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Visual perception of facial expressions of emotions and alexithymia among people suffering from schizophrenia

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Abstract

Aim of the study: The aim of the study is to find out whether there is a relationship between the severity of alexithymia and the visual perception of facial expressions of emotions among people suffering from schizophrenia.

Subject or material and methods: 41 people suffering from schizophrenia and 41 healthy people participated in the study. In the first stage, the subjects completed the Toronto Alexithymia Scale (TAS-20) questionnaire. The second stage was based on eye-tracking measurements made during a computer experiment of recognising facial expressions.

Results: People with schizophrenia showed significantly higher intensity of alexithymia than healthy people. In the group of patients with schizophrenia, a negative correlation between alexithymia and the length of saccades on the nose was found.

Discussion: In the group of people with schizophrenia, alexithymia is associated with less intensive exploration of the nasal area. A wrinkled nose is an important area, first of all, in the manifestation of negative emotions, in recognition of which the sick people make the most mistakes.

Conclusions: Problems with recognising emotions in people suffering from schizophrenia are associated with neuronal dysfunction and abnormalities in the eye movement. These factors disrupt the early stages of sensory processing. The relationship of alexithymia with the visual perception of patients with schizophrenia suggests that top-down processes may also contribute to the development of these deficits.

facial emotion; facial expression; schizophrenia; alexithymia

INTRODUCTION

Almost all conducted studies showed disturbances in the recognition of emotions among people with schizophrenia [1-5]. However, these studies do not explain the causes and pathomechanism of the development of these deficits. Before a person recognises emotions on the face exposed to him, he / she must first register sensory data. The visual sensation on the retina of the eye is transmitted to the brain. Nerve signals transmit information to the thalamic nucleus (lateral geniculate body) so that the signal can then travel to the visual cortex (occipital part). Then, the information provided is analysed on the higher levels of the nervous system, includ-

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ing the analysis of the cerebral cortex [6]. This is known as bottom-up processing [7, 8]. Deficits in the perception of facial expressions of emotions may have their source in the early stages of sensory data recording, which leads to errors at further stages of their processing, such as identification and recognition of perceived objects [8]. Research suggests that people suffering from schizophrenia are characterised by dysfunctions of the neural structures that mediate the process of recognising emotional facial expressions [9-11]. Dysfunctions at both the stage of visual attention [12-14] and the transmission of nerve signals [15-17] suggest that worse recognition of emotions by sick people may be due to distortions in bottom-up data processing [7]. An alternative explanation, however, could be distortions in the field of top-down processing. These processes concern cases where a greater role in the perception process is played by memory processes that guide the search and interpretation of sensory data [7]. The lack of knowledge and experience in the field of understanding behavioural indicators of emotional states may mean that sick people, despite the correct reception of sensory stimuli, are unable to adequately categorise them. Lack of knowledge about the emotional indicators manifested on the face may direct the sick people's attention to areas that do not carry information about the affective state of another person. Deficits at the cognitive level of emotional processing are observed precisely in alexithymia. It can be defined by factors such as: problems in identifying feelings and distinguishing them from the bodily indicators of emotional arousal; problems in describing and communicating feelings to others and a shortage of affect-related fantasies [18]. The alexithymia syndrome manifests itself through the lack of a sufficiently developed mental representation of emotions, which in turn makes it impossible to identify visual emotional stimuli [19, 20]. Some researchers suggest that in patients suffering from schizophrenia, alexithymia affects up to 65.5% of subjects [21]. The article discusses the relationship between visual perception and alexithymia.

AIM OF THE STUDY

The initial issue verified in the study is the assessment of differences in the visual perception of expressions of emotions between people with schizophrenia and healthy people. These differences have already been confirmed by other researchers [22-24]. However, it is still not clear what influences the described differences. The research conducted so far has focused on bottom-up factors, such as neuronal dysfunctions and the related cognitive deficits of sick people [10, 25]. So far, no studies have been conducted that would indicate a relationship between the severity of alexithymia and eye tracking indicators of visual perception among people suffering from schizophrenia. This dependence could suggest that the deficits in the field of visual perception of facial expressions of emotions result from the lack of developed representations of mental emotions, and thus from top-down processes [19]. The main aim of the study is therefore to find out whether there is a relationship between the severity of alexithymia and the visual perception of facial expressions of emotions among people suffering from schizophrenia. In connection with the above, two hypotheses were put forward in the study.

Hypothesis 1: Among people suffering from schizophrenia there are differences in visual perception of facial expressions of emotions compared to healthy people.

Hypothesis 2: The higher the level of alexithymia, the less attention is paid to the areas of the face crucial for recognising facial expressions (nose, eyes and mouth).

MATERIAL AND METHODS

41 people suffering from paranoid schizophrenia and 41 healthy people participated in the study. In the group of sick people, the mean age was significantly higher (M = 39.95 years, SD = 13.07) than in the group of healthy people (M = 34.31 years, SD = 12.28): $t(76) = 1.96$; $p < 0.05$, Cohen's $d = 0,45$. Also, the sex ratio in the group of sick people (33 men and 6 women) was significantly different than in the group of healthy people (16 men and 24 women): $\chi^2(2) = 17.70$; $p < 0.001$. These data are presented in the tables (Table 1-2).

Table 1. Age of the subjects

Group	N	M	SD	Min	Max
Schizophrenia	41	39.95	13.07	19.00	65.00
Control	41	34.31	12.08	21.00	56.00

Table 2. Sex of the subjects

Group	Sex	N	%
Schizophrenia	Woman	8	19.51
	Man	33	80.48
Control	Woman	25	60.97
	Man	16	39.02

Healthy people did not suffer from mental illness, were not addicted to psychoactive substances and had no other health problems. All subjects suffering from schizophrenia were diagnosed with paranoid schizophrenia by psychiatrists using the ICD-10 system. The subjects did not suffer from somatic diseases, did not have neurological disorders, and were not addicted to alcohol or other psychoactive substances. Sick people were treated with antipsychotics (risperidone n = 16, aripiprazole n = 3, olanzapine n = 18, clozapine = 4). Sick people who were changing treatment were not included in the study.

The study was carried out in the Psychiatric Wards for Adults at SPS ZOZ (Independent Public Specialist Healthcare Centre) "Zdroje" in Szczecin, Poland. Before starting the study, all participants signed an informed consent to participate in it. The study was ethically approved by the Quality Team operating in the hospital. The study was also positively assessed by the Senate Committee on the Ethics of Empirical Research with Human Participation as Test Subjects. The research was conducted in accordance with the Helsinki Declaration of the World Association of Physicians.

The examination on sick people was carried out in a doctor's office in the psychiatric ward. Healthy people were examined in a private psychologist's office. In the first stage of the study, participants were informed about its purpose and anonymity, they also signed consent to participate in it. Then the Toronto Alexithymia Scale–20 (TAS-20) questionnaire was completed [26]. The result obtained on this scale is an indicator of the severity of alexithymia. The reliability of the whole scale as measured by the Cronbach's alpha coefficient is 0.73.

The second stage was based on eye tracking measurements made during a computer experiment of recognising facial expressions. There was a laptop on the desk. The subject's distance from the monitor ranged from 50 to 60 centimetres, which depended on the subjects' height, quality of sight, and calibration.

Before starting the eye movement recording, a 9-point calibration was performed, then the subject started the experiment.

In the studied experiment, 36 photos of facial expressions selected from the Warsaw Set of Emotional Facial Expression Pictures [27] were presented. These photos show 6 basic emotions (joy, fear, disgust, anger, sadness, surprise). For 2000 ms, the subject was exposed individually on a monitor screen with the photos of facial expressions of emotions. The subject had unlimited time to mark on the answer sheet the name of the emotion, the expression of which had been previously exposed to him. Whenever he wanted to recognise another emotion, he / she hit the spacebar. Before starting the assignment, participants completed three trial exercises. The experiment was performed with the OGAMA software. The study used a Gazepoint eye tracker with a sampling frequency of 60 Hz. Thanks to this method, we can find out where a person is looking, which elements of the exposed faces are noticed by him / her and which are omitted. The basic elements of eye movement are saccades and fixations. Fixations are moments when the eye stops on a selected object. Saccades are jumps between successive objects of fixation [28]. The following eye-tracking indicators were used in the study: number of fixations, average fixation duration and average saccade duration on the mouth, nose and eyes, and average saccade length and average saccade velocity.

RESULTS

The collected data were statistically analysed in SPSS Statistics ver. 23.0 software. 6.3% of outliers the values of which exceeded 3 SD from the mean were removed. Kurtosis and skewness values, within the range <-2; 2>, indicate the consistency of the distribution of the examined variables with the normal distribution [29]. The assumptions regarding the homogeneity and nor-

mality of distribution of all variables included in the analyses were confirmed.

The initially verified assumption in the study was the assessment of differences in the visual perception of expressions of emotions between people with schizophrenia and healthy people. In order to verify the first hypothesis, a two-way mixed-design ANOVA with repeated measures: 2 (health status: people with schizophrenia vs healthy people) x 6 (type of emotion: fear vs anger vs disgust vs joy vs sadness vs surprise). The factor measured within individuals was the type of emotion, the factor measured between individuals was the health status. The dependent variable was the average saccade length and the average saccade velocity.

As expected, a significant main effect of health status on the average saccade length was observed: $F(1, 53) = 8.94$; $p<0.01$; $\eta^2 = 0.144$. In the group of patients with schizophrenia, a significantly lower saccade length was found ($M = 68.85$; $SE = 5.73$) than in the control group ($M = 92.86$; $SE = 5.63$; $p < 0.01$). There was no main effect of health status on the average saccade velocity: $F(1, 46) = 1.19$; ni. In the case of the average saccade length and the average saccade velocity, no significant main effect of the type of emotion was found, nor was there any effect of the interaction of health status and type of emotion. These results allow us to accept the second hypothesis, which assumes that among people suffering from schizophrenia there are differences in the visual perception of facial expression of emotions compared to healthy people. Differences in visual perception between the groups, however, concern only the average saccade length. To show the shape of the distribution of this variable in both groups, box plots were used (Figure 1).

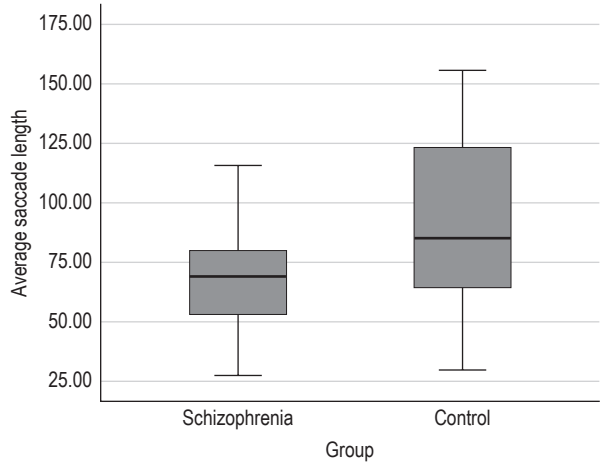

Figure 1. Box plots – average saccade length in the group of people suffering from schizophrenia and in the control group

In order to check whether there are differences in the level of alexithymia between the group of people suffering from schizophrenia and the group of healthy people, the Student's t-test was carried out for two independent groups, where the factor was schizophrenia (healthy people vs. sick people), and the dependent variable was the intensity of alexithymia. The obtained results showed statistically significant intergroup differences in the total alexithymia score, $t(76) = 2.61$, $p < 0.01$, Cohen's $d = 0,60$. People with schizophrenia showed significantly higher intensity of alexithymia ($M = 57.20$; $SE = 23.02$) than healthy people ($M = 45.20$; $SE = 15.09$). The shape of the distribution of alexithymia severity in both groups is shown by box plots (Figure 2).

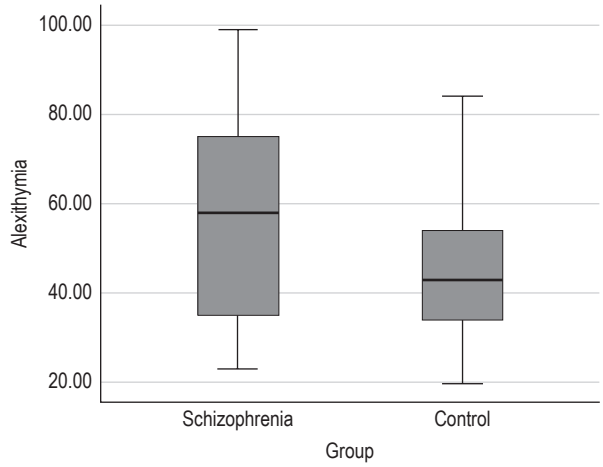

Figure 2. Box plots – severity of alexithymia in the group of people suffering from schizophrenia and in the control group

The study also assessed the relationship between alexithymia and the visual perception of facial expressions of emotion. The Pearson's correlation coefficient r was used between the total score of alexithymia and its three subscales (identification, verbalisation, operational thinking) and the number of fixations on the nose, eyes and mouth, fixation duration on the nose, eyes and mouth, and the average saccade length on the nose, eyes and mouth. Calculations were made separately for the whole group of subjects

and the group of people with schizophrenia and that of healthy people. The obtained results are presented in Table 3.

Table 3. The value of Pearson's correlation coefficient r between the intensity of alexithymia and the number of fixations, average fixation duration and average saccade duration on the nose, mouth and eyes

		Number of fixations			Fixation duration			Saccade duration		
Alexithymia	Group	nose	mouth	eyes	nose	mouth	eyes	nose	mouth	eyes
Overal score	General	-0.33***	-0.29*	-0.21*	-0.09	0.02	-0.17	-0.27*	-0.06	-0.20#
	Schizophrenia	-0.17	-0.11	-0.08*	-0.17	0.08	-0.07	-0.27*	-0.20	-0.14
	Control	-0.33*	-0.11	-0.19	-0.15	-0.22	-0.20	-0.28*	0.11	-0.15
Difficulty identifying emotions	General	-0.09	-0.11	-0.20*	-0.15	-0.02	-0.19*	-0.25*	-0.05	-0.11
	Schizophrenia	-0.18	-0.15	0.08	-0.15	0.04	-0.08	-0.05	-0.25	-0.20
	Control	-0.30*	-0.07	-0.19	0.18	-0.21	-0.19	-0.26*	-0.23	-0.10
Difficulty verbalising emotions	General	-0.18	-0.16	-0.19*	-0.12	0.03	-0.21*	-0.25*	-0.08	-0.11
	Schizophrenia	-0.12	-0.10	0.14	-0.16	0.02	-0.14	-0.14	-0.34	-0.04
	Control	-0.34*	-0.06	-0.07	0.10	-0.26	-0.07	-0.27*	-0.14	-0.13
Operational thinking	General	-0.33***	-0.29**	-0.21*	-0.09	0.02	-0.17	-0.27*	-0.06	-0.20*
	Schizophrenia	-0.17	-0.11	-0.08	-0.17	0.08	-0.07	-0.27*	-0.20	-0.14
	Control	-0.33*	-0.11	-0.19	0.15	-0.22	-0.20	-0.28*	0.11	-0.15

*** $p < 0{,}001$; ** $p < 0{,}01$; * $p < 0{,}05$; # $p < 0{,}10$

The results indicate that the subscale of operational thinking correlates negatively with the length of the nasal saccade in the group of people suffering from schizophrenia. The subscales of difficulty identifying and verbalising emotions correlate negatively with the number and duration of fixations on the eyes in the general group. In the control group, the number of fixations on the nose correlates negatively with both the total alexithymia score and all three subscales.

The obtained results showed that in the general group, the higher intensity of alexithymia is associated with a lower number of fixations on the nose, mouth and eyes, and shorter saccades on the nose. In the control group, a higher intensity of alexithymia is associated with a lower number of fixations on the nose and shorter saccades on the nose. In the group of patients with schizophrenia, higher intensity of alexithymia is associated with shorter saccades on the nose. These results allow us to accept the second hypothesis, which assumes that the higher the level of alexithymia, the less attention is paid to facial areas crucial for recognising facial expressions (nose, eyes and mouth). It should be emphasised that people with schizophrenia showed a significantly higher intensity of the total alexithymia score than healthy people.

DISCUSSION

People with schizophrenia have problems processing visual information. These problems are manifested, among others, during eye tracking of moving objects [14, 30]. In sick people, the ratio of eye movement speed to tracked object speed (gain) is reduced. They show a slowdown in the tracking movement and then its saccadisation. Some researchers suggest that the abnormalities of eye movements in sick people result from the dysfunction of the frontal lobes [31]. Due to the reduced gain in the sick people following the tracked object, the study verified the differences in the average saccade velocity between the compared groups. However, the results showed no significant differences in this variable between healthy people and patients suffering from schizophrenia. It probably results from the methodology of the conducted study. It is possible that if the exposed faces were dy-

namic, it would have an impact on the differences in the average saccade velocity between the compared groups. In order to conduct future research in this area, virtual reality may be helpful. It enables testing the ability to recognise emotions from the dynamic faces of avatars.

The results obtained by other researchers suggest that disturbances in visual perception may result from abnormalities of neuronal structures [32] and neurotransmitter systems [33, 34]. They are related to the deficits of visual perception in sick people. Also in the study presented in this paper it was confirmed that sick people differ from healthy people in terms of visual perception. In the group of patients with schizophrenia, the saccade duration was significantly shorter than in the control group. Similar results were obtained in other studies conducted on patients in the acute phase of the disease, as well as during partial remission of schizophrenia symptoms [35]. Patients from both of these groups were characterised by shorter saccades when recognising emotions on the faces exposed to them. This may lead to less smooth integration of information from different areas of the exposed face [22, 36] and, as a result, slow down or prevent the identification of a given emotion. The differences in visual perception between patients with schizophrenia and healthy people, confirmed in the study, may suggest that already at the stage of transmitting visual information to the occipital cortex, these data qualitatively differ between groups.

In postmortem studies of the brains of people suffering from schizophrenia, it was found that the total number of neurones in the striate cortex was reduced by 25% and its volume decreased by 22% compared to the control group [37]. MRI also showed a reduction in the thickness of the primary visual cortex (Brodmann area 17) in patients with the first episode of schizophrenia [38]. These data suggest that neurological dysfunctions may affect the deficits in the perception of emotional facial expressions at the early stages of perceiving visual impressions [32]. Still an important area of research is the role of top-down factors in the process of recognising emotional facial expressions. For this purpose, a series of correlations between the severity of alexithymia and selected eye-tracking variables were calculated in the study. Alexithymia, measured with the TAS-20 questionnaire, allows for an insight into the subjective experiences of the subjects. People with high levels of alexithymia have difficulty distinguishing feelings from the bodily indicators of emotional arousal. In extreme cases, such people may not know whether they are sweating due to the experienced stress or whether it is due to the high temperature in the room [19, 20]. The lack of a developed mental representation of emotions makes it impossible to correctly identify and describe one's own and others' feelings [20]. In order to recognise the expression of facial emotions, emotional knowledge is needed, which sick people with alexithymia do not have. Indeed, the conducted study confirmed that people with schizophrenia showed a significantly higher intensity of alexithymia compared to healthy people. The study also found associations between alexithymia and visual perception of sick people. The lack of knowledge about emotional indicators on the face makes it impossible to properly scan facial expressions and draw accurate conclusions based on them. In the present study, it was shown that alexithymia is associated with less intensive exploration of the area of the nose. Among patients with schizophrenia, this dependence concerned especially the saccade length on the nose. Perception studies [39, 40] showed that the exploration of the face by healthy people takes place by fixating their eyesight several times within the triangle: left eye – right eye – mouth. The association of alexithymia with weaker exploration of the area of the nose can be interpreted as an expression of the lack of competence in directing visual attention to the parts of the face important from the point of view of the emotional message. A wrinkled nose is an important area, first of all, in the manifestation of negative emotions, i.e. disgust, and some studies show that patients with schizophrenia are characterised by difficulties in recognising, in particular, negative emotions [41-44].

The conducted study showed significant differences in terms of age and sex in the study groups. Some researchers [45] indicate that women recognise emotional expressions on the face better than men, based on visual perception. The conducted meta-analysis [1] also suggests that men and the elderly are less able to

recognise facial expressions of emotions. Other studies [46] question sex differences in the visual perception of facial expressions of emotions or acknowledge their occurrence only for subtle emotional expressions. However, the issue of controlling such variables as sex and age in this group of patients requires a broader discussion. If the probability of a diagnosis of schizophrenia increases with age [47], an attempt to control age differences between the groups could reduce the representativeness of the compared groups. The same is true of sex differences. Some systematic reviews suggest that 60% of people with schizophrenia are men [48, 49]. The average incidence rate for men compared to women is 1.42%. This means that there are about 42% more cases in the group of men than in the group of women [50]. Matching the group of patients with the control group in terms of sex and age would carry the risk of distorting the representativeness of the sample of schizophrenic patients. When assuming that variables such as age and sex are related to the etiopathogenesis of schizophrenia, the use of analysis of covariance could reduce the validity of the schizophrenia construct itself. This argumentation stems from the analysis of the authors of the paper on the inadequate use of analysis of covariance in research in the field of psychopathology [51]. Accepting this argumentation, no analysis of covariance for age and sex was performed in the study presented in this paper. Thus, the variances associated with these variables were not removed. It is worth emphasising, however, that some studies do not confirm sex disparities among patients with schizophrenia [47, 48]. Therefore, further research is necessary to better understand the mechanisms – both biological and social – leading to a statistically significantly earlier diagnosis of schizophrenia in men and gensexder differences in the manifestation of psychopathological symptoms in this group of patients [47].

The relatively small sample size in the study may seem disputable. The study involved 41 people suffering from schizophrenia. A meta-analysis of 57 studies on people suffering from schizophrenia, in which the eye tracker was used, showed that the average sample size was 35.95 [52]. However, in order to increase the validity of the results of future studies, it would be beneficial to carry them out on larger samples.

The main limitations of the study include the lack of measurement of cognitive processes, including the selectivity of attention, and the lack of measurement of disease symptoms. Analysis of these variables would allow for a broader interpretation of the results. The conclusions of the study concern a sample selected on the basis of the criteria for schizophrenia according to ICD-10. Unfortunately, the heterogeneity of the concept of schizophrenia complicates research efforts. This paper was created within the dominant model of mental disorders, which conceptualises these phenomena as categorical states reflecting the binary distinction of "healthy person" – "sick person". Understanding mental illness in terms of a set of neurobehavioural dimensions and processes opens up new research opportunities. Future research should address the hypotheses regarding the relationship between the intensity of psychopathological symptoms and cognitive deficits and the visual perception of facial expressions of emotions discussed in this paper, including also the role of neurobiological, neurochemical, genetic and epigenetic processes being played by them in these relationships.

Conclusions

Deficits in the field of recognising emotional expressions by sick people fall within the scope of the issues of social cognition. Social cognition can be defined as the ability to construct mental representations about others, oneself, and one's relationships with others. The scope of social cognition includes cognitive processes involved in understanding, perceiving and interpreting the social world [53]. This is why problems in the field of recognising emotions can be a source of failure in social functioning for sick people. Understanding the genesis of these deficits is therefore motivated by the improvement of the future quality of life of people suffering from schizophrenia.

Based on the conducted study, as well as the integration of its results with the source literature, it can be concluded that the problem of the pathogenesis of emotion recognition deficits depends on dysfunctions in both top-down and bottom-up processing of sensory stimuli. Neu-

ral dysfunctions and the resulting abnormalities of eye movements in sick people impede proper integration and categorisation of perceptual data [32]. According to the proposed model, disturbances in the early stages of bottom-up sensory data processing result in the inhibition of the development of the mental representation of emotions, which is manifested by the alexithymia syndrome. Correct recognition of emotions also requires top-down processing of the received sensory data [7]. This requires the involvement of memory processes that guide the search and interpretation of sensory impressions. On the other hand, the lack of knowledge about emotions is associated with secondary dysfunctions in the field of visual perception of emotional expressions. The subjects, having no knowledge about the facial expressions of emotions, do not focus their attention on the areas of the face that express emotions. This process is a vicious circle in the pathogenesis of deficits in the recognition of facial expressions by sick people and leads to their consolidation. Paying attention to this process is crucial for the development of future facial expression recognition training. The results of the presented study suggest that alexithymia is related to the perceptual deficits of sick people, which means that therapeutic interventions should be focused on the development of the mental representation of sick people's emotions [19]. Training in the correct categorisation and verbalisation of emotional facial expressions should constitute a starting point for the development of future therapeutic programmes. This issue, apart from practitioners, should also be addressed by researchers in order to assess the effectiveness of these interventions. It is possible that the diagnosis of alexithymia in this group of patients will increase the effectiveness of future interventions and improve the social functioning of patients with schizophrenia.

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