Neuropsychological Profile in Early-Onset Schizophrenia-Spectrum Disorders: Measured With the MATRICS Battery

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Objective: Neurocognitive impairments have been documented in adolescents with early-onset schizophrenia (EOS). There is still inconsistency regarding an average profile, which could be due to the fact that each study uses different tests. The purpose of this study was to examine whether the "Measurement and Treatment Research to Improve Cognition in Schizophrenia" (MATRICS) battery is useful in detecting differences between the patient group and the healthy controls, and to describe the neuropsychological pattern in the EOS group. *Method*: Neuropsychological functioning was examined in 31 adolescents with schizophrenia spectrum disorders and 67 healthy controls, using the MATRICS battery. *Results*: There were significant differences between the patients and the controls on every domain except for social cognition. Patients showed a generalized neurocognitive deficit of 0.8–1.8 SDs compared with controls, with verbal learning, working memory, and visual learning being the most affected areas. *Conclusions*: The MATRICS battery is sensitive in detecting differences between patients and controls in the adolescent population. However, we question the use of Mayer-Salovey-Caruso Emotional Intelligence Test in this age group. Results document a significant generalized deficit in adolescents with EOS.

Key words: neurocognition/psychosis/adolesecents

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Introduction

Cognitive impairments are regularly found in patients with adult-onset schizophrenia (AOS) and are a core feature of the disorder.[1] The deficits span from early sensory information processing to attention, verbal/ visual learning and memory, and executive functions.[2,3] New findings suggest that neuropsychological (NP) status is a better predictor of functional outcome than symptom status in AOS and a possible target for interventions.[4] The lack of a consensus core battery to evaluate cognitive functioning has hampered both possibilities to compare findings across the now numerous studies on cognition in AOS and the development of treatments. This is one of the main reasons behind the National Institute of Mental Health "Measurement and Treatment Research to Improve Cognition in Schizophrenia" (MATRICS) initiative, which aimed at developing a consensus cognitive battery for use in clinical trials in schizophrenia.[5] The MATRICS group has identified 7 cognitive domains that are dysfunctional in schizophrenia and thought to be a core feature of the disorder. From these 7 domains, 6 were included on the basis of multiple factor-analytic studies of cognitive performance in schizophrenia. The seventh domain, social cognition, was included because of its promising nature as a mediator of neurocognitive effects on functional outcome.[6] The MATRICS test battery covers these domains and seeks to be a gold standard for measuring cognition in schizophrenia. The tests within the battery have been chosen with a thorough emphasis on reliability and validity.[5–7]

Cognitive deficits are also prevalent in patients with early-onset schizophrenia (EOS),[8] and they seem to have more severe premorbid neurodevelopmental abnormalities and worse long-term outcome than AOS patients.[9] To date, studies on cognitive functioning in EOS are rare. Overall, they support the presence of a global profile of cognitive deficits similar to findings in AOS, but the results on specific deficits are partly inconsistent[8,10–23] (see table 1). While all studies assessing verbal memory, speed of processing, and working memory showed a significant deficit, the results varied considerably for all other domains.

Earlier works on identifying a specific NP profile in AOS provide support for the conclusion that these

Table 1. Deficits Found in Specific Neurocognitive Domains in Early-Onset Schizophrenia Patients Compared With Healthy Adolescent Controls

	Verbal Memory	Visual Memory	Working Memory	Attention	Speed of Processing	Planning and Problem Solving	Mental Flexibility/ Executive Functions
Kenny et al[10]	Yes (verbal list learning)	Not assessed	Yes (Trigram Recall With Interference Test)	Yes (PASAT/digit span distraction)	Yes (Category Instance Retrieval Test)	Not assessed	Yes (WCST)
Oie et al[11]	Not assessed	Not assessed	Not assessed	No (covert visual attention task)	Not assessed	Not assessed	Not assessed
Rund et al[12]	Not assessed	Not assessed	Not assessed	No (DS-CPT)	Not assessed	Not assessed	Not assessed
Oie and Rund[22]	Yes (CVLT)	Yes (Kimura Recurring Figures Test)	Not assessed	No (DS-CPT/ dichotic listening)	Yes (Trail Making A and B/WISC-R digit symbol)	Not assessed	Yes (WCST/WISC-R similarities)
Kravariti et al[13]	Yes (WMS-R)	Yes (WMS-R)	Yes (computerised executive golf task)	Yes (WMS-R)	Not assessed	No (3-D CTL Test/3-D CTL control)	Yes (computerised Trail Making Task)
Brickman et al[14]	Yes (Serial Verbal Learning Test)	Not assessed	Not assessed	Yes (Trail Making A/Digit Span Test)	Not assessed	Not assessed	Yes (WSCT/Stroop/ Trail Making B)
McClellan et al[15]	Yes (CVLT-C)	Yes (WRAML)	Not assessed	Not assessed	Yes (VMI)	Yes (Controlled Oral Word Association)	Yes (WCST)
Ueland et al[16]	Not assessed	Yes (Kimura Recurring Figures Test)	Yes (Digit Span Backward Task, WISC-R)	No (DS-CPT)	Yes (digit symbol, WISC-R)	Not assessed	Yes (WCST)
Rhinewine et al[23]	Yes (CVLT)	Not assessed	Not assessed	Yes (Trail Making A/ CPT-IP)	Not assessed	Not assessed	Yes (WCST/ Trail Making B)
Fagerlund et al[8]	Yes (CANTAB)	Not assessed	Not assessed	Yes (CANTAB)	Yes (Trail Making B)	Not assessed	Yes (WCST)
Kester et al[17]	Not assessed	Not assessed	Not assessed	Not assessed	Not assessed	Yes (Iowa Gambling Task)	Not assessed
Roofeh et al[18]	Yes (CVLT)	Not assessed	Not assessed	Not assessed	Not assessed	Not assessed	Not assessed
Kravariti et al[19]	Yes (WMS-R)	No(WMS-R)	Yes (Computerized analogue of the CANTAB)	No (Computerized Trail Making Task)	Not assessed	Yes (3-D CTL Test/ 3-D CTL Control)	No (Computerised Trail Making Task)
Vance et al[20]	Not assessed	Yes (DMTS, CANTAB)	Not assessed	Not assessed	Not assessed	Not assessed	Not assessed
Groom et al[21]	Yes (RAVLT)	Not assessed	Not assessed	Yes (CPT-IP)	Not assessed	Not assessed	Yes (HSCT/FAS)

Note: CVLT, California Verbal Learning Test; WMS-R, Wechsler Memory Scale–Revised; CANTAB, Cambridge Neuropsychological Test Automated Battery; RAVLT, Rey Auditory Verbal Learning Test; WRAML, Wide Range Assessment of Memory and Learning; DMTS, The Delayed Matching to Sample Trials; PASAT, Paced Auditory Serial Addition Test; DS-CPT, The Degraded Stimulus Continuous Performance Task; CPT-IP, Continuous Performance Test, Identical Pairs; WISC-R, Wechsler Intelligence Scale for Children–Revised; CTL, Computerised Tower of London Test; WCST, Wisconsin Card Sorting Test; HSCT, Hayling Sentence Completion Test; FAS, FAS Test of Orthographic Verbal Fluency; VMI, Test of Visual-Motor Integration.

Table 2. Characteristics of Patients With Schizophrenia Compared With Normal Control Subjects

	Patients (*n* = 31)	Healthy Controls (*n* = 67)	Test Statistics		
Sex (female)	15 (48%)	34 (51%)	χ^2 = .00	*df* = 1	ns
Hand dominance (R)	27 (87%)	60 (90%)	χ^2 = .00	*df* = 1	ns
Age (y)	15.8 (2.0)	16.0 (1.9)	*t* = −0.49	*df* = 96	ns
Mother's education (y)	13.3 (2.9)	14.3 (2.3)	*t* = −1.96	*df* = 95	ns
FSIQ (WASI)[a]	97.1 (14.6)	107.9 (14.1)	*t* = −3.49	*df* = 96	<.001
GAF[b]					
Symptom	47.5 (13.4)				
Function	46.7 (15.5)				
PANSS[c]					
Positive	14.9 (4.1)				
Negative	12.1 (5.2)				
Total	57.5 (12.5)				
Duration of untreated psychosis (wk)	35.0 (51.5)				

[a]Full-Scale IQ from the Wechsler Abbreviated Scale of Intelligence.
[b]Global Assessment of Functioning Scale—Split Version.
[c]Positive and Negative Syndrome Scale, *n* = 28.

patients do show a distinct pattern of cognitive deficits, which are different from other diagnostic categories, such as depression.[2,24–27] Few studies have to our knowledge investigated the cognitive profile of the EOS population. Two of them[16,22] found that the patient group performed worse on every cognitive domain except for selective and sustained attention. Other findings[8,13,23] suggests a general cognitive deficit across all domains investigated. Due to lack of studies on EOS, and the diversity in results, it is hard to establish a typical, distinct profile. A major problem in establishing a profile of cognitive deficits in EOS is the use of different NP test batteries across different studies making direct comparisons difficult.[8]

Because EOS is a rare disorder, the use of a standard test battery such as the MATRICS would be particularly useful because this would allow for comparing or merging small samples. The studies going into the scientific foundation of the MATRICS battery are however based on AOS patients, and the battery has to the best of our knowledge not yet been used in an adolescent sample. The aims of the current study are thus to examine whether the MATRICS battery will differentiate between patients with EOS and an adolescent control group. We will investigate if any areas are more affected than others and evaluate the practical use of the battery in this age group.

Methods

Subjects

The inclusion criteria were patients with treatment referral to one of the psychiatric departments in the southern part of Norway for a disorder meeting the *Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition (DSM-IV)*, criteria for a broad schizophrenia-spectrum disorder (schizophrenia, schizophreniform disorder, schizoaffective disorder, brief psychotic disorder, and psychosis not otherwise specified [NOS]) and age between 12 and 18 years. Patients with a history of central nervous system pathology or trauma (loss of consciousness for greater than 30 min and/or any neurological sequelae) or with an estimated IQ less than 70 were excluded. A total of 31 psychotic adolescents (table 2) were included; 16 (52%) with a schizophrenic disorder, 10 (32%) with psychotic disorder NOS, 3 (10%) with schizoaffective disorder, 1 (3%) with schizophreniform disorder, and 1 (3%) with brief psychotic disorder. Twenty-six (84%) were born and educated in Norway. Three patients did not have Norwegian as their mother tongue but could be tested and interviewed in Norwegian. One of these had for practical and cultural reasons a very short formal education. Twenty-three (75%) had started antipsychotic treatment before testing (median 24 wk, range 3–80). Of these, 3 patients (13%) used a combination of first- and second-generation antipsychotics and 20 (87%) used second-generation antipsychotics alone. None used first-generation antipsychotics separately.

Healthy controls were recruited through personal letters to a randomly selected group from the Norwegian population register and from schools in the patient catchment area. They were matched to patients on gender, age, and length of mother's education. They were screened for mental problems using the Mini-International

Neuropsychiatric Interview screening module[28] and were excluded in the case of any positive answer to the screening questions. Due to the fact of overrepresentation of adolescents with mothers of high education in the control group, we systematically excluded the last 15 of the eligible, normal controls where the mother had more than 17 years of education. The final number of controls was then 67.

After complete description of the study to the subjects, written informed consent was obtained from patients and controls, as well as their parents, if the adolescents were below 16 years of age. The study is approved by the Regional Committee for Medical Research Ethics and the Norwegian Data Inspectorate.

Clinical Instruments

The patients were interviewed by clinical psychologists working as research fellows. They also had access to medical records and information from family members and treating clinicians. Diagnoses were established using the Structural Clinical Instrument of Diagnosis for *DSM-IV* Axis I disorders (SCID-I), modules A–D. All interviewers were trained in use of the SCID, participated in regular diagnostic consensus meetings led by a well-experienced clinical researcher in the field of diagnostics in psychotic disorders, and finished a training course in SCID assessment based on the training program at UCLA. Mean overall kappa for SCID diagnoses as assessed in the UCLA training course was 0.77.

Psychopathology was assessed using the Positive and Negative Syndrome Scale (PANSS)[29] and the Global Assessment of Functioning (GAF) Scale (split *DSM-IV* version).[30]

Neurocognition

Neurocognitive assessment was carried out by clinical psychologists with training in standardized NP testing. Assessments were done using the MATRICS battery with the addition of IQ tests. The battery covers the following 7 domains:

Speed of Processing. Category fluency[31]—verbal fluency for animals was tested for 60 seconds. Scores were obtained for the number of words produced. Symbol coding (Brief Assessment of Cognition in Schizophrenia)[32]—writing numbers corresponding to nonsense symbols as quickly as possible during a period of 90 seconds. Scores were obtained for the number of symbols coded right. Trail making A[33]—involves connecting consecutive numbers arranged in random order on a sheet of paper. The scores used were the total time for the completion.

Attention/Vigilance. Continuous Performance Test, Identical Pairs (CPT-IP)[34]—a test of monitoring numbers on a data screen and press the button whenever 2 digits in a row are presented identically. Mean d' value across 2-, 3-, and 4-digit conditions was used as the score. d' is an index of signal/noise discrimination computed by the CPT-IP program.

Working Memory. University of Maryland—Letter-Number Span[35]: requires mental reordering of orally presented list with letters and numbers and repeating them back. Total number correct was used as score. Spatial Span (Wechsler Memory Scale III)[36]—involves remembering the locations of a series of blocks pointed to by the administrator, forwards and backwards, respectively. Sum of raw scores on both conditions are used as measurement.

Verbal Learning. Hopkins Verbal Learning Test-Revised[37]—a list of 12 words were presented 3 times. The sum of words repeated after these learning trials was used as a measure of verbal learning.

Visual Learning. Brief Visuospatial Memory Test-Revised[38]—6 geometrical figures were displayed for 10 seconds, 3 times altogether. The sum of number of points awarded after recalled drawings on 3 learning trials is used as the score of visual learning.

Reasoning and Problem Solving. Mazes (Neuropsychological Assessment Battery [NAB])[39]—7 mazes, with gradually increasing difficulty, were distributed on single sheets of paper, to be resolved with a pencil. Points are awarded based on the time used to solve the maze. The score used was the sum of points awarded after 7 consecutive trials.

Social Cognition. Mayer-Salovey-Caruso Emotional Intelligence Test (MSCEIT)[40]—the part Managing Emotions (D & H) were distributed. The score of this branch of the test was calculated using general consensus scoring. These scores were computed with the MATRICS scoring program.

Intelligence. The 4 Wechsler Abbreviated Scale of Intelligence (WASI) subscales (vocabulary, similarities, block design, and matrix reasoning) were used to calculate full-scale IQ, using Norwegian norms.[41]

Statistical Analyses

Data analysis was done using the statistical package SPSS for Windows (version 16.0). All tests were 2 tailed. If not indicated otherwise, the applied methods were Student t test for group comparisons of continuous data, chi-square for group comparisons of categorical data, and Pearson r for correlations. The level of significance was set at $P = .05$. For figure 1, the raw test scores were transformed to standard equivalents (z scores) on
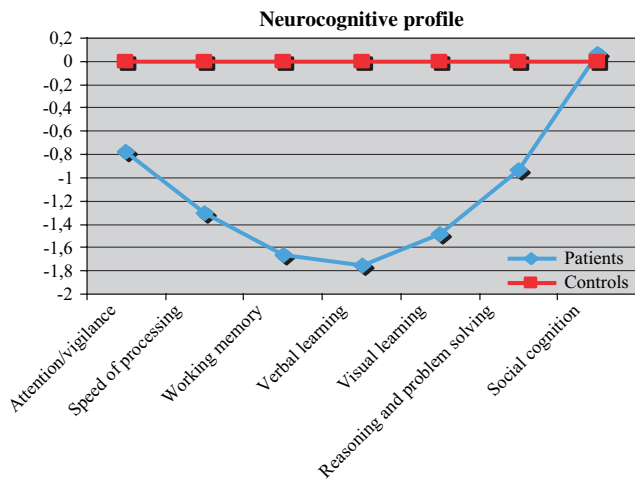
Neurocognitive profile

Fig. 1. Scores on 7 Neurocognitive Composite Scores for Patients With Schizophrenia Compared With Normal Control Subjects.

Table 3. Neuropsychological Test Results for Patients With Schizophrenia Compared With Normal Control Subjects

	Patients		Controls			
	Mean	SD	Mean	SD	*t*	*P*
WASI						
Vocabulary	45.7	10.9	52.3	9.9	−2.97	.004
Similarities	31.1	6.2	36.0	7.0	−3.34	<.001
Block design	43.7	16.3	54.4	12.0	−3.68	<.001
Matrix R	25.3	4.8	27.0	4.1	−1.82	.071
Category fluency	18.4	5.6	23.2	4.8	−4.09	<.001
Symbol coding	46.3	10.8	61.9	11.8	−6.24	<.001
Trail Making A	35.4	14.1	27.7	10.0	2.93	.004
CPT-IP	1.7	0.7	2.2	0.7	−3.50	<.001
Letter-number span	11.8	2.8	16.1	3.0	−6.73	<.001
Spatial span total	15.0	2.6	19.1	2.9	−6.79	<.001
HVLT-R total	22.8	5.4	28.9	3.5	−6.75	<.001
BVMT-R total	22.6	8.7	28.6	4.1	−4.71	<.001
Mazes (NAB) total	17.8	5.7	21.7	4.2	−3.83	<.001
MSCEIT	87.0	11.9	87.0	8.8	.02	.982

Note: WASI, Wechsler Abbreviated Scale of Intelligence; CPT-IP, Continuous Performance Test, Identical Pairs; HVLT-R, Hopkins Verbal Learning Test-Revised; BVMT-R, Brief Visuospatial Memory Test-Revised; NAB, Neuropsychological Assessment Battery; MSCEIT, Mayer-Salovey-Caruso Emotional Intelligence Test.

the basis of the means and SDs of the normal comparison group. By definition, the normal comparison group mean is represented by the zero line, with SD = 1 for all functions. Where high scores indicated impairment, scores were transformed (direction reversed) so that high scores always indicated better cognitive functioning. We then renormed the sum scores for the 2 domains working memory and speed of processing. To assess the percentage of patients considered neuropsychologically impaired on each neurocognitive domain, a cutoff score of 1.5 SD below the mean of the normal control group was used as a threshold for impairment and 1.0 SD below the mean of the control group as a threshold for slight impairment. Using the impairment cutoff (1.5 SD), we classified the subjects further into the categories "moderately impaired" (performing deviantly on 2–4 domains) and "severely impaired" (performing deviantly in 5–7 domains).[2]

To investigate the possible differences between the patients with psychosis NOS and the group with narrow schizophrenia-spectrum disorders, we performed a 1-way analysis of variance (ANOVA) followed up by Tukey post hoc tests for group comparison.

To investigate the possible differences between the patients that were nonmedicated by the time of testing (*n* = 8) and the ones who were on medication, we performed a 1-way ANOVA followed up by Tukey post hoc tests for group comparison.

To further investigate the issue of a generalized vs. specific impairment, we performed a multivariate analysis of covariance (MANCOVA) to adjust for IQ on the cognitive functions of the MATRICS battery.

Results

Demographic characteristics of patients with schizophrenia-spectrum disorders and healthy control subjects, as well as clinical characteristics of the patient group, are listed in table 2.

Table 3 summarizes the raw scores of the 2 groups on individual NP tests. Patients with schizophrenia were significantly more impaired than healthy control subjects on every measure, except social cognition. The differences are largest on the domains verbal learning, visual learning, and working memory. As a group, the patients performed between 0.8 and 1.8 SD below the control group.

The *z* score profile on the MATRICS battery is presented in figure 1. As figure 1 shows, there was a clear difference in performance pattern across groups.

The percentages of patients and controls that performed 1.0 SD and 1.5 SD below the mean, respectively, are presented in table 4. In total, 52% of the patients showed impairments within 2 or more domains using a cutoff of 1.5 SD below the mean of the normal subjects, ie, 32% were classified as moderately impaired and 20% as severely impaired. The corresponding figures for the healthy controls were 12 % and 0 %, respectively.

Because some test performances can be influenced by differences in general intelligence, we repeated the analysis correcting for differences in IQ, using a MANCOVA analysis to ascertain that there are differences over and above those directly related to IQ differences. This analysis reproduces the exact same patterns of differences for

Table 4. Percentage of Patients and Healthy Controls With Neurocognitive Impairment Using Cutoffs of 1 SD and 1.5 SD Below the Mean of the Controls

	1 SD		1.5 SD	
	Patients	Controls	Patients	Controls
Attention/vigilance	41	13	29	8
Speed of processing	48	10	26	3
Working memory	77	12	39	5
Verbal learning	61	9	58	6
Visual learning	48	13	42	6
Reasoning and problem solving	48	16	29	10
Social cognition	16	12	16	6

all neurocognitive domains (F's ranging from 1.1 to 26.6, all dfs = 1, P's ranging from .000 to .044), with the possible exception of the speed of processing domain (Category Fluency Test [F = 3.3, df = 1, P = .07] and Trail Making Test [F = 0.6, df = 1, P = .43]).

There were no significant differences between the psychosis NOS group and the narrow schizophrenia-spectrum group on any test (F's ranging from 1.4 to 26.0, dfs ranging from 76 to 97, P's ranging from .102 to .924) (1-way ANOVA with the 2 diagnostic groups and normal controls).

Also, there were no significant differences between the group that was not medicated at the time of testing and the medicated group on any test (F's ranging from 0.7 to 20.9, dfs ranging from 71 to 89, P's ranging from .31 to 1.0) (1-way ANOVA with the medicated and unmedicated patients and normal controls). The association between neurocognitive domain scores and medication dosage at time of testing was additionally explored. There were no significant correlations between defined daily dose (DDD) and for any of the domain scores (Pearson r ranging from −.15 to .24, P's ranging from .25 to .91), the only partial exception was Trail Making A Test (r = 0.35, P = .11).

Discussion

Our data shows that the MATRICS battery clearly is able to differentiate between the patients and the healthy controls in every cognitive domain except social cognition and must therefore be regarded as a sensitive neurocognitive battery.

Sensitivity is an important issue in this field of research. Palmer et al[42] suggested the concept of a "continuum of neurocognitive functioning" to better understand NP test results. This model is validated here by our finding of 20% of the patients being severely impaired, 32% moderately impaired, and 48% unimpaired, suggesting that psychosis in adolescence may exist in the

context of relatively preserved cognition. Because there are no existing instruments that can be used to measure premorbid cognition for patients with EOS, we cannot infer anything about a possible decline from their presumed premorbid level. There were no differences in the level of impairment between patients with a narrow schizophrenia diagnosis and patients with psychotic disorder NOS (mainly patients with monosymptomatic hallucinosis), indicating that they were not overrepresented in the unimpaired group.

Also, our data show a general and explicit cognitive deficit in the patient group relative to the controls, with the apparent exception of social cognition. However, other studies[43] have found several areas of cognitive functioning relatively spared, indicating that the previously used NP tests were not sensitive enough. Our findings of impairments in all 4 higher order neurocognitive domains (executive function, working memory, visual learning, and verbal learning) support other studies implicating both frontal and temporal hippocampal involvement in the pathophysiology in schizophrenia.[2]

One partially unexpected finding is that the area of reasoning and problem solving appears as the second least impaired domain. Studies of adults with schizophrenia regularly show that reasoning and problem solving is the most affected area, besides learning and memory.[44] Our results could be explained by random sample characteristics or it may be that concept formation deficits are milder than others in this phase. This notion is in part supported by the fact that the Matrix-R part of the WASI was the least impaired one. The finding could also be related to test characteristics. The Mazes Test was chosen because it—compared with tests like the Wisconsin Card Sorting Test—has a low potential for learning effects and thus can be used in repeated testing. However, it does not take into account mental flexibility and verbal abilities and might be an easier test for persons with compromised cognitive functioning.

There were no differences at all between the 2 groups in social cognition as measured by the MSCEIT. This might have 2 explanations, either that both groups performed well or that both groups performed poorly. Supporting the first interpretation are findings that patients with schizophrenia do not differ from healthy controls when it comes to having knowledge about how to act in social situations. The problems appear when they have to actually perform it.[45] This is an argument for using role-play tests to assess deficits in social cognition in this group. Supporting the second interpretation is the finding that the controls in our sample perform far below expectation compared with the American norms for the age groups 20–22 years, the lowest age group with existing norms. Being made for the adult population, the situations described in the MSCEIT vignettes are far from every day life, also for healthy adolescents. The clinical impression when administrating the test was that both

the instructions and the vignettes were hard to understand and answers were given in a fairly random order. The alternatives are on the other hand rare. The first 6 MATRICS cognitive domains were based on multiple factor-analytic studies of cognitive performance in schizophrenia.[5] Because there were very few test data available for the domain of social cognition, the domain was included because it was viewed as a promising mediator of neurocognitive effects on functional outcomes.[46] In lieu of better alternatives or age-dependent norms, it appears very important not to evaluate MSCEIT results in adolescent patients without an age- and gender-matched control group.

One possible limitation of the study is that the patient group's IQ scores were significantly lower than that of the control group. This is a complex issue because IQ is known to be impaired premorbidly[47] and also covary with current NP performance.[48] It is thus problematic to use IQ as a matching variable because it can be argued to be an inherent part of the disorder. We did, however, find that the cognitive functions in the MATRICS are impaired over and above IQ. Another limitation is that we did not have adequate control over medication effects. However, it would be unethical to withdraw medical treatment from the patients, and if we had a selection of medically naive patients, it would probably be skewed in the sense that patients with no medical treatment often have less symptoms and better functioning. Also, we found no relationship between DDD and cognitive performance, indicating that antipsychotic medication is unlikely to explain the poor performance of the patient group. An additional limitation is that there are currently no existing norms for our age group for the MATRICS battery. Our healthy control sample is matched for age, gender, and mothers' education but is relatively small and not selected as a normative sample. It is assumed that people volunteering to control samples tend to perform better than the average and also belong to a higher socioeconomical level than patient groups.

A strength of the study is that the MATRICS battery is used on an EOS population for the first time.

In summary, the results in this study suggest that the MATRICS battery is sensitive in detecting differences between EOS patients and controls. The different test composing the battery also functions well, with the possible exception of the MSCEIT that might be insensitive to impairments in social cognition in this group.

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