Factor analyzing the Norwegian MATRICS Consensus Cognitive Battery

Original research article

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Abstract

Aim: The MATRICS Consensus Cognitive Battery (MCCB) assesses seven cognitive domains with ten subtests. This domain structure has not been demonstrated. Three factors have been produced in US samples. We examined the dimensional structure of the Norwegian MCCB. In addition, we studied the contribution of each subtest to the battery sum score.

Methods: The participants were 131 patients with schizophrenia spectrum disorders and 300 healthy controls. Their Norwegian MCCB test scores were subject to exploratory and confirmatory factor analysis and regression analysis.

Results: The theoretical MCCB factor structure was not shown. In the patient group, three-factor and two-factor models had acceptable fit. In both groups, symbol coding, spatial span, letter-number span, and visual learning subtests contributed most to the sum score.

Conclusion: The theoretical domain structure of the MCCB could not be demonstrated in these Norwegian participants. Consonant with US studies, models with three and two factors had mediocre fit, and in the schizophrenia spectrum disorder group only. In both groups, the subtests symbol coding, working memory, and learning were the most sensitive in tapping general neurocognitive performance, supporting US results. We conclude that in both Norway and the US, the MCCB generates the same cognitive domains through factor analysis, but that these domains are not the ones suggested by the MATRICS project.

Key words: cognition; factor analysis; MCCB; neuropsychology; schizophrenia

Introduction

Impaired neurocognitive function is a core feature of schizophrenia spectrum disorders. [1-3] A widely used standardized test battery assessing cognitive function in this patient group is the MATRICS Consensus Cognitive Battery (MCCB) consists of ten neuropsychological tests assessing seven cognitive domains: Speed of Processing, Attention/Vigilance, Working Memory, Verbal Learning, Visual Learning, Reasoning/Problem Solving, and Social Cognition.[4] In addition to the United States norms, [4] Spanish, [5] Norwegian, [6] Japanese, [7] and Singaporean [8] reference data have been published for the MCCB.

It has never been demonstrated that the ten tests assess the seven separate domains. [9] Using the beta battery of the original MCCB, McCleery et al. [10] recently reproduced the seven domains structure in a confirmatory factor analysis (CFA) of test responses from 281 schizophrenia patients. In order to perform the CFA, additional tests were included where a domain consisted of only one subtest. In another study using Korean versions of neuropsychological tests identical or similar to those comprising the MCCB, Noh and colleagues [11] found that a six-factor model identical to the theoretical MCCB structure (Working memory, Attention/Vigilance, Verbal learning, Visual learning, Reasoning/Problem solving, and Speed of processing) provided the best fit in a sample of 114 schizophrenia patients. Also in this study additional tests were included for domains consisting of single items.

Using exploratory factor analysis (EFA), two studies have generated a three-factor model of nine of the MCCB subtests (excluding the Social Cognition test). Burton et al., [12] in a study of 183 participants with schizophrenia spectrum disorders, demonstrated that a three-factor model consisting of processing speed, attention/working memory, and learning provided the

best fit for different combinations of the nine subtests. However, a proper test of the theoretical framework behind the domain structure of the MCCB was not conducted, as a six-factor model could not be produced. In a sample that included affective disorders, totaling 300 participants, this three-factor model has recently been reproduced. [13]

All of these studies rely on data from schizophrenia and other severe mental illness samples only. Although the MCCB was developed for assessment of patients with psychosis, it is used in other clinical groups as well, e.g., patients with mood disorders, [14,15] and has a dominant status in current neurocognitive research. Neurocognitive impairment is more pronounced in schizophrenia than in other mental illnesses, [16] probably due to altered brain connectivity in the schizophrenia group. [17] A step in the process of examining the factorial validity of the MCCB for different clinical populations would be to compare the dimensional structure in samples of patients with schizophrenia and healthy controls. The scores of the clinical groups are always compared to the norms of the healthy population in order to determine the level of impairment. The underlying assumption is that the seven domains relate to each other in the same way in clinical and healthy groups. However, this may not be the case, as the brain structure of at least a sizable minority of schizophrenia patients seems to be qualitatively different compared to healthy individuals. [3,17]

In the present study, we aimed to extend the findings of Burton et al. [12] and Lo et al. [13] by performing similar factor analyses of data from both schizophrenia patients and healthy controls. As our test battery consisted of the MCCB subtests only and not additional tests of original single-item domains, our point of departure was exploratory factor analysis (EFA). First, we performed EFAs with six specified factors and the three specified factors obtained by Burton et al. [12] and Lo et al., [13] followed by free EFAs. Next, we performed CFAs on the

three-factor and free models in order to obtain information on model fit. The Mayer-Salovey Emotional Intelligence Test (MSCEIT) [18] was not part of the test protocol used for the schizophrenia sample. Therefore, we used only nine of the ten MCCB subtests in our analyses.

The previously mentioned studies [10-13] used the original US English and the translated Korean version of the MCCB, respectively. Their results may not generalize to the Norwegian cultural context or to participants with Norwegian as their native tongue. In light of the widespread, international popularity of the MCCB, studies of this battery's psychometric properties should be undertaken in different ethnic and linguistic groups. Compared to the US and Korea, Norway is characterized by ethnic, religious, and linguistic homogeneity, a large gross domestic product per capita, low population density, little geographic mobility, an expansive welfare state with generous disability pensions, and hardly any severe economic setbacks or political/social unrest since 1945. Such factors may influence the well-being of and structural conditions of individuals with mental illness, and could theoretically be reflected in the responses individuals from different nations and cultures give during psychological assessments. To our knowledge, this is the first factor analytic study of the MCCB from a European country. This is an important step in the cross-cultural validation process of this translated version of the battery in order to properly interpret neurocognitive findings and enable comparisons across cultures and samples.

The MCCB is rapidly becoming the preferred assessment instrument in many studies of neurocognitive function. The completion of the battery is, however, rather time consuming, and the test results could be biased due to fatigue in severely ill individuals. Thus, a briefer version of the MCCB retaining those tests that contribute most strongly to overall

neurocognitive function (the composite sum score) seems warranted. Burton and colleagues [12] demonstrated the tests of symbol coding, spatial span, and visual learning accounted for 83% of the variance of the composite score in patients with schizophrenia. In line with this strategy, a second aim of this study was to identify the MCCB subtests that best predict the composite score.

Methods

Subjects

The demographic and clinical characteristics of the participants are presented in Table 1. The recruitment process and test procedure of the participants in the schizophrenia group has been described elsewhere. [19] Briefly, this sample consists of 131 (92 men, 39 women) participants between the ages of 18 and 65 in a multisite vocational rehabilitation study (the Job Management Program; JUMP) for adults with a main diagnosis of psychotic disorders, meeting the criteria according to the Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition (DSM-IV). [20] Of these 131 participants, 116 had schizophrenia, 10 had schizoaffective disorder, 2 had psychosis NOS, and 3 had delusional disorder. Of the 131 patients, 66 had experienced a previous or ongoing depressive episode, and 7 had experienced a previous manic episode. The participants were referred from local mental health centers and vocational services, and underwent neurocognitive assessment prior to entering the rehabilitation program. All participants provided written informed consent after complete description of the study. The JUMP study was approved by the Regional Committee for Medical Research Ethics Region South-East (REK Sør-Øst) and the Norwegian Data Protection Authority (Clinical.Trials.gov identifier: NCT01139502).

The recruitment process, test procedure, and demographic characteristics of the healthy participants have also been described elsewhere. [6,21] Briefly, 300 healthy Norwegian men (n=149) and women (n=151) between the ages of 12 and 69 were tested with the Norwegian MCCB. [22] All participants signed an informed consent form. The study was approved by the Regional Committee for Medical Research Ethics for Health Region South-East (REK Sør-Øst).

(Insert Table 1 here)

Neuropsychological tests

The MCCB consists of the following tests: Trail Making Test A (TMT-A), [23] Symbol Coding (Brief Assessment of Cognition in Schizophrenia, BACS), [24] the revised Hopkins Verbal Learning Test (HVLT-R), [25] Spatial Span (The Wechsler Memory Scale, SS-WMS), [26] the University of Maryland Letter Number Span test (LNS), [27] the revised Brief Visuospatial Memory Test (BVMT-R), [28] the Mazes test (Neuropsychological Assessment Battery, NAB), [29] Category Fluency (Fluency), [30] the Managing Emotions part of the MSCEIT, [18] and the Continuous Performance Test – Identical Pairs (CPT-IP). [31]

In the MCCB theoretical framework, these ten tests may be described as seven cognitive domains: Speed of Processing (TMT-A, BACS, and Category Fluency), Attention/Vigilance (CPT-IP), Working Memory (WMS-SS and LNS), Verbal Learning (HVLT-R), Visual Learning (BVMT-R), Reasoning/Problem Solving (Mazes), and Social Cognition (MSCEIT). General intellectual function (IQ) was estimated with two subtests from the Wechsler Abbreviated Scale of Intelligence (WASI). [32]

Statistics

The IBM SPSS statistical program version 20 was used to perform the EFAs and the regression analyses. The Mplus statistical program version 6.12 was used to perform the CFAs. In all factor analysis procedures, the previously reported raw scores of nine MCCB subtests are used. [6,19,21] In the regression analyses, our own calculated T-scores are used (Mean = 50, *SD* = 10) in order to enable us to regress the subtests on the composite sum score, which was the mean of the nine subtests.

In the schizophrenia group, the TMT-A score was skewed (1.3, *SE* 0.22) and had a positive kurtosis (3.0, *SE* 0.43). In the control group, the LNS (1.34, *SE* 0.28) and BVMT-R (1.32, *SE* 0.28) had a positive kurtosis.

The subtest inter-correlations were generally statistically significant (data not shown). The EFAs were performed for each group separately in the following manner: First, we calculated free models letting the statistical program decide which factors to retain based on the eigenvalues above 1.Then, we specified our wish to obtain six-factor and three-factor models regardless of eigenvalues. The KMO value was .83, and the Bartlett test of sphericity was statistically significant ($p < .001$). Varimax was chosen as the rotation method due to several cross loadings.

Next, the fit of the two- and three-factor models were tested with CFAs for each group separately. Finally, we tested a unifying one-factor model in both groups. A model was determined to have good fit if the SRMR was below .08, the RMSEA was below .05, and the CFI was above .90.

Results

Correlation analyses revealed no effect of medication on the performance of the cognitive tests in the schizophrenia group. In this group, there were 10 participants with Norwegian as their second language. The removal of these participants from the analyses did not alter the following results.

Exploratory factor analyses (EFA)

For the schizophrenia group, the forced six-factor model explained 48.7 % of the total variance. Of these factors, only one (3: Verbal learning) corresponds to a similar MCCB domain (Table 2). Three of the other factors (1: Visual learning and working memory, 2: Attention and working memory, and 6: Symbol coding) make intuitive sense, although they are not part of the original MCCB structure. The remaining two factors (4: Speed of processing I and 5: Speed of processing II) are so similar that it is impossible to explain their unique contribution to the overall model. The forced three-factor model explained 41.2 % of the total variance (Table 3). This model is near identical to the one previously identified by Burton et al. and Lo et al., i.e., Factor 1: Learning and working memory. Factor 2: Attention and working memory. Factor 3: Speed of processing and reasoning. The free two-factor model explained 33.6 % of the total variance, and consists of Factor 1: Working memory, learning and attention, and Factor 2: Speed of processing, working memory, and attention. The most important factor consists of tests that assess working memory, attention, and learning (Table 4). For all models, cross loadings occurred.

(Insert Tables 2-4 here)

In the healthy control group, the forced six-factor model explained 54.4 % of the total variance. Three of the factors (1: Visual speed, learning, and working memory, 2: Working memory and verbal learning, and 3: Verbal learning and speed) make intuitive sense, and one (5: Attention) is similar to an MCCB domain (Table 5). This procedure generated several cross-loadings. The forced three-factor model (Factor 1: Visual speed, learning, and working memory, Factor 2: Learning and working memory, and Factor 3: Verbal learning and speed) explained 45.1 % of the total variance. CPT-IP was removed from the model. These factors are not the same as found in the schizophrenia group (Table 3), and the existence of several cross loadings renders the model difficult to interpret within a cognitive domain framework. Again, the most important factor consisted of tests that assess speed and visual short-term memory/learning (Table 6).

The free two-factor model explained 41.0 % of the total variance. The most important factor was defined by tests measuring speeded visual processing and short-term memory/learning (Table 7). In this model, CPT-IP and Fluency were removed from the final pattern matrix. There were several cross loadings also in these models.

There were considerably more participants in the healthy control group compared to the schizophrenia group, and the age span of the healthy participants was larger. Therefore, we repeated the EFAs without healthy respondents younger than 20 (n=50) and older than 59 years (n=50). This procedure did not alter the above results in any significant manner.

(Insert Tables 5-7 here)

Confirmatory factor analyses (CFA)

Of the six EFA models (three for each group), only the three- and two-factor models for the schizophrenia group could be optimized, both with mediocre fit. For the three-factor model, the fit results were as follows: $X^2 = 760.65$ (*df* 26, $p < .001$), SRMR = .04, RMSEA = .14, and CFI = .66. For the two-factor model, the fit results were as follows: $X^2 = 75.98$ (*df* 26, $p < .001$), SRMR = .11, RMSEA = .12, and CFI = .77.

As the correlation analyses in both groups demonstrated a statistically significant relationship between most variables, we subjected a unifying one-factor model of all nine subtests to CFA. Only in the schizophrenia group could a one-factor model be optimized, the fit results being $X^2 = 100.64$ (*df* 27, $p < .001$), SRMR = .11, RMSEA = .14, and CFI = .66, indicating a relatively poor fit.

Regression analyses

Regression analyses were used to identify the subtests with the strongest contribution to the composite score. In contrast to Burton and colleagues, [12] we chose a data driven approach and did not enter independent variables into the analyses based on the results of the factor analyses. Instead, we entered the nine MCCB subtests into the analyses in a stepwise manner.

This procedure revealed that all of the MCCB subtests contributed significantly to the composite score (all t's > 6.21, all p's < .001) in the schizophrenia group. The models presented in Table 8 consist of the following subtests: Model 1: BACS, Model 2: Model 1 and LNS, Model 3: Model 2 and BVMT-R, Model 4: Model 3 and Mazes, Model 5: Model 4 and TMT-A, Model 6: Model 5 and CPT-IP, Model 7: Model 6 and Fluency, Model 8: Model 7 and SS-WMS, Model 9: Model 8 and HVLT-R.

Likewise, in the healthy control group, all the MCCB subtests contributed significantly to the Composite score (all t's > 9.92, all p's < .001). The models presented in Table 9 consist of the following subtests: Model 1: BACS, Model 2: Model 1 and BVMT-R, Model 3: Model 2 and SS-WMS, Model 4: Model 3 and Fluency, Model 5: Model 4 and CPT-IP, Model 6: Model 5 and HVLT-R, Model 7: Model 6 and TMT-A, Model 8: Model 7 and LNS, Model 9: Model 8 and Mazes.

(Insert Tables 8-9 here)

Discussion

The factor structure of the MCCB

In this study of the Norwegian MCCB factor structure in patients with schizophrenia spectrum disorder and healthy controls, we were unable to produce the theoretical model of this battery, which aims to assess seven independent cognitive domains. [4] In the schizophrenia group, we optimized three- and two-factor models by CFA, albeit with inadequate fit. The factors including tests of working memory, learning, and attention generally explained the largest proportion of the total variance of these two models, but cross loadings do not permit us to define them as unique.

In addition, a unifying one-factor model was optimized in the schizophrenia group, but again with inadequate fit. This is in line with the Burton et al. [12] study, although their model fit was better.

One explanation for this result may be the number of single item factors of the six-factor models, making it difficult to obtain statistically sound results. Noh and colleagues [11] have presented a six-factor model, but one consisting of several other tests in addition to the MCCB subtests. A similar approach was taken by McCleery et al. [10] However, in our study, not even the EFAs produced the theoretically expected domain structure. Moreover, several of the EFA components cross loaded in a manner not compatible with the theoretical MCCB structure. Thus, the suggested seven domain structure of the battery seems purely theoretical.

In the control group, none of our EFA models could be optimized by CFA. This may indicate that the theoretical domain structure of the MCCB is not appropriate for healthy people based on the current selection of tests. The MCCB was originally intended for schizophrenia patients only, and the ideal of specificity may have been considered less pertinent than the urgent need for psychometrically sound as well as tolerable tests for individuals with severe mental illness.

These results have theoretical, but not necessarily clinical implications. The factor analytic studies of the MCCB have demonstrated that the theoretically driven dimensional structure of the battery is not substantiated by the tests intended to assess it. However, there is no doubt that the MCCB test scores provide a valuable picture of general neurocognitive function, and neither our data nor those of others justify questioning the clinical utility of the battery. The implication is that the seven domains structure of the MCCB tests is not necessarily the same in other groups of respondents as in psychosis patients. The MCCB is currently used to assess cognitive function in severe depression disorders. [14,15] In such cases, regarding the tests of this battery as representing the same latent cognitive domains as in schizophrenia patients may not be warranted.

The regression analyses of the MCCB

The results of the regression analyses were rather similar in the two groups. For both schizophrenia patients and healthy controls, BACS was the individual test that contributed the most to the Composite score, explaining more than half of the variance. About 75 % of the variance of the Composite score was explained by a combination of BACS, LNS, and BVMT-R in the schizophrenia group and BACS, BVMT-R, and SS-WMS in the control group. This result accords with that of Burton and colleagues, [12] who reported that a combination of BACS, SS-WMS, and BVMT-R predicted 85 % of the sum score variance, and that BACS was by far the most important single factor in this regression procedure. We have put the Burton et al. [12] findings on a more secure footing by replicating these results in a healthy sample.

Taken together, these data suggest that the BACS, SS-WMS, LNS, and BVMT-R are the most sensitive tests of the MCCB. The clinical implication is that, if pressed for time or when assessing a very tired client, the administration of these four tests may be sufficient to gain an estimate of neurocognitive function.

Strengths and limitations

This is the first factor analytic study of the MCCB in Norway. A further strength is the inclusion of a healthy control group, demonstrating that the theoretical domain structure of the Norwegian MCCB may not be found in this population or in Norwegian schizophrenia patients. Factor analytic studies with MCCB scores from other clinical groups, e.g., patients with severe depression or bipolar disorder, should be performed in order to explore the seven domain structure – or lack thereof – further.

There are several limitations of our study. First, we did not include the social cognitive test MSCEIT, and thus could not attempt to model the original seven domains of the MCCB. The same limitation characterizes the Burton et al.'s [12] and Lo et al.'s [13] studies. Thus, we do not know how analyzing all ten subtests would have affected the factor structure.

Second, the schizophrenia sample was relatively small (N=131). In order to obtain optimal model fit through CFA, larger samples are recommended. This may explain the fact that our model fits were not as good as those of others. [12,13]

Third, we performed both EFA and CFA on the same data sets. In general, this strategy is not recommended as it increases the risk of obtaining a too good fit of the CFA models. However, the fit of our CFA models was low to mediocre, rendering our analytic strategy acceptable.

Fourth, the schizophrenia spectrum disorder sample included individuals with symptoms of affective disorders and substance use. The presence of other symptoms and disorders may have affected the cognitive capacity of our patients. However, given the prevalent co-occurrence of affective symptoms and use of alcohol and illegal substances in patients with psychosis, a sufficiently powered schizophrenia sample without additional symptoms would be both unrepresentative and difficult to recruit. Moreover, the factor analytic studies that served as the points of departure for for this paper [12,13] included patients with affective symptoms and substance use for the same reasons.

Conclusions

By using factor analytic procedures on test results from Norwegian participants with schizophrenia and healthy controls, we were not able to model the theoretical seven (or six) domain structure of the MCCB. In the schizophrenia group three- and two-factor model could be optimized. This is in accordance with previous US studies. Regression analyses show that BACS, SS-WMS, LNS, and BVMT-R are the most sensitive tests of the Norwegian MCCB, supporting previous findings from the US. Thus, in a cross-cultural perspective, the Norwegian MCCB could not confirm the theoretical domain structure of the battery. Moreover, the regression analyses revealed significant similarities between the US and the Norwegian batteries. Hence, the US and Norwegian MCCBs seem to behave similarly in schizophrenia patients, facilitating cross-cultural comparison of data.

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Disclosure statement

The authors declare no conflict of interest.

Author contributions

TU, EF, and BRR designed the projects from which this paper was issued. CM and JUL designed the present study, collected the data, and performed the statistical analyses. CM drafted the manuscript. All authors contributed to the interpretation of the analyses and the writing of the paper.

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Table 1. Demographic and clinical characteristics.

	Schizophrenia spectrum disorder patients (n=131)	**Healthy controls (n=300)**
Age in years	33.0 (*SD* 8.2, range 18-59)	39.4 (*SD* 17.3, range 12-69)
Gender	92 (70.2%) men	149 (49.0 %) men
	39 (29.8%) women	151 (51.0 %) women
Years of education	11.8 (*SD* 2.4)	12.2 (*SD* 2.7)
IQ	102.4 (*SD* 13.1)	109.3 (*SD* 14.7)
Duration of illness in years	7.0 (*SD* 6.4)	n/a
Current medication		n/a
Atypical antipsychotics	64.0 %	
No medication	5.3 %	
Current substance use		n/a
Alcohol dependence	6.9 %	
Alcohol abuse	9.9 %	
Drug dependence	6.1 %	
Drug abuse	3.1 %	

Table 2. Factor loadings based on an EFA with varimax rotation for nine subtests of the MCCB with six factors specified, schizophrenia spectrum disorder patients (N = 131).

	Components (explained variance)					
	1 (28.4 %)	**2 (7.6 %)**	**3 (6.2 %)**	**4 (4.1 %)**	**5 (1.5 %)**	**6 (0.8 %)**
BVMT-R	.81					
SS-WMS	.57	.35				
CPT-IP		.74				
LNS		.62				
HVLT-R			.58			
Fluency				.47		
BACS				.38		.38
TMT-A					-.47	
Mazes				.37	.46	

Factor 1: Visual learning and working memory. Factor 2: Attention and working memory. Factor 3: Verbal learning. Factor 4: Speed of processing I. Factor 5: Speed of processing II. Factor 6: Symbol coding.

Table 3. Factor loadings based on an EFA with varimax rotation for nine subtests of the MCCB with three factors specified, schizophrenia spectrum disorder patients (N = 131).

	Components (explained variance)		
	1 (15.4 %)	**2 (13.6 %)**	**3 (12.1 %)**
BVMT-R	.91		
SS-WMS	.53	.38	
HVLT-R	.30		
CPT-IP		.72	
LNS		.62	
BACS			.56
TMT-A			-.46
Fluency			.44
Mazes			.43

Factor 1: Learning and working memory. Factor 2: Attention and working memory. Factor 3: Speed of processing and reasoning.

Table 4. Factor loadings based on a free EFA with varimax rotation for nine subtests of the MCCB, schizophrenia spectrum disorder patients (N = 131).

	Components (explained variance)	
	1 (26.6 %)	**2 (7.0 %)**
SS-WMS	.79	
BVMT-R	.61	
LNS	.50	.34
CPT-IP	.43	.33
HVLT-R	.35	
BACS	.35	.58
TMT-A		-.46
Mazes		.43
Fluency		.41

Factor 1: Working memory, learning and attention. Factor 2: Speed of processing, working memory, and attention.

Table 5. Factor loadings based on an EFA with varimax rotation for nine subtests of the MCCB with six factors specified, healthy controls (N = 300).

	Components (explained variance)					
	1 (36.5 %)	**2 (7.3 %)**	**3 (3.9 %)**	**4 (3.6 %)**	**5 (2.0 %)**	**6 (1.2 %)**
Mazes	.80					
SS-WMS	.52	.45				
BVMT-R	.49					
LNS		.75				
HVLT-R		.40	.55			
Fluency			.43			
BACS	.35			.60		
CPT-IP					.53	
TMT-A	-.36					-.55

Factor 1: Visual speed, learning, and working memory. Factor 2: Working memory and verbal learning. Factor 3: Verbal learning and speed. Factor 4: Symbol coding. Factor 5: Attention. Factor 6: Visual speed.

Table 6. Factor loadings based on an EFA with varimax rotation for nine subtests of the MCCB with three factors specified, healthy controls (N = 300).

	Components (explained variance)		
	1 (22.2 %)	**2 (16.6 %)**	**3 (6.3 %)**
Mazes	.80		
TMT-A	-.58		
SS-WMS	.58	.50	
BACS	.55	.47	
BVMT-R	.47	.34	
CPT-IP		-	
LNS		.76	
HVLT-R		.47	.36
Fluency			.51

Factor 1: Visual speed, learning, and working memory. Factor 2: Working memory and learning. Factor 3: Verbal learning and speed.

Table 7. Factor loadings based on a free EFA with varimax rotation for nine subtests of the MCCB, healthy controls (N = 300).

	Components (explained variance)	
	1 (35.1 %)	**2 (5.9 %)**
Mazes	.83	
TMT-A	-.57	
SS-WMS	.54	.46
BVMT-R	.46	.41
LNS		.69
HVLT-R		.58
BACS	.52	.57
CPT-IP	-	-
Fluency	-	-

Factor 1: Visual speed, working memory, and learning. Factor 2: Working memory and learning.

Table 8. Stepwise regression analyses of nine MCCB subtests, schizophrenia spectrum disorder patients (N = 131).

Model	***Adj. R2***	***R2* change**	***F* (change)**
1	.509	.513	131.56 ***
2	.680	.173	67.98 ***
3	.781	.101	58.38 ***
4	.837	.056	43.30 ***
5	.876	.038	38.59 ***
6	.913	.036	52.39 ***
7	.945	.031	71.83 ***
8	.973	.026	122.98 ***
9	.1000	.025	-

Dependent variable: the MCCB Composite score. ***: $p < .001$.

Table 9. Stepwise regression analyses of nine MCCB subtests, healthy controls (N = 300).

Model	***Adj. R2***	***R2* change**	***F* (change)**
1	.603	.605	451.20 ***
2	.726	.123	133.40 ***
3	.799	.073	107.32 ***
4	.856	.057	116.94 ***
5	.899	.043	127.14 ***
6	.932	.032	140.50 ***
7	.967	.034	308.76 ***
8	.982	.014	233.92 ***
9	.1000	.018	-

Dependent variable: the MCCB Composite score. ***: $p < .001$.