Title: **Utility of the MoCA for cognitive impairment screening in long-term psychosis patients**

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Abstract

Cognitive impairment is a key feature in patients with psychotic disorders. The Montreal Cognitive Assessment (MoCA) is a brief tool that has been shown to be effective in identifying mild cognitive impairment and early dementia. This study explores the usefulness of this instrument to detect cognitive impairment in long-term psychotic disorders.

One hundred-forty stabilized patients were re-evaluated more than 15 years after a First Episode of Psychosis (FEP). Patients were psychopathologically assessed, and the MoCA test and MATRICS Consensus Cognitive Battery (MCCB) were administered. Two cut-off scores for cognitive impairment using the MCCB were applied (T score <40 and <30).

Concurrent validation was found between the total scores of the MoCA and MCCB. We also found significant associations between 5 out of 7 MoCA subtests (visuospatial-executive, attention, language, abstraction and delayed recall) and MCCB subtests but not for the naming and orientation MoCA subtests. Receiver operating characteristic (ROC) analysis suggested a <25 cut-off for cognitive impairment instead of the original <26.

Our results suggest that the MoCA test is a useful screening instrument for assessing cognitive impairment in psychotic patients and has some advantages over other available instruments, such as its ease-of-use and short administration time.

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1. Introduction

Cognitive impairment is a core disturbance of schizophrenia that usually predates the onset of clinical manifestations. In most cases, cognitive impairment is linked to abnormalities in neurodevelopment (Bora, 2015) and is not strongly associated with either acute episodes or psychopathological symptoms of the illness (Cuesta and Peralta, 1995; Green, 1996) and endures over the course of the illness without remission (Bilder et al., 2000; Bilder et al., 2002; Saykin et al., 1991; Saykin et al., 1994).

Cognitive impairment is highly prevalent in schizophrenia and other psychotic disorders, and it is significantly more related to disabilities in social, vocational and work functions (Green, 1996; Harvey et al., 1998; Velligan et al., 1997).

Moderate to severe deficits in working memory, attention, processing speed, and visual and verbal learning are the hallmarks of cognitive impairment in schizophrenia (Heinrichs and Zakzanis, 1998). Patients underperform by between 0.5 and 1.5 standard deviations in these cognitive domains compared to healthy controls (Cuesta et al., 2015).

Until the last two decades, there was no neuropsychological battery specifically validated for schizophrenia patients. The National Institute of Mental Health (NIMH) sponsored the development of the Measurement and Treatment Research to Improve Cognition in Schizophrenia (MATRICS) battery (Marder and Fenton, 2004). The tests included in the MATRICS Consensus Cognitive Battery (MCCB) were selected by consensus among a group of experts to address the profile of cognitive impairment of schizophrenia patients (Kern et al., 2008; Nuechterlein and Green, 2006; Nuechterlein et al., 2008).

The use of batteries such as MCCB requires specialised training, computer equipment and time (between 60 and 90 minutes). If there is not enough time to carry out a thorough assessment, there are brief instruments for the estimation of cognitive impairment in clinical practice, such as the Brief Assessment of Cognition in Schizophrenia (BACS) (Keefe et al., 2004), a Brief Cognitive Assessment Tool for Schizophrenia (B-CATS) (Cuesta et al., 2011; Hurford et al., 2011) and Screen for Cognitive Impairment in Psychiatry (SCiP) (Pino et al., 2008; Purdon, 2005). These instruments usually do not require specific training or equipment (except BACS and more recently MoCA). These instruments have different test components, and their administration time ranges from 10 to 35 minutes.

Another brief cognitive instrument with good diagnostic accuracy for detecting mild cognitive impairment and early dementia is the Montreal Cognitive Assessment (MoCA) (Nasreddine et al., 2005), which is accurate even in patients who generally score within the normal range on the Mini Mental State Examination (Folstein et al., 1975). Moreover, the MoCA covers a wider range of cognitive functions than previous

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brief cognitive instruments for schizophrenia patients (Fisekovic et al., 2012; Musso et al., 2014; Wu et al., 2014; Yang et al., 2018), but its utility in schizophrenia patients remains to be determined.

The aim of this study is to explore the effectiveness of the MoCA to detect cognitive impairment in long-term patients with psychosis as measured by the MCCB.
Moreover, we aimed to identify whether the reported cut-off for cognitive impairment in neurological disorders is also valid for detecting cognitive impairment in schizophrenia patients. It is expected that the MoCA scores will agree with those obtained with MCCB.

2. Materials and methods

2.1 Participants

We re-contacted 180 patients who were admitted for a first episode of psychosis (FEP) in our unit between 15 and 18 years ago. The inclusion criterion at intake was to be aged between 18 and 55 years old upon first psychiatric admission. The exclusion criteria included: severe intellectual disability, neurologic or general medical illness and/or antecedents of lifetime substance abuse. Forty patients refused to participate in the study.

The sample comprised 140 patients. These patients were assessed with an exhaustive protocol including clinical, motor and neurocognitive tests. For this research, we used neurocognitive data. The mean age of the sample was 49.08 years (10.88 SD), with 66 females and 74 males and a mean duration of illness of 21.28 years (7.65 SD). Out of the 140 patients, 22 of the patients were living in an institutional setting, and the others were outpatients. All patients were clinically stable at the time of the assessment.

The study was approved by the Ethics Committee of the Complejo Hospitalario de Navarra. We obtained written informed consent from each participant and/or their legal representative, as appropriate.

2.2. Instruments

2.2.1. Clinical assessment

The Comprehensive Assessment of Symptoms and History (CASH) (Andreasen et al., 1992) was used to assess patients' clinical symptoms. Positive, negative, disorganization, mania and depression scores were obtained from the CASH interview as reported elsewhere (Cuesta and Peralta, 2009). DSM-5 diagnosis was established by consensus between the two senior psychiatrists (MJC and VP) using all available information, including direct examinations and clinical records.

2.2.2. Cognitive assessment

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The MoCA includes assessments of the following functions: executive, visuospatial, naming, memory, attention, language, abstraction, recall and orientation. The highest possible score is 30 points (a correction is made with 1 point added for people with less than 12 years of education), with a cut-off score for cognitive impairment of 26 to identify patients with possible mild cognitive impairment or early dementia (Nasreddine et al., 2005). The MoCA only require 10-15 minutes to be administered, and its diagnostic accuracy in detecting mild cognitive impairment and Alzheimer's disease is good to excellent (sensitivity 90% and specificity 87%).

The MATRICS Consensus Cognitive Battery (MCCB) includes 10 standardized cognitive tests with measures in 7 cognitive domains: speed of processing (Trail Making Test Part A; Brief Assessment of Cognition in Schizophrenia: Symbol coding; Category fluency test, animal naming), attention/vigilance (Continuous Performance Test: Identical Pairs), working memory (Wechsler Memory Scale, spatial span subtest; Letter Number Span test), verbal learning (refers to immediate verbal memory, Hopkins Verbal Learning Test (HVLT)-Revised, immediate recall), visual learning (refers to immediate visual memory, Brief Visuospatial Memory Test-Revised), reasoning and problem solving (Neuropsychological Assessment Battery (NAB), mazes subtest), and social cognition (Mayer-Salovey-Caruso Emotional Intelligence Test (MSCEIT): managing emotions branch). The application time of the MCCB is approximately 75 minutes. The MCCB was administered in one or two sessions following the same order of presentation of tests to measure the best performance and to reduce fatigue and lack of cooperation.

The MoCA was administered to all patients before beginning the MCCB. Neuropsychological assessments were carried by two neuropsychologists (AST and GGB). Both neuropsychologists were blind to the patients' psychopathological examinations and achieved good interrater reliability (ICC>0.9). Standard score calculation was carried out with the MCCB computer scoring software, which includes normalized, standardized and validated data according to age and level of education for the Spanish population (Rodriguez-Jimenez et al., 2012).

2.3 Statistical analysis

Clinical and cognitive measures were examined for deviations from the normal distribution using the Kolmogorov–Smirnov test. The internal consistency of the MoCA was determined by item-to-total correlations and Cronbach's alpha coefficient.

To examine the concurrent validity of the MoCA, Spearman's correlation coefficients among the total/subtest scores of the MoCA and the MCCB were applied, as not all variables were normally distributed. MoCA residual scores via linear regression after partialing out effects of education and age were used. The Bonferroni inequality correction was chosen to account for the high number of correlations among MCCB and MoCA subtests.

To determine and compare the diagnostic values of the MoCA total score, a receiver operating characteristic (ROC) curve was drawn. The ROC curve allowed a complete sensitivity/specificity report of the MoCA total score as it relates to the MCCB total score. We tested two cut-off points with the MCCB to identify mild and

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severe cognitive impairment in our sample (below 1 and 2 standard deviations, T-score <40 and <30, respectively). For the ROC curve, sensitivity is plotted against specificity for different cut-off points of the MoCA test, and the AUC shows how well these cut-off points are able to distinguish between cognitively impaired and non-impaired patients as defined by the MCCB total score. An AUC between .80 and .90 indicated good criterion validity.

Youden's index (J) (Youden, 1950) is often used in conjunction with ROC curve analysis. Sensitivity and specificity are often used simultaneously as a joint measure of screening test behaviour. Selecting the cut-off point that maximizes the difference between true positive and true negative fractions is the Youden index, which is a commonly used measure of overall diagnostic effectiveness.
Positive and negative likelihood ratios were also calculated.

Statistical analyses were carried out using IBM SPSS Statistics for Windows, Version 25.0 (Corp., 2017).

3. Results

One hundred-forty patients with long-term psychosis diagnoses were included. We chose to exclude 7 patients for analyses since they did not have MCCB data. The demographic characteristics, DSM 5 diagnoses, chlorpromazine equivalent of antipsychotic treatment and CASH scores are displayed in Table 1. Negative symptoms were the predominant symptomatology of patients and were higher than positive, disorganized and affective symptoms, as patients were mainly long-term clinically stabilized. There were no significant differences between patients who agreed to participate in our study (n=140) and those who refused (n=40) in age (t= -2.41, p=0.58), years of education (t= 2.86, p=0.67), age at onset (t= -1.08, p= 0.41), duration of illness (t= -2.23, p= 0.17) or gender (χ^2= 1.12, p= 0.29).

Cronbach's alpha of all 7 MoCA subtests was 0.76, suggesting only moderate reliability. Two out of the 7 MoCA subtests had results suggesting a ceiling effect since patients achieved high scores and overperformed compared to the remaining subtests (Table 1). The naming and orientation subtests were easily and correctly answered by nearly all patients. However, deletion of these 2 subtests (or any other) of the 7 items did not improve Cronbach's α for the MoCA.

The MoCA total score showed an inverse and significant association with age (r=-0.4, p<0.01) and a direct and significant association with years of education (r=0.45, p<0.01). There was no gender difference (t(138)=-0.74, p=0.053). The subtests showed a similar pattern. The only difference was that there was no significant correlation between orientation and age or between naming and years of education.

The descriptive data for the MCCB scores are shown in table 1. The mean scores for 6 out of the 7 MCCB cognitive domains ranged between a T-score of 34.6 and 39.4, suggesting a mean performance between 1 and 1.5 standard deviations from the normative values. However, patients achieved a mean value on the social cognition

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subtest close to the normative values (mean T-Score=44.8) and only 0.5 standard deviations below the general population.

Not all patients could complete the MCCB due to major cognitive impairment. There were patients (n=7) with severe impairment making impossible to run the full battery. Other patients with pronounced impairment were able to partially complete the battery, mostly leaving the attention/vigilance test unfinished (n=17) and, to a lesser extent, the social cognition test (n=5) and reasoning and problem solving test (n=1) unfinished. For the latter group, we proceeded to impute missing values (using sequential regression multiple imputation) following MCCB manual appendix B instructions.

The MoCA total score showed a strong association with the MCCB composite score (ρ=0.613, p<0.01) (Table 2). Moderate to strong and significant associations between the MoCA total score and the MCCB subtests after Bonferroni correction were found, ranging from Reasoning and problem solving (ρ=0.3, p<0.01) to verbal learning (ρ=0.57, p<0.01). MCCB Social cognition domain was the only not associated with MoCA total score.

The MoCA executive/visuospatial subtest showed significant associations with all the domains except social cognition and attention/vigilance. The MoCA attention subtest correlated with speed of processing, working memory visual learning and reasoning and problem solving MCCB domains. The MoCA language subtest was significantly associated with speed of processing, attention/vigilance and working memory MCCB domains (Table 2).

The MoCA abstraction subtest showed significant associations with the MCCB processing speed and verbal learning. The MoCA delayed recall subtest correlated with the MCCB verbal and visual learning domains (Table 2). Finally, the MoCA naming and orientation subtests did not show significant associations with any of the cognitive domains of the MCCB or with the total score (Table 2).

To detect mild cognitive impairment, we set a cut off criterion of T<40 for the MCCB total score. Thus, the optimal cut-off point on the MoCA for detection of cognitive impairment was <25 according to Youden's index. The AUC for the MoCA was 0.872 (p<0.001) (Figure 1). We also added a MCCB T<30 as a severe cognitive impairment criterion (AUC = 0.86). The sensitivity, specificity, and positive/negative likelihood ratios for MoCA cut-off scores for both the T<40 and T<30 criteria are shown in Table 3. The positive likelihood ratio (i.e., diagnostic odds) ranged between 3.37 and 5.45 for mild and severe cognitive impairment respectively, indicating that following administration of the battery, a MoCA cut-off of <25 would increase the probability of correctly identifying patients with mild/severe cognitive impairment by up to 15-30%. The negative likelihood ratio ranged between 0.11 (mild) and 0.32 (severe). The absence of impairment on the MoCA decreases the probability of finding patients with mild impairment by up to 45% and finding those with severe impairment by up to 20-25%.

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4. Discussion

The MoCA is a useful screening instrument for long-term psychosis patients to detect cognitive impairment as measured by the MCCB. Based on Youden's index, we can differentiate patients with cognitive impairment due to psychosis using a cut-off of <25 (mild impairment: sensitivity 0.92 and specificity 0.73; AUC 0.873. Severe impairment: sensitivity 0.73, specificity 0.87; AUC 0.86). Based on these results, we would expect 92% of psychosis patients with mild cognitive impairment to be correctly identified with the MoCA, while 8% would be wrongly classified as not having cognitive impairment; 73% of patients who do not have cognitive impairments would be correctly identified as not having mild cognitive impairment while 27% would be false positives and might be referred for further testing. On the other hand, for severe cognitive impairment, 27% would be wrongly classified as not having severe cognitive impairment, but only 13% would be false positives and might be referred for further testing. The lower sensitivity for severe cognitive impairment is due to comparing severe impairment patients with both no impairment patients and mild impairment patients.

In our study, the MoCA showed adequate concurrent validity as a screening test for cognitive impairment due to the associations between the MoCA total/subtests scores and the MCCB composite/subdomains scores. A moderate convergence between the corresponding subtests of the MoCA and MCCB was found. Verbal, working memory and executive functions had the highest associations. On the MoCA, verbal, working memory and executive functions correlate with the language, attention and executive subtests. On the MCCB, verbal, working memory and executive functions have significant associations with the verbal/visual learning, working memory and speed of processing subtests. The less correlated domains of the MCCB (social cognition and vigilance) are explained either because MoCA test does not assess social cognition or have a sustained attention task, nor does MCCB have temporal-spatial orientation. Other studies show mixed concurrent validity results between the MoCA and BACS, ranging from no significant correlation between the MoCA and BACS scores (Musso et al., 2014) to adequate concurrent validity and moderate agreement between the MoCA and BACS total scores and 5 subscores (except the Token Motor Task of the BACS, which evaluates psychomotor functioning) (Yang et al., 2018).

Our results regarding sensitivity and specificity are similar to those obtained by other short tests in psychotic populations. The BACS has a sensitivity/specificity of 0.9/0.83 (Sachs et al., 2011), the SCIP has a sensitivity/specificity of 0.88/0.75 (Pino et al., 2008) and the B-CATS has a sensitivity/specificity of 0.86/0.73 (Cuesta et al., 2011).

The BACS (Keefe et al., 2004), B-CATS (Cuesta et al., 2011; Hurford et al., 2011) and SCIP (Pino et al., 2008) are validated in patients with psychosis, with few studies using the MoCA in this kind of population. A comparative analysis of available screening cognitive instruments and their subtests is shown in Table 4. The B-CATS is the least comprehensive instrument, only evaluating processing speed (symbol coding and fluency) and executive function (Trail Making Test form B). Working memory and

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verbal learning are common components assessed in the BACS, SCIP and MoCA. The major difference among these instruments lies in the assessment of executive function. The assessment of executive function is omitted in the SCIP, BACS uses the Tower of London and MoCA/B-CATS use TMT-B. In addition, the MoCA uses another executive component, abstraction, but lacks a processing speed component (one of the core cognitive impairments in schizophrenia population), which all of the other screening tools include. The MoCA also adds two additional tests, naming and orientation, but these tests have a ceiling effect in the psychotic population. The BACS has an evaluation time of ~35 minutes compared to ~15 minutes for the MoCA and SCIP and ~10 minutes for the B-CATS. The MoCA test in our study showed high sensitivity for the detection of cognitive impairment and high specificity for the detection of severe cognitive impairment. However, this result should be taken cautiously because there were relevant differences in the sample composition and the gold standard to define cognitive impairment in schizophrenia spectrum populations among studies.

The cut-off point for mild impairment in our sample is one point lower than that obtained by Nasreddine and colleagues who developed the MoCA for a population with mild cognitive impairment (Nasreddine et al., 2005) but is analogous to other research findings suggesting lower cut-off scores than the standard one for dementia (Damian et al., 2011; Luis et al., 2009; Rossetti et al., 2011) and schizophrenia (Yang et al., 2018). Our results are in partial agreement with Yang et al. (2018) for a schizophrenic population, as they suggest a cut-off point below 25 for mild impairment. However, when we used a MCCB T-score <30 (-2 SD) as the criterion for severe impairment, we concluded that the optimal cut-off was the same as for mild impairment, <25. Our results differed from those of Yang et al. (2018), who used a cut-off point of <23 for severe cognitive impairment. This difference may be due to the use of a different gold standard for cognitive impairment assessment and the inclusion of a sample composed of younger schizophrenia patients without other psychoses. Musso et al. (2014) used a <26 cut-off for impairment, but their data suggested using a cut-off below that number.

The naming and orientation MoCA subtests did not show convergent associations with the MCCB. There could be several reasons for this finding. The first reason is the low variability in response in these subtests. For the naming subtest, almost the entire sample scored 2-3 points (except for some exceptions scoring only 1 point). For the orientation subtest, no patient scored less than 4 points (out of a total of 6). For both subtests, our sample showed a noticeable ceiling effect. A second reason is that the naming and orientation subtests do not have as much relevance in the psychotic population as they may have in screening patients for dementia (Cecato et al., 2016; Zhou et al., 2015). Moreover, the lack of association between the MoCA naming and orientation subtests and the MCCB composite score and subtests agrees with the results in the literature since the MCCB does not include assessments of these functions because they are not impaired in schizophrenia patients (Cuesta et al., 2015).

Concerning the orientation subtest, Wu et al. (2014) suggested that orientation is a temporary indicator associated with psychotic symptomatology, meaning orientation

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is state-dependent. Given that our sample is a chronic but stabilized population, this statement is consistent with the fact that the orientation subtest was not significant. Yang et al. (2018) also suggested reducing the weight or even removing subtests that seem to lack relevance in this population, such as the naming task.

In our sample, the MoCA test can detect cognitive impairment, but it is less sensitive for determining whether it is mild or severe according to the MCCB criteria, the gold standard for assessing these patients. As a screening tool, what is relevant is whether it can detect impairment, rather than the degree of such impairment.

Regarding its utility, we can argue that MoCA is a good screening tool in the detection of cognitive impairment. On the other hand, it seems that the concurrent validity between its subtests and the MCCB subtests shows its limited character. Knowing this, the clinician can consider whether it is convenient to perform a quick cognitive screening of a patient and then undergo a specific function test, or whether it is more appropriate to opt for a brief assessment from the very beginning (i.e. BACS) which, despite taking a little longer, will provide more information.

One of the strengths of this study is that it includes a large sample of long-term psychosis patients. The MoCA uses a cut-off point with good criterion validity, showing significant associations among all of its domains (except naming and orientation) with those of the MCCB.

One limitation of our study is that due to severe impairment, 17 patients were unable to complete the MCCB. As a consequence, we had to impute missing scores in order to the MCCB scoring program calculate a composite score. Another potential limitation of our study is that our sample consists of relatively old patients (mean age 49.08±10.88) with long-term psychosis. This can affect the generalization of results.

Moreover, the MoCA does not specifically assess processing speed, which is one of the core cognitive impairments in schizophrenia patients (even though the semantic fluency subtest has a time-based component). In addition to processing speed, the MoCA also does not prominently consider another cognitive area impaired in the psychotic population: verbal learning. Musso et al. (2014) suggested considering and scoring the MoCA memory subtest to be used as an added measure of verbal learning.

In summary, the results obtained in this study support the use of the MoCA just as a screening tool for detecting cognitive impairment in patients with long-term psychotic disorders. The MoCA has several advantages, such as its short time requirement and ease of administration, relevance to clinical practice, and being a free and easy-to-access test. As a drawback, it offers a limited supply of information beyond orienting on impairment. In this regard, a brief cognitive assessment should be the recommended choice.

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The use of the MoCA in psychotic patients shows that an alternative <25 cut-off point must be used to detect possible cognitive impairment. As a screening tool, it should not be overlooked that its use should be indicative. A more exhaustive and complete subsequent evaluation (such as the MCCB) must be carried out to evaluate overall performance and different cognitive domains.

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Appendix 1:

The SEGPEPs group is composed of the following members: Alejandro Ballesteros, Rebeca Hernández, Lucía Janda, Katia Llano, José López-Gil, José López-Ilundain, Patricia Macaya, Elena Martínez-Parreño, Sergi Papiol, David Peralta, María Ribeiro, Ángela S. Rosero and Héctor Saiz.

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Table 1: Demographic characteristics and descriptive data of the sample

	Patients (*n*=140)	
Age (years) ± SD	49.08 ± 10.88	
Education (years) ± SD	10.66 ± 3.3	
Sex	66F: 74M	
Age (years) at onset ± SD	26.83 ± 9.33	
Duration of illness (years) ± SD	21.28 ± 7.65	
CPZ equivalent daily dose	296.82 ± 320.2	
DSM-5 Dx Breakdown (n)	Schizophrenia disorder	59
	Schizoaffective disorder	29
	Brief psychotic disorder	16
	Bipolar disorder	31
	Other psychosis	5
CASH Score ± SD	Positive	0.72 ± 1.11
	Negative	1.5 ± 1.15
	Disorganization	0.7 ± 0.74
	Mania	0.28 ± 0.78
	Depression	0.77 ± 1.15
MoCA Score ± SD	Visuospatial/Executive	3.71 ± 1.34
	Naming	2.85 ± 0.4
	Attention	4.69 ± 1.55
	Language	1.7 ± 1.16
	Abstraction	1.28 ± 0.77
	Delayed Recall	2 ± 1.58
	Orientation	5.79 ± 0.49
	Total Score	22.64 ± 4.92
MCCB T-Score ± SD	Speed of processing	34.59 ± 12.24
	Attention/Vigilance	39.69 ± 10.84
	Working Memory	39.67 ± 12.56
	Verbal Learning	35.05 ± 16.05
	Visual Learning	36.52 ± 15.15
	Reasoning and problem solving	36.57 ± 10.2
	Social Cognition	44.8 ± 11.78
	Overall Composite	33.3 ± 13.92

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Table 2: Correlations between the MoCA and MCCB subtests and total scores

	MCCB							
MoCA	Speed of processing	Attention/Vigilance	Working memory	Verbal learning	Visual learning	Reasoning and problem solving	Social cognition	Composite score
Visuospatial / Executive	**.288***	**.**238	**.335****	**.331****	**.361****	**.356****	.076	**.412****
Naming	-.165	-.063	-.189	.008	-.092	-.127	-.040	-.099
Attention	**.410****	**.**272	**.405****	**.**281	**.359****	**.327****	.116	**.429****
Language	**.348****	**.333****	**.390****	.281	.272	**.**276	.264	**.427****
Abstraction	**.307***	.215	**.**185	**.283***	.133	.144	.282	**.304***
Delayed recall	**.**224	.029	.110	**.344****	**.344****	.167	.131	.269
Orientation	.032	-.061	-.115	-.045	.024	.104	-.061	-.043
Total score	**.520****	**.368****	**.561****	**.572****	**.543****	**.302****	**.**227	**.613****

Significance level (after Bonferroni inequality correction for multiple correlations): * p<.05, ** p<.01

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Table 3: Diagnostic information of the MoCA: mild impairment (MCCB T<40, top) and severe impairment (MCCB T<30, bottom) criteria

Cut-off point	Sensitivity	Specificity	Youden's index	+LR	-LR
<15	1	0.05	0.05	1.06	0
<16	1	0.06	0.06	1.07	0
<17	1	0.11	0.11	1.12	0
<18	1	0.17	0.17	1.20	0
<19	1	0.22	0.22	1.28	0
<20	1	0.27	0.27	1.38	0
<21	1	0.35	0.35	1.53	0
<22	0.97	0.41	0.38	1.65	0.06
<23	0.97	0.47	0.45	1.85	0.06
<24	0.92	0.62	0.54	2.43	0.13
<25	**0.92**	**0.73**	**0.65**	**3.37**	**0.11**
<26	0.76	0.82	0.58	4.26	0.29
<27	0.61	0.90	0.50	5.75	0.44

Cut-off point	Sensitivity	Specificity	Youden's index	+LR	-LR
<15	1	0.08	0.08	1.09	0
<16	1	0.10	0.10	1.11	0
<17	1	0.17	0.17	1.20	0
<18	1	0.27	0.27	1.36	0
<19	1	0.35	0.35	1.54	0
<20	0.99	0.42	0.40	1.69	0.03
<21	0.97	0.52	0.49	2.01	0.05
<22	0.92	0.57	0.48	2.12	0.15
<23	0.89	0.63	0.52	2.43	0.17
<24	0.80	0.78	0.58	3.67	0.26
<25	**0.73**	**0.87**	**0.59**	**5.45**	**0.32**
<26	0.55	0.90	0.45	5.48	0.50
<27	0.40	0.93	0.33	5.96	0.65

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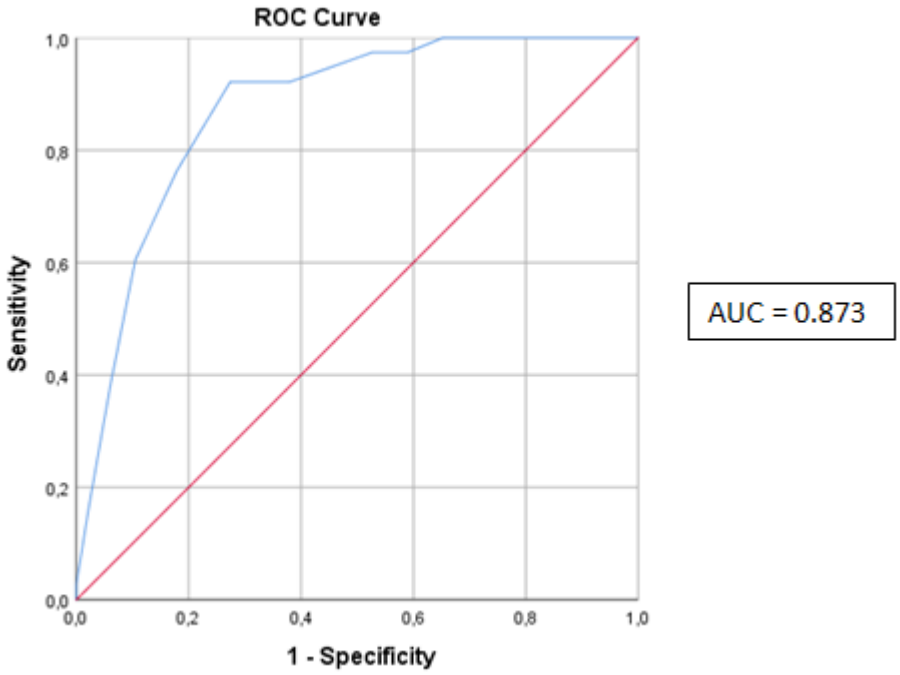
Table 4: Cognitive domain comparison represented in each screening test

	BACS	B-CATS	SCIP	MoCA
Processing speed	X	X	X	
Working memory	X		X	X
Verbal learning	X		X	X
Executive functioning:				
Planning	X (Tower of London)	X (TMT-B type)		X (TMT-B type)
Abstraction				X
Naming				X
Orientation				X
Sensitivity	0.90	0.86	0.88	0.92 (mild) / 0.73 (severe)
Specificity	0.83	0.73	0.75	0.73 (mild) / 0.87 (severe)

Figure 1: Receiver Operating Characteristic curve showing the accuracy of MoCA classifying patients using mild impairment criterion (MCCB T<40) versus no impairment



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