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Cognitive Screening Scale for Schizophrenia (CSSS) Part 1. Design and structure of the scale

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Summary

Introduction. This paper presents the construction of the CSSS – a short screening scale intended for diagnosis of cognitive deficits among people with schizophrenia.

Material and methods. 160 persons (124 with schizophrenia and 36 healthy controls) were tested using the initial version of the CSSS scale consisting of 11 subscales. Correlation analysis between the subscales' results was carried out, as well as confirmatory factor analysis, internal consistency analysis of the scale, IRT (item response theory) analysis of the items' difficulty, and analysis of the scale's accuracy as a classifier.

Results. One factor (overall cognitive efficiency) explains 37% of the variance of the subscales' results. The scale has satisfactory internal consistency (Cronbach's alfa = 0.83). Subjects with schizophrenia achieved significantly lower scores than healthy subjects. The area under the ROC curve (AUC) for discriminating between subjects with schizophrenia and healthy subjects was 0.83. Cut-off point of 16 raw points is 86% sensitive and has 70% specificity.

Conclusions. The form of the tool that has been achieved as a result of presented analyses suggests that this scale has a potential to fulfil the assumed goals, which will be tested during continuing validation studies.

Key words: schizophrenia, cognitive impairment, screening scale

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The authors report no conflict of interest.

Introduction

Cognitive impairment in the course of schizophrenia, starting even before the first episode of psychosis and maintaining or exacerbating under the influence of additional factors have been well documented in numerous studies and meta-analyses [1–3]. More and more often, the symptoms of schizophrenia are also perceived as entropy of the mind, an integral part of which is cognitive impairment in the procedural area (operational functions and motor skills) and disorders of basic cognitive functions like attention, memory, or concentration [4]. Typical areas of cognitive functioning that need measuring and that are included in tools designed for patients with schizophrenia are: linguistic learning, operational memory, motor rapidity, verbal fluency, attention, operational functions, as well as social cognition and visual learning (BACS and MATRICS test batteries) [5, 6]. Research on methods designed for patients with schizophrenia have mostly been based on assumptions related with: 1) highly unsatisfactory results of pharmacological treatment of cognitive impairments; 2) verified significant influence of cognitive rehabilitation on social functioning and biological functions; and 3) documented specific areas that become hindered in the course of this illness [6]. Application of the MATRICS standard, however, usually requires a computer, specialist training for diagnosticians and between 90 and 120 minutes [6]. Those methods are also expensive and that makes them barely available in the Polish healthcare system.

Some of the screening methods, like the Mini-Mental State Examination (MMSE), are designed to identify more severe cognitive disorders [7], while those with sufficient sensitivity and specificity in identifying milder disorders were not created with schizophrenic patients in mind. Surprisingly, some of those methods have better diagnostic properties than methods specifically designed for diagnosing cognitive functions in schizophrenia. One of the examples of such a situation is the Montreal Cognitive Assessment Scale (MoCA) – a short, free, non-computer based screening scale that turned out to be a better classifier in identifying patients that meet the criteria of a severe mental illness (SMI) than the Brief Assessment of Cognition in Schizophrenia (BACS). 89% of people meeting the criteria of SMI obtained a result below 26 points on that scale, with its 61% specificity [8, 9]. Such results suggest that the use of simple, inexpensive methods that do not require long-term trainings in order to identify people who experience difficulties in functioning and at the same time cognitive impairments can be just as efficient as using more complex tools. Such results can be explained by the fact that both the complex overall result of the BACS and the overall result of the MoCA measure a very similar factor (overall cognitive ability), which in both cases correlates with the level of overall functioning. Moreover, the MoCA was created in order to recognize mild cognitive disorders, so the essence of this method is to find a subtle threshold, beyond which cognitive disorders become functionally noticeable. This might be the factor that can explain the slight advantage of this short and simple method.

All methods of assessing cognitive functions in schizophrenia have limited predictive value. One may attempt to predict the occurrence of an episode of psychosis

based on a deterioration in cognitive function that takes place beforehand. However, such deterioration may also occur under the influence of other factors. In the course of the illness, it is difficult to predict future levels of cognitive functions on the basis of measuring them, as deterioration caused by the illness itself usually takes place before the first episode of psychosis, and the possibility of further decline of cognitive functioning depends on too many factors (treatment, addictions, social stigmatization, rehabilitation, etc.) However, overall results of methods used for the assessment of cognitive functions in schizophrenia are usually good predictors of the overall level of functioning [10, 11]. The described aspect of diagnostic value also seems to be considerably closely related to the purpose of applying such methods in clinical practice: identifying patients whose functioning in the society could be influenced by cognitive rehabilitation.

This article presents the first stage of construction of a short screening method that would meet all of the following criteria: assess overall cognitive functioning, be easy to use, relate to cognitive difficulties experienced by patients with schizophrenia, take no longer than 15–20 minutes to perform. At this stage, the structure and some reliability parameters were measured; it was also evaluated whether this method is able to efficiently distinguish people with schizophrenia from healthy people.

Further stages of the research are going to be presented in a subsequent article. It is going to concern external accuracy, accuracy in relation to clinical data, and a comparison of the efficiency of the CSSS and the Brief Assessment of Cognition in Schizophrenia in differentiating patients fulfilling and not fulfilling the criteria of Severe Mental Illness.

Aim

The aim of this article is to present the method of constructing the Cognitive Screening Scale for Schizophrenia (CSSS), along with its factor structure, internal consistency and initial tests on whether the CSSS is a good classifier distinguishing hospitalized patients with schizophrenia from a control group of healthy people. This article shall deliver preliminary data for further validation research.

Material and method

Construction of the tool

In a draft version of the method, the sub-tests planned to be used are based on well-known and widely used methods, elements of a psychiatric test traditionally applied in examining patients with schizophrenia, and experimental and clinical trials.

The sub-test Planning and Switching is based on the popular TMT B connect-the-dots test and on the MoCA scale [12. 13]. It is, however, given to the patient without preparation or time control. In this case, it measures various functions: understanding and remembering long instructions, planning, attention switching, and visuospatial functions. It was assumed that all difficulties with supervisory and attention functions

should be reflected in the score. Correct execution of the task without intervention of the assessor results in receiving 2 points, and correct execution with one mistake corrected by the assessor – 1 point. The need for more interventions to be made or incorrect execution of the task results in no points received.

In the Linguistic Learning sub-test, the participant has 3 attempts to learn a list of 8 words read out loud by the assessor. If the participant repeats all 8 words in the third trial, they receive 2 points, and for 6 or 7 words – 1 point. A smaller number of correct answers is not awarded with any points. In one of the next parts of the scale, the participant is asked to recall the memorized material learned in this sub-test – for which separate points are given (Memory-Recalling from Memory sub-test).

The Attention sub-test is inspired by "go/no-go" trials. Along with the sub-test Inhibitory control, it is derived from the Frontal Assessment Battery method [14]. The participant is taught to react in such a way that when the assessor makes two taps with a pencil, the task of the participant is to tap once. When the assessor taps once, the participant should tap twice. Afterwards comes a series of mixed signals, to which the participant is supposed to react properly. More than two mistakes result in no points granted, for one mistake the participant gets 1 point, and if no mistakes were made – 2 points.

The next sub-test [14] (Inhibitory Control) is built in the same way as the previous one, but the participant is taught to react differently to the same stimuli – to reply with one tap in response to one signal from the assessor, and no taps in response to a double signal from the assessor. Afterwards comes a series of signals with the same rules of scoring as in the previous test.

In the part Mechanical Memory, the participant learns 3 series of numbers consisting of 4, 5 and 7 digits forward and 2 series of numbers (4 and 5 digits) backwards. Correct repetition of 4 or 5 series results in 2 points granted, 3 correct series – 1 point, and less than 3 series – 0 points.

The purpose of the sub-test Reasoning through Analogy, inspired by experimental and clinical trials, is to deliver rough information about operating on concepts. The participant is given two trials consisting of sentences to be finished. The sentences include relations between concepts, and the task of the participant is to choose some of the words given in order to create an analogical conceptual relation. The participant can receive 1 point for each correct analogy. This means that in this sub-test, it is possible to receive between 0 and 2 points.

The sub-test Creating General Concepts. Concepts are presented to the participant in pairs. For each pair, the participant is supposed to create a general concept. In case of an accurate, correct answer, the participant receives 1 point. If the answer is correct but incomplete or too specific – 0.5 points. If the final score is not an integer, it should be rounded up to the nearest integer. In this sub-test the participant can receive between 0 and 2 points.

The Abstract Reasoning sub-test consists of two proverbs, often used in psychiatric trials for clinical examination of reasoning disorders. The nature of this sub-test makes its evaluation the most subjective one. Answers that reflect the sense of the proverb to the fullest are awarded with 1 point. Answers that partly reflect the sense, or in an

overly specific yet generally correct way, are awarded with 0.5 points. If the score is not an integer, it should be rounded up to the nearest integer. The score in this test is always between 0 and 2 points.

In the assessment of visual constructive functions (the Visual Constructive Functions sub-test), the participant's task is to copy a complex figure shown on a sheet of paper. The task of the participant is both to correctly reproduce the spatial aspect of the figure [13] and to notice peripheral elements like in the Rey Complex Figure Test [15]. Creation of the figure requires planning, efficient perception and perceptional structuration. Complete, mistake-free and accurate reproduction of the figure is awarded with 2 points. Any single mistake, in the central or in the peripheral figure, results in granting 1 point for the task in total. In case of two or more mistakes (regardless if in the central or peripheral figure), there are no points for this task.

In the Verbal Fluency sub-test, the aim is to list as many words starting with the letter A and as many sharp objects as possible. 60 seconds are given for the execution of each of those tasks. The speed of actualization of words is reflected in the amount of words spoken in the course of 60 seconds. It is possible to receive a maximum of 2 points for this sub-test (1 point for 11 and more words starting with A, and 1 point for 9 and more sharp objects).

The last sub-test is Memory-Recalling from Memory, related to the material learned in the sub-test Linguistic Learning. The participant's task is to recall as many of the 8 words learned in that sub-test as possible. The participant receives 2 points for recalling 7 or 8 words correctly, and 1 point for 5 or 6 words. No points are granted for 5 words or less. It is possible to receive a maximum of 2 points.

The results of all sub-tests are added up to calculate an overall score. In the draft version of the method, participants could receive between 0 and 22 points.

The study group

In order to determine the final number of sub-tests and the factor structure of the scale, 160 people were tested. The clinical group consisted of 124 people hospitalized due to schizophrenia, examined in the state of remission before being discharged from the Department of Psychiatry in the Faculty of Health Sciences of the Medical University of Warsaw. 45.6% of the group were women, and 54.4% were men. In the control group (N = 36), the percentage of men and women was 40% and 60% respectively. The mean age in the clinical group was 41.4 years (SD = 12.8), and in the control group 34.2 years (SD = 14.36).

The tests were conducted individually by trained psychologists working in one of the units of the Department. Their training included conducting the scale, assessment criteria, as well as manner and conditions of running the test (psychologist's office, silence, patient in euthymia). Nosological diagnoses of schizophrenia were made or confirmed on the basis of an interview, psychiatric observations, and psychological test methods conducted by the staff of the Department, based on the criteria of ICD-10. Supervision of the diagnosis was performed by the head physician of the Unit. The Bioethical Commission of the Medical University of Warsaw

was informed about the study and has not submitted any claims concerning the method or study material.

Statistical analyses

The following software was used to analyze the data: StatSoft STATISTICA10, PASW Statistics 18, jMetrik and AMOS. Descriptive statistics of obtained data were calculated and a confirmatory factor analysis was performed. Item Response Theory analysis and internal consistency analysis were conducted with the help of several coefficients. The diagnostic value of the CSSS as a classifier in differentiating patients from the clinical group from people from the control group was verified with the use of a ROC curve and an analysis of cut-off points.

Results

Analyses of cross-correlations of the results of individual sub-tests, and of the results of sub-tests with the overall score suggest that nearly all of the sub-scales of the method correlate significantly with each other, as well as significantly (and quite strongly) correlate with the overall score.

A single factor structure of the method was presumed, taking into consideration that simple sub-tests that the scale consists of, their potential contribution to the overall result and the scoring method may cause this scale to actually measure overall cognitive ability, just like similar methods. This assumption was verified with the use of confirmatory factor analysis (CFA) performed in the clinical group (N = 124). In the first place, the basic model was tested – assuming, as mentioned previously, a single factor structure of the method. The Mardio index did not suggest that the distribution was different from normal, so the Maximum Likelihood (ML) method was applied. Obtained indexes of matching the model with the data were unsatisfactory ($\chi^2 = 76.40$; df = 44; p = 0.02, RMSEA = 0.07, LO 90 = 0.04, HI 90 = 0.10, PCLOSE = 0.06). Verification of MI modification indexes resulted in the necessity to free a covariance of variable specificity. This allowed to achieve better indexes of matching the model with the data ($\chi^2 = 48,14$; df = 40; p = 0.17; RMSEA = 0.04, LO 90 = 0.00, HI 90 = 0.07, PCLOSE = 0.62). It was presumed that the correlated specific variance of individual variables was consistent with the nature of the method. The following covariances of sub-test results (in pairs) were detected: Planning and Switching – Reasoning through Analogy (0.28), Planning and Switching – Verbal Fluency (0.22), Reasoning through Analogy – Creating General Concepts (0.20), Visual Constructive Functions – Recalling from memory (-0.35). Table 2 below presents all other goodness of fit indicators.

Table 1. **Correlation coefficients (Spearman's rho) between individual sub-tests and between sub-tests and the overall score – in clinical and control groups (N = 160)**

	Planning and Switching	Linguistic Learning	Attention	Inhibitory Control	Mechanical Memory	Reasoning through Analogy	Creating Concepts	Abstract Reasoning	Visual Constructive Functions	Fluency	Recalling from Memory	Total
Planning and Switching	1	0.21*	0.22*	0.31*	0.29*	0.49*	0.24*	0.39*	0.43*	0.50*	0.35*	0.70*
Linguistic Learning		1	0.26*	0.30*	0.36*	0.20*	0.34*	0.39*	0.17*	0.32*	0.40*	0.58*
Attention			1	0.33*	0.22*	0.24*	0.31*	0.24*	0.30*	0.28*	0.25*	0.46*
Inhibitory Control				1	0.35*	0.24*	0.27*	0.19*	0.24*	0.23*	0.24*	0.55*
Mechanical Memory					1	0.27*	0.21*	0.35*	0.18*	0.32*	0.24*	0.58*
Reasoning through Analogy						1	0.37*	0.28*	0.37*	0.33*	0.28*	0.60*
Creating Concepts							1	0.36*	0.30*	0.34*	0.12*	0.53*
Abstract Reasoning								1	0.25*	0.41*	0.24*	0.64*
Visual Constructive Functions									1	0.37*	0.14*	0.54*
Fluency										1	0.37*	0.68*
Recalling from Memory											1	0.56*

Spearman's BD rank order correlation removed by pairs; * marked correlations are significant with $p < 0.05$

Table 2. **Indicators of matching the model with the data. Comparison of the basic model and the model with free covariance (N = 124)**

Goodness of fit indicators		Model with free covariance	Basic model
X^2/ degrees of freedom	Cmin/df	1.736	1.203
Comparative Fit Index	CFI	0.864	0.966
Goodness of Fit Index	GFI	0.905	0.939
Adjusted Goodness of Fit Index	AGFI	0.858	0.900
Standardized RMR	SRMR	0.069	0.056
Normed Fit Index	NFI	0.740	0.836
Relative Fit Index	RFI	0.675	0.775
P value of close fit	PCLOSE	0.066	0.620
Default model	AIC	120.402	100.140
Saturated model	AIC	132.000	132.000
Independence model	AIC	316.001	316.001

An analysis of differences in goodness of fit indexes between individual models was also conducted (Table 3).

Table 3. **Comparison of goodness of fit indexes to the data – differences (N = 124)**

Model	NFI Delta1	RFI rho1	IFI Delta2	TLI rho2	CFI
Model with free covariance	0.836	0.775	0.968	0.953	0.966
Basic model	0.740	0.675	0.870	0.831	0.864

NFI – Normed Fit Index; RFI – Relative Fit Index; IFI – Incremental Fit Index; TLI – Tucker-Lewis index (non-normed fit index); CFI – Comparative Fit Index

Chart 1 presents the model with better parameters (the model with free covariance), along with factor loadings.

Satisfactory values of factor loadings were achieved. No factor loading obtained a value lower than 0.40, although two subscales – Abstract Reasoning and Reasoning through Analogy, achieved a result barely over 0.40. The decision to keep or remove those test positions has been postponed for later, after further analyses are performed.

The next step taken in the process of constructing the scale was an IRT analysis of difficulty and differentiating power of test items (Table 4).

Medians obtained during the analysis of difficulty of individual sub-tests suggest that the most difficult items of the scale are the sub-tests: Memory-Recalling, Abstract Reasoning and Mechanical Memory. The easiest tests are: Attention, Creating General Concepts, Reasoning through Analogy and Visual Constructive Functions. Sub-tests of medium difficulty are: Planning and Switching, Linguistic Learning, Inhibitory Control and Verbal Fluency. Tests of medium difficulty have the highest differentiating power.

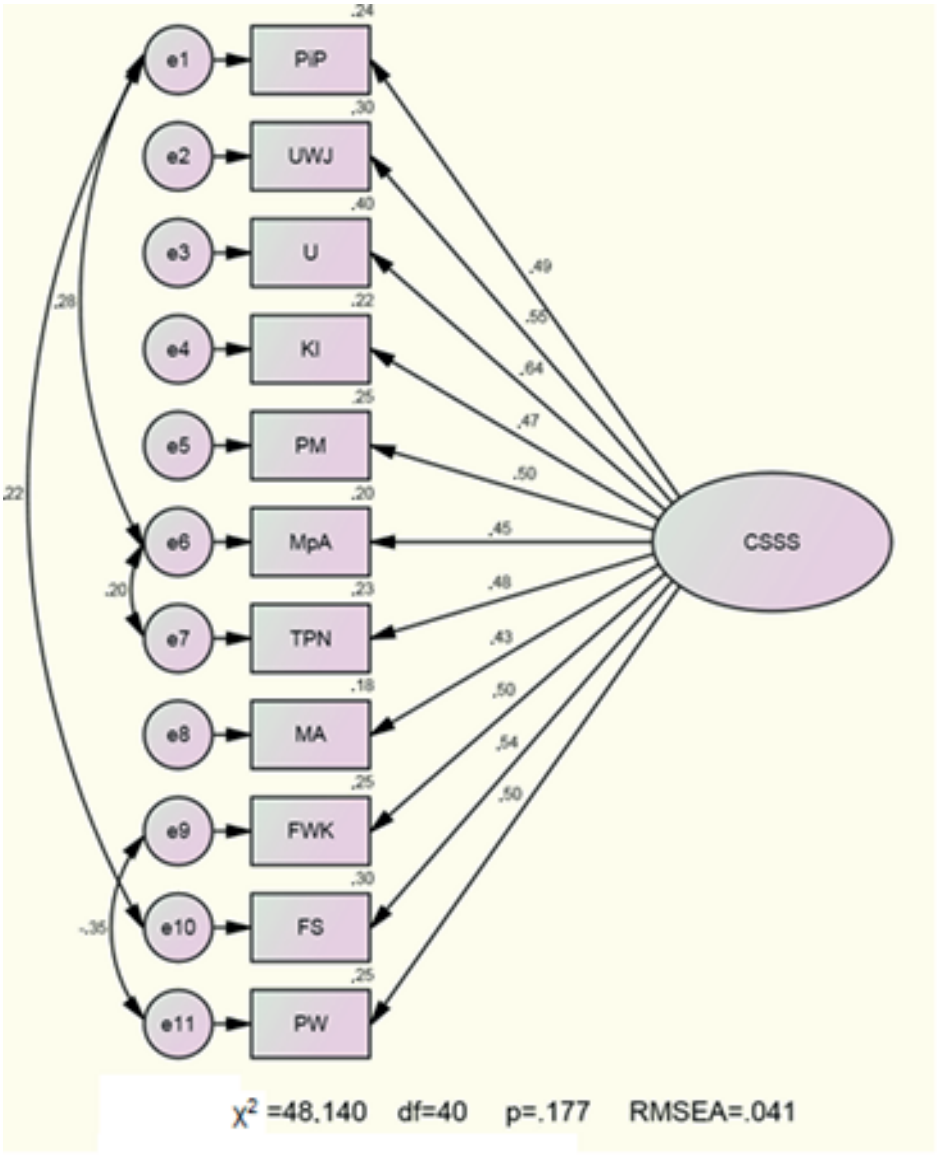

Figure 1. **Model with factor loadings**

PiP – Planning and Switching; UWJ – Linguistic Learning; U – Attention; KI – Inhibitory Control; PM – Mechanical Memory; MpA – Reasoning through Analogy; TPN – Creating General Concepts; MA – Abstract Reasoning; FWK – Visual Constructive Functions; FS – Verbal Fluency; PW – Memory-Recalling

Table 4. **IRT analysis of sub-tests in the CSSS (N = 160)**

Sub-test	Difficulty	SD	Differentiating power
Planning and Switching	1.06	0.94	0.59
Linguistic Learning	1.15	0.73	0.56
Attention	1.63	0.74	0.47
Inhibitory Control	1.34	0.91	0.47
Mechanical Memory	0.86	0.82	0.45
Reasoning through Analogy	1.49	0.74	0.52
Creating General Concepts	1.58	0.67	0.48
Abstract Reasoning	0.65	0.76	0.50
Visual Constructive Functions	1.46	0.73	0.46
Verbal Fluency	0.82	0.79	0.57
Memory-Recalling	0.55	0.73	0.44

SD–standard deviation

All values of the studied coefficients turned out to be close to 0.83, which indicates satisfactory internal consistency of a single factor structure of the method (Table 5). Performed analyses of internal consistency coefficients showed a reduction of the reliability coefficient after the removal of any of the individual test items.

Table 5. **Reliability understood as internal consistency and standard error of the mean SEM (N = 160)**

Method	Value of the coefficient	SEM
Guttman's L2	0.834	2.136
Cronbach's Alpha	0.830	2.158
Feldt-Gilmer Coefficient	0.833	2.144
Feldt-Brennan Coefficient	0.834	2.145
Raju's Beta	0.830	2.158

The conducted analysis of Mantel-Haenszel differential item functioning (DIF) showed that all of the sub-tests obtained an AA classification level (poor differentiation between people with schizophrenia and healthy people). Bearing in mind the described tendency, an attempt was made to examine the cumulative differentiating power of the overall score, which, as the only indicator of the screening method, should have the power to differentiate the clinical group from the control group. For that purpose, an ROC curve analysis was performed.

The ROC curve analysis was conducted in three stages. At first, the ROC curve was created for an average result of tests considered the most difficult (Memory-Recalling, Abstract Reasoning and Mechanical Memory sub-tests). The same operation was then performed for the easiest tests (Attention, Creating General Concepts, Reasoning

through Analogy and Visual Constructive Functions). The most difficult and the easiest tests differentiated patients (N = 124) from the control group (N = 36) with similar precision (AUC = 0.78 and AUC = 0.71, respectively). The sum of results of all 11 test positions has better differentiating properties (AUC = 0.83, SEM = 0.04, p = 0.00, confidence interval 0.75–0.91). The difference between values of the χ^2 calculated for both models was 28.26. The model with free covariance turned out to be better fit to the data (χ^2 = 48.14; p = 1.77) in comparison with the initial model (χ^2 = 76.40; p = 0.00).

The area under the ROC curve was then calculated, while eliminating sub-tests one by one (starting from the lowest factor loading, then according to the difficulty criterion). In every case, the values of AUC were decreasing. This was the final argument in favor of keeping the version of the scale with eleven tests. The factor measured by the scale explains 37% of the variance of results.

The mean overall score of the CSSS in the group of people with schizophrenia was 11.40 (SD = 4.90), and in the control group – 17.08 (SD = 3.55). The distribution of results in both groups was different than normal (Shapiro-Wilk test < 0.05). The intergroup difference proved to be statistically significant (Mann-Whitney U test = 745.00; p = 0.00).

Discussion and conclusions

The aim of the Cognitive Screening Scale for Schizophrenia is to identify people with cognitive impairments in the course of schizophrenia, who experience a decline in overall functioning due to cognitive difficulties. The research presented in this paper concerns more basic matters: structure of the method and certain aspects of reliability.

The results of all sub-tests appear to have a significant, considerably strong relation with the overall result of the scale; a large majority of the sub-tests have significant correlations with one another. The confirmatory factor analysis confirmed the presumed single factor structure of the method. A score lower than 16 points out of a maximum of 22 points shows 86% sensitivity and 70% specificity in identifying the schizophrenia diagnosis, as compared to the group of healthy people. The differentiating power of individual items shows moderate variability, and according to the criteria of differential item functioning evaluation, all of them individually do not have the power to accurately differentiate people with schizophrenia from healthy people. One of the possible explanations of this could be an insufficiently small number of examined persons. Another explanation could be the fact that cumulative differentiating power is demonstrated in the overall score, which in the end is going to be the only indicator from the test subject to interpretation. Insufficient specificity does not seem to be a substantial flaw considering the purpose, for which the method was created. A false positive result should be verified in further, more accurate psychological trials, to which the patient should be directed after obtaining a low score in the CSSS.

For the purpose of the creation of this method to be fulfilled – identifying patients, in which cognitive impairments are related to a deterioration in functioning and the need of further diagnostics, this method should still be thoroughly tested with regard to its theoretical and external accuracy. Further stages of research are

going to consist of verifying the accuracy of the tool by correlating the results of the CSSS with the results of a more complex BACS scale; verification of the efficiency of both methods in differentiating people meeting the criteria of severe mental illness (SMI) from the ones not meeting the criteria, and verification of the relation between the results of the scale with overall functioning scales and information about the course of the illness.

The described method is not free from limitations. A significant limitation is the fact that most people with schizophrenia are hospitalized patients. Attempts were made to include only people in a stabilized mental state in the clinical group, but that does not change the fact that the trial might not be sufficiently representative for the population of people suffering from schizophrenia.

In conclusion, research on the structure and reliability of the CSSS suggests that it is essential to perform its further validation in the aspect of its accuracy in identifying cognitive impairments in people with schizophrenia.

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