., Harrah, C. H.Jr., Chance, J. M., & Filos, S. (1982). Measurement of functional activities in older adults in the community. *Journal of Gerontology*, *37* (3), 323–329. doi:10.1093/geronj/37.3.323

R. (2014). *A language and environment for statistical computing. Foundation for Statistical Computing*. Retrieved from http://www.R-project.org/

Reban, J. (2006). Montrealsky kognitivni test/MoCA/: Prinos k diagnostice predemenci. *Česká geriatrická revue [Czech Geriatric Revue]*, *4*, 224–229.

Richard, E., Schmand, B. A., Eikelenboom, P., & Van Gool, W. A. (2013). MRI and cerebrospinal fluid bio markers for predicting progression to Alzheimer's disease in patients with mild cognitive impairment: A diagnostic accuracy study. *BMJ Open*, *3*(6): e002541.

Roalf, D. R., Moberg, P. J., Xie, S. X., Wolk, D. A., Moelter, S. T., & Arnold, S. E. (2013). Comparative accuracies of two common screening instruments for classification of Alzheimer's disease, mild cognitive impairment, and healthy aging. *Alzheime's and Dementia*, *9*(5), 529–537. doi:10.1016/j.jalz.2012.10.001

Roalf, D. R., Moore, T. M., Wolk, D. A., Arnold, S. E., Mechanic-Hamilton, D., Rick, J.,… Moberg, P. J. (2016). Defining and validating a short form Montreal Cognitive Assessment (s-MoCA) for use in neurodegenerative disease. *Journal of Neurology Neurosurgery and Psychiatry*. doi:10.1136/jnnp-2015-312723

Rossetti, H. C., Lacritz, L. H., Cullum, C. M., & Weiner, M. F. (2011). Normative data for the Montreal cognitive assessment (MoCA) in a population-based sample. *Neurology*, *77*(13), 1272–1275. doi:10.1212/WNL.0b013e318230208a

Royle, J., & Lincoln, N. B. (2008). The everyday memory questionnaire-revised: Development of a 13-item scale. *Disability and Rehabilitation*, *30*(2), 114–121. doi:10.1080/09638280701223876

Salthouse, T. A. (1996). The processing-speed theory of adult age differences in cognition. Psychological Review, *103*(3), 403–28.

Sheikh, J. I., & Yesavage, J. A. (1986). Geriatric depression scale (GDS): Recent evidence and development of a shorter version. *Clinical Gerontologist*, *5*, 165–173.

Solomon, T. M., deBros, G. B., Budson, A. E., Mirkovic, N., Murphy, C. A., & Solomon, P. R. (2014). Correlational analysis of 5 commonly used measures of cognitive functioning and mental status: An update. *American Journal of Alzheimer's Disease and Other Dementias*, *29*(8), 718–722. doi:10.1177/1533317514534761

Štěpánková, H., Nikolai, T., Lukavský, J., Bezdíček, O., Vrajová M., & Kopeček, M. (2015). Mini-mental state examination – Czech normative study. *Czech and Slovak Neurology and Neurosurgery*, *78*(1), 57–63.

Tombaugh, T. N., McDowell, I., Kristjansson, B., & Hubley, A. M. (1996). Mini-mental state examination (MMSE) and the modified MMSE (3MS): A psychometric comparison and normative data. *Psychological Assessment*, *8*(1), 48–59. doi:10.1037/1040-3590.8.1.48

Velayudhan, L., Ryu, S. H., Raczek, M., Philpot, M., Lindesay, J., Critchfield, M., & Livingston, G. (2014). Review of brief cognitive tests for patients with suspected dementia. *International Psychogeriatrics*, *26*(8), 1247–1262. doi:10.1017/S1041610214000416

Wechsler, D. (1997). *Wechsler Memory Scale* (3rd ed.). San Antonio, TX: The Psychological Corporation.

Wechsler, D. (2010). *Wechslerova inteligenční škála pro dospělé*: Praha: Hogrefe - Testcentrum.

Wechsler, D. (2011). *Wechslerova zkrácená paměťová škála - WMS-IIIa*. Praha: Hogrefe - Testcentrum.

Wittchen, H. U., Jacobi, F., Rehm, J., Gustavsson, A., Svensson, M., Jonsson, B., … Steinhausen, H. C. (2011). The size and burden of mental disorders and other disorders of the brain in Europe 2010. *European Neuropsychopharmacology*, *21*(9), 655–679. doi:10.1016/j.euroneuro.2011.07.018