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Differences in performance on English and Hebrew versions of the MoCA in Parkinson's patients☆,☆☆

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ABSTRACT

Introduction: The Montreal Cognitive Assessment (MoCA), an instrument widely used for cognitive screening in Parkinson's disease (PD), is validated in Hebrew and English. However, it remains unknown whether the scores are comparable.

Methods: The MoCA was analyzed in 483 Ashkenazi Jewish PD patients in Tel-Aviv and New York who had MoCA ≥21. Each section of the MoCA was compared between English and Hebrew. Linear regression models were used to test the association between MoCA performance and language.

Results: Total MoCA scores were lower in Hebrew than in English (25.4 versus 26.1; $P = 0.007$), even after adjustment for age, sex, PD duration, genotype, levodopa equivalent dose, the Unified Parkinson's Disease Rating Scale (UPDRS-III), and Geriatric Depression Scale score in a linear model ($P < 0.001$). However, when language sections were removed from the total, scores were similar between the languages (Hebrew 23.7 versus English 23.4, $P = 0.111$).

Conclusion: The language section of the MoCA may be more difficult in Hebrew. The comparability of MoCA in different languages requires further evaluation.

1. Introduction

The Montreal Cognitive Assessment (MoCA) is recommended by the Movement Disorder Society task force for cognitive screening in Parkinson's disease (PD) [1,2]. The duration of the MoCA is approximately 10 min, is paper-based and is easily accessible and administered. It has been widely used in both clinic and research settings. Several ongoing clinical trials [3] and longitudinal PD cohorts [4] have been using the MoCA as the instrument for evaluating participants' cognitive functioning.

The MoCA is available in >60 languages and dialects including Hebrew and English. Both the Hebrew and English versions of the MoCA have been validated for detection of Mild Cognitive Impairment (MCI) using a cutoff score of 26/30 [1,5]. However, it remains unclear if the scores in different languages are comparable. This is especially important for multi-center studies that use the MoCA in various languages. In this study, we compared MoCA performances in English and Hebrew-speaking PD patients to determine whether language affects MoCA performance.

2. Methods

2.1. Participants

Participants included Ashkenazi Jewish (AJ) PD patients who participated in the AJ-*LRRK2* (Leucine rich repeat kinase 2) consortium [6]. Participants were recruited from three recruitment sites, Columbia University Medical Center (CUMC), Mount Sinai Beth Israel Medical Center (BIMC), both in New York, USA, and Tel-Aviv Medical Center (TLVMC), in Tel Aviv, Israel. Institutional review boards at all participating sites approved the protocols, and all participants signed consent prior to any research procedure. Diagnosis of PD was made by a movement disorder specialist based on the UK PD brain bank criteria. Participants were genotyped for *glucocerebrosidase* (*GBA*) and the Leucine rich repeat kinase 2 (*LRRK2*) G2019S mutations. We excluded patients who were known carriers of *GBA* mutation (n = 32) from the analysis, as it is associated with cognitive dysfunction [7].

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The MoCA was administered to 557 patients from the above three sites. Patients from CUMC (n = 141), and BIMC (n = 137) were evaluated using the English version of the MoCA, while 273 patients from TLVMC were evaluated using the Hebrew version. We excluded seven Israeli participants for whom the MoCA was administered in other languages. In addition, we excluded 28 English-speaking and 39 Hebrew-speaking PD patients who potentially had dementia using a MoCA <21/30 cutoff [2]. We included 483 PD patients, age 31–89, in the statistical analysis. Additional clinical evaluations included a demographic and family history interview, the Unified Parkinson's Disease Rating Scale (UPDRS) [8], the 15 item Geriatric Depression Scale (GDS) [9], and the Beck Depression Inventory II (BDI-II) [10]. Higher than post-secondary education was defined as having received ≥12 years of education.

2.2. Statistical analyses

Demographic information, clinical characteristics, *LRRK2* G2019S carrier status, UPDRS-III, GDS, BDI-II, and MoCA scores were compared between English- speaking and Hebrew-speaking participants. Continuous variables were compared using Student's *t*-tests. Categorical variables were compared using chi-squared tests and Fisher's exact tests as appropriate. Performances on each section (visuospatial/executive, naming, attention, language, abstraction, delayed recall, and orientation) of the MoCA was compared between English-speaking and Hebrew-speaking participants using Student's *t*-tests. We repeated these analyses in four subgroups: participants with college education (13–16 years of education), with graduate education (17–20+ years of education), *LRRK2* G2019S non-carriers, and participants with a GDS score ≤ 4 (not depressed) [9]. We also repeated these analyses in patients with total MoCA score = 29, suggesting likely preserved cognition, to identify the most difficult questions for people with presumably intact cognition in the two populations. We also compared performance on each section of the MoCA between the CUMC cohort and BIMC cohort to examine the differences between two English-speaking sites.

Linear regression models were constructed to test the associations between MoCA performance (outcome), clinical and demographic features, and language in which MoCA was administered (predictors). The models were adjusted for age, sex, disease duration, post-secondary education (Yes/No), UPDRS-III, Levodopa equivalent daily dose, GDS or BDI-II scores, and *LRRK2* G2019S carrier status. All analyses were performed using SPSS version 20.0 (SPSS, Inc., Chicago IL).

3. Results

Demographics and disease characteristics of English-speaking and Hebrew-speaking PD patients are presented in Table 1. English-speaking patients were older (67.9 years old vs. 65.2 years old, $P = 0.03$). They had longer disease duration (7.2 years vs. 5.8 years, $P = 0.02$), were more likely to receive post-secondary education (92.1% vs. 70.4%, $P < 0.001$), were treated with higher levodopa equivalent daily doses (383.6 mg/day vs. 224.5 mg/day, $P < 0.001$), and had lower UPDRS-III scores (18.3 vs. 20.5, $P = 0.026$). English-speaking patients had significantly higher total MoCA score than Hebrew-speaking patients (26.1 vs. 25.4, $P = 0.007$). However, when language sections were removed from the total, scores were similar between English and Hebrew-speaking patients (23.4 vs. 23.7, $P = 0.111$) (Table 2). When performance by individual sections was compared, most of the differences stemmed from the Sentence Repetition (Hebrew 1.3 vs. English 1.8, $P < 0.001$) and Fluency items (Hebrew 0.5 vs. English 0.9, $P < 0.001$). The total number of words generated in 1 min was significantly different between the groups (Hebrew 10.6 words vs. English 15.7 words, $P < 0.001$). Hebrew-speaking patients had significantly better performance in Naming (Hebrew 2.9 vs. English 2.8, $P < 0.001$) and in Delayed Recall (Hebrew 3.0 vs. English 2.8, $P = 0.05$).

When analyses were restricted to those who scored 29 (assuming normal cognition and lost one point from a single question), Hebrew-speaking patients were more likely to lose a point in Language (13% of Hebrew-speaking compared to 2% of English-speaking lost a point in the language section, $P = 0.007$). English-speaking patients were less likely to remember the word "daisy" in Delayed Recall (39% of English-speaking compared to 11% of Hebrew-speaking participants, $P = 0.039$). Performance on Language was consistently better in English than in Hebrew in those stratified analyses including (a) only participants with college education (Supplementary Table 1; $P < 0.001$), (b) participants with post graduate education (Supplementary Table 2; $P < 0.001$), (c) participants with no evidence of depression ($P < 0.001$), and (d) participants who are non-carriers of the *LRRK2* G2019S mutation ($P < 0.001$).

In adjusted regression analyses, lower MoCA score was significantly associated with Hebrew-speaking ($P = 0.014$), not receiving post-secondary education ($P = 0.023$), older age ($P < 0.001$), female ($P = 0.008$), higher UPDRS-III score ($P = 0.011$), and higher GDS score ($P = 0.022$) (Supplementary Table 3). When language questions (Sentence Repetition and Fluency) were excluded from the total MoCA score, Hebrew-speaking ($P = 0.173$) and post-secondary education ($P = 0.192$) were not significantly associated with MoCA performance, while older age, female and higher UPDRS-III score remained predictors of lower MoCA scores (Supplementary Table 4).

Table 1
Demographics and disease characteristics of English and Hebrew-speaking Parkinson's patients.

Variable	English speaking	Hebrew speaking	P
	n = 250	n = 233	
Male sex (%)	156 (62.4%)	125 (53.6%)	0.051
Age, yrs (SD)	67.9 (9.9)	65.2 (9.7)	0.030
Age-at-onset, yrs (SD)	60.7 (10.7)	59.5 (10.1)	0.189
Duration, yrs (SD)	7.2 (5.1)	5.8 (5.4)	0.020
Post-secondary education (%)[a]	223 (92.1%)	164 (70.4%)	<0.001
LRRK2 G2019S mutation carrier (%)	61 (24.4%)	62 (26.6%)	0.578
Levodopa equivalent daily dose, mg (SD)	383.6 (359.1)	224.5 (337.5)	<0.001
Total UPDRS-III score (SD)[b]	18.3 (10.3)	20.5 (11.9)	0.026
GDS score (SD)[c]	3.4 (3.2)	3.7 (3.1)	0.338
BDI-II score (SD)[d]	10.2 (9.2)	8.6 (6.3)	0.227
Total MoCA score (SD)	26.1 (2.4)	25.4 (2.4)	0.007

Abbreviations: SD, standard deviation; *LRRK2*, leucine-rich repeat kinase 2; UPDRS-III, Unified Parkinson's Disease Rating Scale, part III (motor); GDS, 15 item Geriatric Depression Scale; BDI-II, Beck Depression Inventory II; MoCA, Montreal Cognitive Assessment.

[a] Post-secondary education was available in 475 participants.
[b] UPDRS-III was available in 482 participants.
[c] GDS score was available in 473 participants.
[d] BDI-II score was available in 155 participants.

Table 2
Comparison of performance on the Montreal Cognitive Assessment between English and Hebrew-speaking Parkinson's patients.

Variable	Maximal score	English speaking, Mean (SD)	Hebrew speaking, Mean (SD)	P
		n = 250	n = 233	
Visuospatial and executive function	5	4.3 (0.9)	4.2 (1.0)	0.138
Naming	3	2.8 (0.5)	2.9 (0.2)	<0.001
Attention	6	5.7 (0.6)	5.5 (0.8)	0.012
Language	3	2.7 (0.6)	1.8 (0.9)	<0.001
Sentence repetition	2	1.8 (0.5)	1.3 (0.7)	<0.001
Fluency	1	0.9 (0.3)	0.5 (0.5)	<0.001
Total number of words		15.7 (5.0)	10.6 (0.5)	<0.001
Abstraction	2	1.9 (0.4)	1.9 (0.4)	0.77
Delayed recall	5	2.8 (1.5)	3.0 (1.4)	0.05
Orientation	6	5.9 (0.3)	5.9 (0.5)	0.509
Total score	30	26.0 (2.4)	25.4 (2.4)	0.007
Total score + education	31	26.1 (2.4)	25.7 (2.4)	0.085
Total score without language	27	23.4 (2.3)	23.7 (2.1)	0.111

Abbreviations: SD, standard deviation.

When the two English-speaking sites were compared, most characteristics were similar except that patients from CUMC were older (69.4 years old vs. 66.4 years old, $P = 0.017$), more likely to have received post-secondary education (95.3% vs. 88.7%, $P = 0.048$) and had higher UPDRS-III scores (20.1 vs.16.3, $P = 0.003$) than those from BIMC. Neither total MoCA score nor performance in individual sections was significantly different between CUMC and BIMC.

4. Discussion

In this analysis, we demonstrate differential performance on the MoCA in the language domain between Hebrew and English-speaking PD patients in Israel and the US respectively, after adjustment for potential confounders. In an era where clinical trials with cognitive outcomes are routinely taking place worldwide, it is important to note that merging data from cognitive testing performed in different languages may result in imprecise data.

The difference between the total MoCA score of the two populations can be attributed to performances in the language section. Performance in the language domain was significantly lower in Hebrew compared to English in those whose total score was 29. This implies that the language section of the MoCA was more difficult for Israeli participants compared to US participants, independent of true cognitive ability. It is possible that the language component of the MoCA, which consists of two sentence repetition and one phonemic fluency with a single letter, is more difficult in Hebrew. Specifically, normative data indicates a higher number of words produced in 1 min for the letter /f/ than BET (the letters used in the MoCA in English and Hebrew respectively) [11,12]. Further, while the two sentences that are repeated are translated literally, they are significantly longer in Hebrew (40 phonemes) than in English (28 phonemes). Alternatively, it is possible that the language section is more difficult for an Israeli cohort because a portion of the Israeli Parkinson's cohort immigrated to Israel and Hebrew may not have been their best language. Unfortunately, we do not have data on the primary language of the participants.

The differences we found in language domain performance should not affect the validity of the MoCA scale. Translated versions of the MoCA test have been validated in Hebrew as well as other languages [1,5]. In a validation study, the Hebrew version of the MoCA showed high sensitivity and specificity in the detection of mild cognitive impairment in a Hebrew-speaking elderly population [5]. While the MoCA remains an effective tool for cognitive screening and evaluation, comparability of the scores should be considered when MoCA scores need to be merged externally across languages. We suggest that information regarding the patient's primary language and the language in which the MoCA was performed, should be included in the data collection and be adjusted for in study analyses in multi-center clinical trials and observational studies. Language differences should not affect the conclusions of studies, if the primary modifiers or interventions are evenly distributed between the populations. For example, the frequency of *LRRK2* G2019S was similar in the Israeli and the US sites, allowing us to combine data observations.

In this study, we compared MoCA performances in English and Hebrew in an ethnically homogeneous large PD cohort. This is the first study to investigate the comparability of MoCA performance across languages. We were also able to adjust for potential genetic confounders by excluding known *GBA* carriers and adjusting for *LRRK2* G2019S mutation status in the analyses. A limitation to our study is that healthy controls were not included. Future studies should include a healthy population or participants who are affected by other neurodegenerative disorders, like Alzheimer's disease, for comparison purposes. Also, there was heterogeneity in demographics and disease characteristics between PD patients recruited from New York and Tel Aviv. Age at immigration and primary language could also contribute to the variation in MoCA language performance, but we were not able to adjust for these factors due to lack of data. Our study population was not evaluated using functional assessments (e.g., Clinical Dementia Rating, CDR) at the time of recruitment for mild cognitive impairment or dementia. These evaluations should be considered in future studies comparing cognitive screening tools between languages. A potential explanation for the differential scoring among Hebrew and English-speaking participants may be a result of the objectivity of the scoring. We estimate that this explanation is unlikely, given that scores on other domains were generally similar across the groups. The newly required MoCA training would be useful to further ensure objectivity and consistency of the MoCA scoring across sites and languages.

Our study cohort was primarily recruited to compare *LRRK2* G2019S mutation carriers to non-carriers. The observation of differential MoCA performance between the MoCA language forms is a secondary finding. Considering the need to merge cognitive data across languages in international clinical trials for diseases like Parkinson's and Alzheimer's, future studies may focus on the comparison of MoCA (and other cognitive batteries) across cultures and languages, accounting for expected confounding factors. Confounders such as education and fluency in the language in which the test was conducted (e.g., primary language, age at immigration) should be carefully collected. Adding a functional evaluation, which is necessary for the diagnosis of mild cognitive impairment or dementia, would help validate the MoCA score interpretation.

In conclusion, the results of this study demonstrate that the language section of the MoCA is more difficult for an Israeli, primarily Hebrew-speaking cohort than an American, primarily English-speaking cohort. The comparability of specific MoCA sections that are affected by languages should be carefully evaluated during application of the scale.

CRediT authorship contribution statement

Yaqian Xu: Methodology, Formal analysis, Writing - original draft. **Anat Mirelman:** Resources, Writing - review & editing. **Rachel Saunders-Pullman:** Resources, Writing - review & editing. **Helen Mejia-Santana:** Project administration, Writing - review & editing. **Elise Caccappolo:** Writing - review & editing. **Deborah Raymond:** Project administration, Writing - review & editing. **Nir Giladi:** Resources, Writing - review & editing. **Susan Bressman:** Resources, Writing - review & editing. **Karen Marder:** Conceptualization, Writing - review & editing, Supervision. **Roy N. Alcalay:** Conceptualization, Methodology, Validation, Writing - review & editing, Supervision

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.prdoa.2020.100042.

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