

NEUROLOGICAL SOFT SIGNS AND SOCIAL COGNITION IN PATIENTS WITH SCHIZOPHRENIA: THE MISSING LINK

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Abstract

Schizophrenia is a debilitating mental disorder characterised by a pronounced decline in mental, physical, and social functioning. Our study aims to investigate the relationship between the socio-cognitive and the subtle motor and sensory symptoms of schizophrenia, which are, respectively, represented by facial emotion recognition deficits (FERD) and neurological soft signs (NSS). Thus, we assessed 60 patients diagnosed with schizophrenia. FERD was measured with the “Averaged Karolinska Directed Emotional Faces” set, and NSS was assessed with the Neurological Evaluation Scale. A strong and significant negative correlation was found between the NSS total score and the FERD total score ($r = -0.7$, $p < 0.001$). There was also a significant negative correlation between several of the subscores of both instruments. The results show that impaired social cognition is significantly associated with soft neurological disturbances in patients suffering from schizophrenia. Taken together, this reinforces the notion that schizophrenia is characterised by dysfunction and disconnection of a complex cerebral network, which can probably be influenced by psychosocial and physical nonpharmacological therapeutic interventions.

Key words: schizophrenia, social cognition, neurological soft signs, NES, AKDEF

Introduction. Schizophrenia is a neuropsychiatric disorder that affects various aspects of one’s life. The etiology and clinical presentation of this disorder

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remain uncertain. However, the current biopsychosocial model offers an opportunity to deeply analyze and study the disorder in order to identify clinically significant correlations. Social cognition is a critical domain of neurocognitive function represented in the DSM-5 [1]. The term refers to the ability to perceive, understand, and implement linguistic, auditory, visual, and physical cues that convey emotional and interpersonal information [2]. Facial emotion recognition is a crucial component of social cognition, and studies have extensively investigated deficits in this ability as a trait of schizophrenia [3]. These deficits in recognizing the universally acknowledged emotions, which are happiness, sadness, anger, fear, disgust, surprise, and neutral, have been associated with impairments in social and emotional functioning, worsened preexisting mental disorders, and negative impacts on treatment outcomes [4]. Both recent onset schizophrenia and chronic schizophrenia display similar patterns of facial processing deficits [5]. Over the course of the illness, the deficit remains stable. Taking all of this into consideration, the idea of a vulnerability indicator rather than an indicator of chronicity is supported. A significant deficit in the recognition of negative emotions was observed in both first-episode and multi-episode patients, suggesting stability across phases of the disease. Facial emotion recognition deficits (FERD) are also found to be associated with negative symptoms of schizophrenia [6].

Another characteristic of schizophrenia is the presence of neurological soft signs (NSS) [7], which represent more subtle disruptions in brain function due to aberrations in neural maturation and connectivity. NSS include abnormalities in motor coordination, sensory integration, and sequencing of complex motor acts, and they are not influenced by antipsychotic treatment. NSS have a strong correlation with negative symptoms, making them an essential domain to explore [8]. In patients with schizophrenia, NSS are significantly more prevalent than in their first degree relatives. Moreover, NSS are more prevalent in first-degree relatives of schizophrenia patients than in healthy controls [9]. In high-risk subjects, NSS occur long before the onset of the disease [10].

The objective of our study is to investigate the relationship between the cognitive and the subtle motor and sensory symptoms of schizophrenia, represented by FERD and NSS, respectively. Exploring this correlation can provide a better understanding of the disorder and lead to the development of new diagnostic and predictive tools. Furthermore, these findings may offer an opportunity to reconsider the impact of biological factors on the social complications of the disorder and vice versa. Investigating these interrelated symptoms can help develop a more comprehensive understanding of schizophrenia and improve treatment strategies and outcome.

Material and methods. Study sample. Between 2022 and 2023, a total of 60 patients diagnosed with schizophrenia according to the ICD-10 criteria were enrolled in this study from four psychiatric hospitals in Bulgaria (Alexandrovskia University Hospital, Mental Health Centre – Sofia, St. Ivan Rilski State

Psychiatric Hospital, Mental Health Centre Prof. Dr. Ivan Temkov – Burgas). The study comprised of 30 male and 30 female patients, all of whom provided written informed consent. The inclusion criteria were individuals aged between 18 to 65 years, while the exclusion criteria were patients with a lifetime history of neurological or systemic disease, head injury, substance dependence, mental retardation, electroconvulsive therapy within the last 12 months and acutely disturbed, suicidal or violent behaviour. We recruited patients using convenience sampling in the wards. Inpatients with diagnosis schizophrenia were identified through hospital records. Those who met inclusion criteria, but not the exclusion criteria, who signed informed consent form and completed the whole set of questionnaires and assessment tools were included in the study. The research protocol was approved by the ethical commission of the Medical University of Sofia (No 65/Ref No 3787/14.06.2021).

Clinical assessment. A structured investigator-administrated questionnaire was used to gather sociodemographic data. Neurological soft signs were assessed using the Neurological Evaluation Scale (NES) [11], which includes 26 items rated on a scale of 0 (no abnormality), 1 (mild but definite impairment) to 2 (marked impairment), except for two items (snout reflex and suck reflex) that are scored on a scale of 0 (absent) or 2 (present). Fourteen items are evaluated bilaterally, and the higher score was used for analysis, as in another study [12]. Results of the short term memory test at the 5th minute were only included in the analysis. Conceptually-based subscales were derived in addition to the total NES score (range 0 to 52), more precisely: Motor coordination (MC) (tandem walk, rapid alternating movements, finger thumb opposition, finger nose test), Sensory integration (SI) (audio-visual integration, stereognosis, graphesthesia, extinction, right-left orientation), Sequencing of complex motor acts (SC) (fist-ring, fist-edge-palm, Ozeretski, rhythm tapping test B) and Other signs (adventitious overflow, Romberg test, Tremor, Memory, rhythm tapping test A, mirror movements, synkinesis, convergence, gaze impersistence, glabellar reflex, snout reflex, grasp reflex, suck reflex). A higher NES value indicates more neurological soft signs and a greater degree of neurological impairment. The examination was performed by a psychiatrist. Additional training was obtained in a neurological department. Face recognition deficits were assessed using the “Averaged Karolinska Directed Emotional Faces” (AKDEF) set [13], which consists of 42 facial stimuli depicting the seven main emotions (fear, anger, disgust, happiness, neutral, sad, and surprise) displayed from three angles (straight, half right, half left) in both genders. For each image, facial recognition was rated as true (1 point) or false (0 points), and a total score (range 0–42) and seven sub-scores (range 0–6) were calculated for each emotion. A higher AKDEF value indicates better recognition of facial emotions and better social cognition.

Statistical assessment. Assumption of normal distribution for all variables is assessed using the Shapiro–Wilk test ($p > 0.05$). Therefore the statistical

analysis in this study utilized Pearson correlation using three levels of significance ($*p < 0.05$; $**p < 0.01$; and $***p < 0.001$). The socio-demographic data were presented with means and standard deviations. Descriptive statistics, including the mean and standard deviation, were provided for the NES and AKDEF tools. In adherence to principles of transparency and scientific rigour, the dataset used in this study can be made available upon request from qualified researchers.

Results. The descriptive statistics of the socio-demographic characteristics, NES, and AKDEF diagnostic results are summarized in Table 1. The study included an equal number of male and female participants as required in the study protocol. The mean age of the patients is 39.6 years (SD = 9.6). The total mean NES score was 17 (SD = 6.8), the lowest score is observed for Motor Coordination 1.5 (SD = 1.3), while the highest is observed “Other signs” (Mean = 7.9, SD = 2.8). The overall AKDEF score was 28.1 (SD = 6.6). The facial emotion “Afraid” has the lowest mean recognition score of 2.1 (SD = 1.6), while the facial emotion “Happy” has the highest mean score of 5.9 (SD = 0.4).

T a b l e 1

Descriptive statistics of socio-demographical characteristics, NES and AKDEF diagnostic results

Variable	Mean	SD
Social-demographic profile		
Gender (male) n , (%)	30 (50%)	
Age (years)	39.6	9.6
Years of education	12.2	3.3
Years of employment	5.6	7.2
NES diagnostic tool		
Motor coordination	1.5	1.3
Sensory integration	3	2.3
Sequencing of complex motor acts	4.5	2.4
Other signs	7.9	2.8
NES total score	17	6.8
AKDEF diagnostic tool		
Neutral	4.3	1.8
Sad	3.9	1.6
Disgust	3.5	2
Afraid	2.1	1.6
Happy	5.9	0.4
Anger	3.5	1.7
Surprised	4.9	1.6
AKDEF total score	28.1	6.6

T a b l e 2
NES and AKDEF – total score and subitems correlation matrix

	Motor coordination (MC)	Sensory integration (SI)	Sequencing of complex motor acts (SC)	Other Signs	NES score
Afraid	−0.05	−0.24	−0.19	−0.25	−0.27
Anger	−0.21	−0.42*	−0.33	−0.32	−0.43*
Disgust	−0.03	−0.54***	−0.29	−0.07	−0.33
Happy	−0.33	−0.30	−0.35	−0.42*	−0.46**
Neutral	−0.34	−0.52***	−0.57***	−0.43*	−0.63***
Sad	−0.34	−0.30	−0.41*	−0.29	−0.43*
Surprized	−0.27	−0.47**	−0.45*	−0.26	−0.48**
AKDEF score	−0.34	−0.68***	−0.61***	−0.45*	−0.7***

0.1 to 0.33 and −0.33 to 0.1 – weak correlation; 0.34–0.66 and −0.34 to −0.66 moderate correlation; 0.67 to 1 and −0.67 to −1 strong correlation

Table 2 presents the correlation matrix, providing insights into the relationships between the NES and AKDEF tools and their respective subscores. The NES total score exhibits moderate negative correlations with Anger ($r = -0.43$, $p < 0.05$), Happy ($r = -0.46$, $p < 0.01$), Sad ($r = -0.43$, $p < 0.05$), Neutral ($r = -0.63$, $p < 0.001$), and Surprise ($r = -0.48$, $p < 0.01$) face recognition. These findings suggest that individuals with higher NES scores may experience difficulties in recognizing these facial emotions. On the other hand, the AKDEF total score demonstrates moderate to strong negative correlations with Sensory integration ($r = -0.68$, $p < 0.001$), Sequencing of complex motor acts ($r = -0.61$, $p < 0.001$), Other Signs ($r = -0.45$, $p < 0.05$), and the overall NES score ($r = -0.70$, $p < 0.001$). These results indicate that impaired facial emotion recognition ability (especially neutral faces) is associated with deficits in sensory integration and sequencing of complex motor acts.

Discussion. The purpose of this study is to investigate the correlation between two variables: neurological soft signs and face emotion recognition deficits. These neurological abnormalities and social cognitive impairments are undeniably prevalent in schizophrenia, and as such, they may serve as potential biomarkers and predictors of severity. One major finding from the current study is: The more severe deficits in face emotion recognition are, the more neurological soft signs appear, and vice versa. Therefore, impaired social cognition is significantly associated with subtle neurological disturbances in patients suffering from schizophrenia.

Another finding was also noteworthy. There is a strong negative correlation between the neutral faces subscale and the NES total score. In addition, the neutral faces subscale has strong negative correlation with two of the NES subscales (SI and SC). This may be related to the abnormal attribution of salience to external and internal stimuli observed in schizophrenia [14], disturbed perception of "low visible" aspects of the surrounding environment, and attribution of significance to low salient stimuli.

NSS's original theoretical concept posits that sensory integration, motor coordination, sequence of complex motor acts, and primitive reflexes are, respectively, function of the following regions: the parietal area, the frontal region and cerebellum, the prefrontal area and the frontal region [15]. The basal ganglia and the cerebellum were identified as structural substrates of NSS, and structural alterations in the somatic motor and somatosensory regions, as well as visual processing and spatial orientation areas. There is evidence that dysfunction of the frontoparietal and cerebellar networks contributes to the pathophysiology of NSS. Scores of the SI subscale are associated with the integrity of the lateral occipital cortex. There is also an association between motor coordination scores and the precentral and inferior parietal gray matter integrity. Patients with recent onset schizophrenia showed reduced gyrification in the right temporal pole, supramarginal and

fusiform cortices [16,17]. The tests measuring SC entail repetition of an observed act, which may involve the mirror motor system.

In facial recognition, the fusiform (static features of faces) and superior temporal gyrus (dynamic features of faces - expression) play a significant role. The amygdala plays an important role in recognition of fear, as well as the other negative emotions. Furthermore, the orbitofrontal cortex contributes significantly to the recognition of neutral facial expressions, and the prefrontal region is involved in identifying emotions in general. The somatosensory areas involved in emotional recognition include the right frontoparietal cortices, insula and anterior supramarginal gyrus [18]. Activation of the mentioned somatosensory system might be provoked by imitation of the observed emotion by the observer, possibly involving the mirror neural system.

It is the goal of this research to gain a deeper understanding of the functional neurological and cognitive manifestation of a disorder caused by neurodevelopmental disturbances and dysconnectivity between the above-mentioned brain regions. White matter aberrations affect NSS and emotional facial recognition. Such are the thalamic radiations which relay sensory and motor data to the precentral and postcentral cortex, superior longitudinal fasciculus linking the frontal to the parietal lobe and contributing to the visuospatial orientation, corpus callosum responsible for interhemispheric senso-motoric and auditory connectivity, the motor descending fibres, the inferior fronto-occipital fasciculus which integrates auditory and visual cortices with the prefrontal cortex and most probably other commissural and associative fibres. Based on the above-mentioned evidence, as well as correlations found between variables that have not been compared to one another before, the notion that schizophrenia is characterized by dysfunction and disconnection of a complex cerebral network may be reinforced. Therefore, seemingly independent presentations of the disorder may share a common ground. But the most important overall is the possibility of translation of the presented data to everyday clinical practice. Both physical and socio-cognitive performance can be improved with non-pharmacological strategies. Exercise therapy focused on the motor skills and sensorium can improve both positive and negative symptoms, quality of life, cognition, and hippocampal plasticity [20]. Meanwhile, social cognitive training appears to improve facial affect recognition, negative symptoms, and functional outcomes [19]. Based on this study, it is possible to conclude that psychosocial interventions could improve senso-motor performance and physical activity could enhance social cognition in schizophrenia. The instruments used in this study are cost and time efficient, and do not exert excessive strain on patients. Furthermore, they provide a deeper understanding of the disorder in terms of neurological dysfunction and socio-cognitive deficits. As a result, they may also be used as a predictor of functional outcome.

Limitations. A major limitation of the study is the small sample size, which may not be representative of the broader population in Bulgaria. Additionally,

the inclusion of only patients on antipsychotic medication could influence their performance on the tests. The absence of a healthy control group makes it difficult to determine if the findings are specific to schizophrenia or shared with other conditions. The study relies on observational data, limiting causal inference, and the correlation may be confounded by unmeasured factors. It is important to note that small sample sizes can increase the risk of false-positive results when analyzing correlation coefficients.

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