The Effect of Working Memory Deficit on Social Functioning in Schizophrenia

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ABSTRACT

Working memory is universal and crucial in daily human life as a cognitive ability involved in organizing, executing, and inhibiting behaviour. Whether an individual can perform well in social functions depends on its development. Schizophrenia, as a neurological disorder, is associated with working memory deficit and is accompanied by poor social functioning. Understanding patients' attachment forms, expressed emotions, and communication deviances have been recognized as a vital area of research and a strong predictor of the development, prevention, and treatment of schizophrenia. This review discussed the effect of working memory deficit on social functioning in schizophrenia through four areas. Previous research has demonstrated that working memory includes both auditory and visual types. Different types of working memory deficits can harm cognitive, learning, and social functioning in schizophrenia patients, so it is important to discuss whether widespread working memory deficits can affect their behaviour, such as regulation behaviour. Good social functioning requires sufficient working memory involvement to understand and cope with social situations. At the same time, it is crucial to investigate whether the associated symptoms exhibited by patients are due to their working memory deficits and whether these deficits affect their social functioning. Furthermore, working memory deficits also appear to affect patients' everyday abilities, such as problem-solving and emotion regulation. Previous studies investigated whether this is related to the patients' associated brain activity and whether their neural mechanisms differ from normal individuals. Considering that working memory and social functioning play a crucial role in the patients' daily lives, it is possible that interventions at the behavioural and neurological levels could improve their associated abilities and symptoms. Notably, the results should be viewed in the context of some of the limitations of the previous studies. Firstly, previous studies have primarily used cross-sectional studies, which caused neglect of the continuum of individual differences and have failed to establish a causal relationship between working memory deficits and social functioning. It is suggested that future studies could be designed with follow-up studies and different types of working memory training to provide more reliable and accurate results. Secondly, previous studies of patients' social functioning do not appear to incorporate the performance of real-life social scenarios, and by designing social scenarios closer to reality, generalizable results could be provided.

Keywords: *Working memory deficit, Social functioning, Schizophrenia*

1. INTRODUCTION

Working memory is an important part of our lives. It is a skill that enables us to retain new information, allows our brain to process information briefly, and relates the new incoming information to other information. Working memory is defined as a cognitive ability to remember and process tasks in a short period of time, for example, learning and comprehension. Working memory allows people to be aware of what is going on around them and to focus on their tasks. The ability to work memory is critical to everyday life. In life, when people need to remember something temporarily, such as a series of phone numbers, working memory helps us store information and process them. Because working memory works, people can do two or more things at once and

combine related information. For example, we can remember what a teacher said in class while recording the information as to their own understanding.

If our working memory cannot complete the task, then people lose their most basic ability to learn, can no longer update information, and their ability to perform and make decisions will be greatly reduced. Working memory is divided into three parts, a central executive system controlled by attention. One of the two is the visuospatial sketchpad, which operates on visual images [1]. The second is the phonological circuit, which stores and practices phonological information as a basis, and plays a large part in our language learning.

Working memory refers to the cognitive process of focusing attention on limited information and performing operations on it quickly. It is an executive function skill that is essential for organizing, executing, and inhibiting behavior, and therefore essential for children to function in social settings. The ability to process social information is considered to be dependent on working memory [2]. Children rely on input and information stored in their working memory to do an activity. If their working memory is weak, it is hard to function both. This makes it challenging to follow a multi-step direction. Children with poor working memory have a hard time remembering what will happen next while doing what they are doing now. It's shown that lower working memory capacity makes children less able to deal with problems and behave appropriately in some social situations.

Also, it shows that the ability to adapt to unconventional situations is often related to the concept of executive function and general intellectual ability. Executive function is based on the prefrontal cortex and consists of three main components: inhibitory control, working memory, and cognitive flexibility. Inhibitory control is considered to be the most fundamental component of executive function. Working memory is the basis for acquiring and following complex rules, which are one of the most important parts of the learning process. The experiment results show that most people with developmental disabilities' social acquisitions are slow and limited, which negatively affects different aspects of their daily functioning and reduces their quality of life.

Attachment is one of the major topics for elucidating psychosocial mechanisms important for research, prevention, and treatment of schizophrenia. The core of attachment is the unique quality of the emotional bond between infants and primary caregivers established through the first 1-2 years of the life of babies. Attachments are divided into organized: secure attachment, dismissing attachment, and preoccupied attachment (insecure attachment). The disorganized pattern consists of some unresolved types, and some types cannot be classified, respectively characterized by momentary ruptures of the organized pattern or profound breakdown. Evidences reveal a strong association between dismissing attachment and psychotic symptoms [3]. Three risk processes are involved in the association between dismissing attachment and psychosis: deactivation effects, impaired mentalization (involved in the development of negative symptoms), and externalizing strategies (involved in the development of positive symptoms). In addition to dismissing attachment, disorganized forms of attachment (unresolved and cannot classify) are risk factors of psychosis, in line with the established emotional abuse and neglect type of trauma. In contrast, secure attachment is an important resilience factor for resolving traumatic experiences in childhood, indicating that secure attachment could moderate the association between trauma and psychosis. The quality of the infant-caregiver attachment relationship most likely interacts with parental and infant factors and various social factors. If the attachment relationships lead to dismissing or disorganized attachment, then various risk developmental processes are present, which can be involved in symptom development in psychosis [3].

The other major topic in schizophrenia is expressed emotion (EE) and communication deviance (CD). EE measures critical, hostile, or emotionally overinvolved (EOI) attitudes held by a key relative toward a mentally or physically ill family member [4]. In general, high EE is related to poorer illness courses for patients with schizophrenia and has been found to be a strong predictor of poor outcomes in individuals with a serious mental disorder. CD is one of the dominating factors that may underlie high-EE attitudes and measure the degree to which a relative's communication lacks clarity and causes disruptions in the focus of attention. Persistent exposure to disordered communication throughout development may contribute to deficits in focusing attention and conducting information. This may increase the likelihood that a vulnerable individual will manifest symptoms of psychopathology. Distorted communication styles are characteristic features of families with young adults with schizophrenia in transcripts of Rorschach protocols. High-CD is related to high-EE, and relatives who were rated as high-EE have been found to manifest higher levels of CD than did relatives rated as low-EE. Family members with high levels of CD may lead to more difficulty expressing their thoughts to patient relatives in a clear and non-critical fashion. Negative affect and deviant communication may be a particularly dangerous predictor of symptom onset and poor course of illness in schizophrenia. CD and EE together will predict significantly better in development of schizophrenia symptoms than use either construct alone. Although base rates of high-EE have been found to vary across cultures, research on the impact of cultural factors on CD in families with schizophrenia is minimal. CD may also be better understood when examined through a cultural lens [4].

Humans evolutionarily acquire attachment needs; an in-depth understanding of nonoptimal forms of attachment has been identified as a vital area of research into the psychosocial mechanisms of multiple mental disorders and can be used to elucidate the development, prevention, and treatment of schizophrenia. Moreover, as strong predictors of schizophrenia, EE and CD are highly correlated and interact with each other, especially as higher levels of either are associated with a poorer illness course in schizophrenia patients, taking into account their cultural background [5]. On the other hand, the individual can adapt well to society depending on working memory involvement. Specifically, working memory and achievement goal pursuit interact [6], meaning that different goal pursuit conditions mobilize different working memory resources to produce various outcome performances. Working memory also acts selectively on goal pursuit processes. Furthermore, working memory's ability is significantly correlated with individual social functioning [7]. The stronger an individual's working memory is, the easier it is to understand complex social relationships and thus to acquire more social skills and interact more actively socially. Although there is no shortage of research on social functioning or working memory in schizophrenia separately, only a few studies have investigated their interrelationships, which is essential and needs attention—considering that there may be some potential limitations in this area. Therefore, this review aims to evaluate the effect of working memory deficit on social functioning in schizophrenia to better and more precisely understand the knowledge base related to this topic while effectively developing a related understanding status by discussing the previous findings in four areas: working memory deficits exhibited by schizophrenia patients, the association between working memory deficits and social functions, non-typical neural mechanisms of working memory deficits and impact of relevant interventions on social functioning.

2. WORKING MEMORY DEFICIT IN SCHIZOPHRENIA

This section needs to emphasize two types of working memory. The visual part is part of working memory. If there is a deficit in the visual part of working memory, then people will not be able to keep visual images in the brain for a few seconds after they disappear from the visual field. This can affect people's ability to recognize objects and focus their attention. So is the cognitive deficit in schizophrenic patients related to visual working memory deficits, which can be supported based on the research. In a study by Gold et al., patients with schizophrenia were tested for the amount and accuracy of stored working memory [8]. Patients would receive a color stimulus and then report the color remembered at a location for a second test 600 milliseconds later. The second measure of memory required participants to compare viewing an array of 4 colored boxes, with the 4 boxes reappearing after the patient clicked on the square that changed color. The comparison results showed that working memory (SD) precision was very similar to the control group and did not differ. Patients produced large differences between groups in memory capacity (K) over 3 to 4 seconds. The overall effect value of the difference was 0.56. In terms of the number of stored working memory items, the patients had worse memory skills. As a result, People with schizophrenia have less storage for working memory than normal people, so they also have deficits in the storage and perception of immediate information.

The second component of working memory is the auditory portion, and again, auditory working memory deficits can also affect cognitive abilities. Auditory working memory affects people's verbal learning, social skills, and life skills. The discussion in this literature can demonstrate that auditory working memory deficits can impact patients' social competence. According to the above, the relevance of visual working memory deficits for patients with schizophrenia has been demonstrated. Therefore, whether auditory working memory is also important for patients with cognitive deficits. In a study by Bowie et al., researchers examined and predicted whether the presence of neuropsychological impairments in patients with schizophrenia would affect functional outcomes and real-world behavior [9]. In this study, patients with schizophrenia were administered the SSPA, a social competence test, and the UPSA, a functional test, in which working memory factors predicted social competence. A brief training session was conducted and, patients were asked to engage in a three-minute conversation that included a number of life situations, and then the patients were scored on their social skills. In the domain of cognitive ability tests, they used the Digit Span Distraction Test, digit symbol, and letter-number sequencing subtests. In the area of working memory, they chose auditory working memory to test and combined these tests to assess patients' cognitive impairment. Patients with schizophrenia are less accurate and less sensitive than normal people on tests of auditory working memory, which means they do have deficits in auditory working memory. These deficits lead to difficulties in their social life as well.

Both Auditory and visual play people's social life, such as carrying out daily conversations, picking up items, and capturing information. Because people need to use their working memory to regulate their emotions in their daily lives, Schizophrenic patients would be likely to have problems regulating their emotions since they have deficits in their working memory. In schizophrenics and violent criminals, these deficits can lead to aggressive behavior and criminality. In some studies, we have seen the effects of cognitive deficits on them. In the study by Anthony et al., researchers investigated the mediating role of parental emotions in the effect of cognitive deficits on aggression, the relationship of cognitive

deficits in the emergence of aggressive behavior and violent crime in schizophrenia symptoms [10]. Participants were tested for deficits in the neuropsychological domain MCCB, which includes working memory. Violent offenders performed worse than the control group on all tests of cognitive variables such as working memory. The poor cognitive reappraisal ability of patients and offenders was related to their inability to retain information in working memory for a long enough period of time, and deficits in this area made it difficult for them to reevaluate the provoked situation and adjust to negative emotions. Patients and violent offenders who damage their working memory areas showed more intense negative emotions, arousal, and aggressive behavior than the normal population. Deficits in working memory and cognitive impairment contribute to criminal behavior and impulsive aggression.

3. THE RELATIONSHIP BETWEEN WORKING MEMORY DEFICIT AND SOCIAL FUNCTIONING

The face recognition system can be used to identify others in photos, videos, or real-time. For example, when we socialize with other people, we can identify an individual according to their facial features and expressions. The face capture process converts analog facial information into a set of information stored based on human facial features. There is also face identification when people name the person and face recall, which occurs when we describe the face from memory. Because all faces contain the same features in the same overall structure, distinguishing individuals is a highly visual task. Nevertheless, we can still perceive changes through various light surfaces or viewpoint or recognize individuals when some facial features are blocked by accessories wearing. The face processing ability is an important part when social functioning. It is fundamental to successful social interaction. The ability of face processing can affect the accuracy of recognizing faces and how quickly a face is learned during initial exposure to a new individual. When the details have been collected, the way we store them is associated with working memory, so a hypothesis has been put forward if patients with schizophrenia have working memory defects, whether this is associated with face processing. The conclusion is supportive. An experiment was done to investigate visual object WM processing in patients with first-episode schizophrenia [11]. In the experiment, a group of first-episode schizophrenics and another group of healthy participants were involved. Damage to the brain regions often leads to abnormalities in identifying, identifying, and naming different classes of objects. Waste Management, also called WM, executes core operating initiatives targeting focused differentiation and continuous improvement. The WM performance was negatively correlated with processing speed, attention, language, and delayed memory deficits in schizophrenia patients with low face task load. The finding may be consistent with the notion that different temporal cortex regions are selective for facial and architectural recognition.

Some of the symptoms of schizophrenia include psychotic symptoms such as hallucinations, delusions, and thinking disorders, such as abnormal thinking patterns, as well as reduced emotional expression, reduced motivation to achieve goals, difficulties in social relations, movement disorders, and cognitive disorders. Although symptoms usually begin in late adolescence or early adulthood, schizophrenia is usually viewed from a developmental perspective. Cognitive impairment and abnormal behavior sometimes occur in childhood, and various persistent symptoms represent the advanced stage of the disease. In all three areas of working memory, schizophrenic patients have serious defects in working memory. However, there were no significant differences between different subdomains or between different working memory tasks. The relationship between spatial working memory, psychiatric symptoms including disorder symptoms, and social functioning in patients with schizophrenia have discovered an experiment. There was a group of clinically stable patients with schizophrenia, and a group of healthy controls participated to be in contrast. The result shows that both spatial working memory deficits and disorders associated with dorsolateral prefrontal cortex dysfunction are effective predictors of social function [2]. Compared with healthy controls, patients with schizophrenia showed poorer when dealing with several aspects of social functioning, such as self-care skills, community skills, and speech disorders, with disorder symptoms.

Empathy is the ability to recognize, understand and share the thoughts and feelings of others, animals, or fictional characters. Developing empathy is essential for building relationships and compassionate behavior. It involves experiencing another person's point of view, not just your own point of view, and supporting or helping behavior from the heart, not forced by other factors. Emotional empathy refers to a person's emotional response to another person's emotional state, and cognitive empathy refers to understanding another person's mental state. Their defects are considered to be one of the causes of schizophrenia-related social behavior abnormalities. And empathic deficits are associated with lower functioning in patients with schizophrenia. A study mainly examines whether performance-based measures of empathy are better than self-reported empathy, neurocognitive, and clinical symptoms in explaining incremental differences in social competence and social achievement [12]. Patients were the same with their personal and family conditions; they had a chronic disease and had a typical daily CPZ equivalent. Samples were collected, and the result shows that disease duration was associated with social skills while daily CPZ levels were not associated with empathy

or other measures. Working memory was significantly correlated with perspective choice and empathic care. With the decrease of individual visual-spatial working memory, cognitive empathy and emotional empathy decreased significantly. Although working memory and empathy structures seem very different, empathy seems to depend on the ability to decode complex emotional information from others and keep this information long enough to form an appropriate response.

4. ATYPICAL NEURAL MECHANISM UNDERLYING WORKING MEMORY DEFICIT

The study of social problem solving is combined with research, prevention, and treatment in schizophrenia. The experiment by Huang et al. examined the contribution of neurocognition and social cognition to components of social problem solving and was carried out with the participation of patients with schizophrenia and controls [13]. They were administrated a range of tests, firstly, the neurocognitive tests (1: SART), which were used to assess the attention of each subject. 225 single digits are presented in the middle of the screen to the test taker over 4.3 minutes. Each digit is presented for 250 milliseconds, followed by 900 milliseconds mask. Participants were required to press a key in response to the digit except on 25 occasions when digit 3 would appear. The second test (2: N-back task) was used to assess the working memory of each subject. The numbers 2, 4, 6, and 8 were presented randomly on a computer screen. There are two types of tasks, 0-back task, and 1-back task, and the 0-back task required the subjects to press a digit key when they were showed with the corresponding digit on the screen. The 1-back task required the subjects to keep the first-shown digit in mind and press the key of the first-shown digit when the next digit was presented on the screen. Then they participated in motion perception tests, which means to depict the happiness to anger emotion continuum. Some ambiguous facial expressions (i.e., with 50% happy signal and 50% angry signal) will be presented as some answers to every question of praising/blaming/inquiring in a conversation. The subjects were required to judge whether this ambiguous facial expression was happy or angry with different question types in the conversations. And then the Chinese Assessment of Interpersonal problem-solving skills (CAIPSS). There will be some scenes, and Each scene shows two characters engaged in social interaction. The subjects were asked questions assessing their ability to identify any social problems and describe them (receiving skills), to find a solution (processing skills), and to role-play the solution with the test administrator (sending skills). The research found that patients with schizophrenia performed worse in sustained attention than healthy controls, working memory, negative emotion, intention identification, and all components of the CAIPSS. The sustained attention, working memory, and negative emotion identification were found to correlate with social problem solving, and 1-back accuracy significantly predicted the poor performance in social problem-solving. Studies show that working memory deficit in patients with schizophrenia may have correlations with a worse performance in social problem-solving [4]. This study reveals a corroboration that working memory contributed most to deficits in social problem-solving in patients with schizophrenia. As working memory deficits significantly affect social functioning in schizophrenia, it is important to find out whether corresponding neural mechanisms also be influenced.

So, whether the discrepancy is the decisive factor or not and what the difference precisely is between working memory deficit and control in prefrontal and parietal activity would relate to the core of neural mechanism in schizophrenia. Advanced study shows that inferior parietal, visual, and prefrontal regions were activated bilaterally during encoding. Inferior parietal and left superior temporal and prefrontal regions were predominately activated during the probe condition [14]. Left superior temporal, inferior parietal, and posterior inferior frontal regions showed significant negative correlations with levels of auditory hallucinations, as did bilateral anterior insula. The experiment by Grot et al. was carried out with the participation of two groups of participants, 19 patients with schizophrenia and 23 matched controls, which have studied the neural correlates of both passive and active binding in working memory in schizophrenia. Participants were instructed to memorize three letters and three spatial locations in two conditions, passive and active binding, and the words and ellipses that in the same colour are combined together in the “passive binding” condition; in the “active binding” condition, participants have to intentionally and mentally link the words and ellipses sharing the same colour. Patients with schizophrenia had greater performances in the passive than active binding task and showed lower overall performance than controls. Patients exhibited similar performance to the controls in the passive binding condition. For active binding, the patients with schizophrenia showed significantly lower performance than the control group. The whole study found that the control group had greater activations than patients with schizophrenia in the left ventrolateral prefrontal cortex. Patients with schizophrenia showed higher activation than the controls group in the left thalamus and also the left postcentral gyrus. Patients had lower activation in the left cerebellum and left fusiform gyrus relative to controls. They showed no higher activations than controls. So, the experiment concludes that active binding deficit in working memory was related to aberrant activity in the posterior parietal cortex and the ventrolateral prefrontal cortex [14].

As mentioned before, neural correlates between the working memory and neural mechanism may reveal the

essence of social problem-solving in schizophrenia, so psychologists suggest that the abnormal neural mechanism of working memory may be related to schizophrenia. The experiment by Wible et al. has tested whether regions involved in verbal working memory and language processing would show activity associated with levels of hallucinations during a condition where subjects were rehearsing the stimuli [15]. Hallucinations are a relatively serious perceptual disorder that can cause anger, sadness, panic, escape, and even produce emotional or behavioural reactions that attack others, which refer to the perceptual experience that occurs when there is no corresponding objective stimulus. Hallucinations can occasionally be seen in normal people, but most of them are pathological. The parietal lobe of the brain is an area with a sensory center and many other important parts. The parietal lobe is damaged, and symptoms such as cerebral cortex abnormal sensation or sensory disturbance, inability to use (apraxia), dyslexia, contralateral isotropic lower quadrant blindness, spatial positioning disorder, and body atrophy may occur. The temporal lobe is located below the sylvian fissure. It is divided into the superior temporal gyrus, the middle temporal gyrus, and the inferior temporal gyrus from the superior temporal sulcus and the inferior temporal sulcus. The superior temporal gyrus is the areas 41 and 42of the superior temporal gyrus and transverse temporal gyrus. The gyrus is the auditory cortex, and the posterior part of the superior temporal gyrus is the auditory speech center in the dominant hemisphere, called Wernicke's area. The hippocampus is the center of smell and taste. The anterior part of the temporal lobe is the mental cortex. Human emotions and mental activities are related to the orbitofrontal cortex and closely related to the temporal lobe. The hippocampus is related to memory. In this study, both hallucinators and controls showed great activation of the right and left parietal and left superior temporal regions during the probe condition. Schizophrenic subjects who did not report having auditory hallucinations showed greater activity during the probe condition, including greater activation of bilateral inferior parietal and left superior temporal regions. No regions showed significantly greater activity in hallucinators than in no hallucinatory for this analysis. The authors found that activity during the probe condition was negatively correlated with levels of auditory hallucinations in schizophrenic subjects. A small region in the visual cortex showed a positive correlation between auditory hallucinations and probe activity, which significantly correlate with working memory [15].

5. RELEVANT INTERVENTIONS AND THEIR IMPACTS ON SOCIAL FUNCTIONING

Emotional regulation, a crucial function in daily life, is defined as the ability of individuals to initiate, inhibit or control their emotional demands [16]. As people are always exposed to potential emotional stimuli, dysregulation can lead to inappropriate behaviour that may interfere with social functioning over time and even lead to some emotional and mental disorders. Considering that working memory plays a significant role in life, there may be a link between it and emotion regulation. Previous studies investigated whether investigations into the neural mechanisms of working memory be used to explain their connection or interplay of effects. Guimond and colleagues explored how different emotional distractors affect performance on working memory tasks of varying difficulty. They used 0-back and 2-back tasks to examine participants' work memory performance, including accuracy and reaction time. In terms of social functioning, they focused on assessing emotion regulation in patients with schizophrenia and healthy controls by displaying fearful, happy, or neutral facial disturbances during the task. At the same time, fMRI was used to capture and compare participants' brain activity [17]. The results indicated that the effortful emotion regulation was impaired in schizophrenia patients during the work memory task; Its impairment was associated with alterations in emotion-cognition interaction processes and more unsatisfactory work memory performance. Furthermore, compared to healthy controls, schizophrenia patients did not show a regular pattern of brain activity (i.e., emotion-specific modulation) in their left inferior frontal gyrus (BA 45) when regulating fearful distractors. Schizophrenia patients also failed to deactivate in the right superior frontal gyrus (BA 10), these abnormal activities contributed to decreased performance on work memory tasks during emotion regulation in schizophrenia patients. As above, these brain areas are relevant and play an essential role in the individual's ability to regulate emotions. Their abnormal activity reflects problems exposed in the neural mechanisms of schizophrenic patients and a hindrance to good social functioning. Now that issues at the level of the patient's neural mechanisms have been identified, it is possible that if intervention improves the patient's working memory, these effects may also be reflected in social functioning.

Abnormal middle frontal gyri and inferior frontal gyri activation reflects poorer working memory and social cognition [18]. Suppose these brain areas are already considered to have such an important role. It is possible that by measuring patient's working ability and training them at the behavioural level, their brain areas activity and neural mechanisms could be influenced to improve social functioning. In the study by Subramaniam et al., the idea that 'cognitive training in schizophrenia improves working memory performance and social functioning was tested using a letter N-back task (0-back, 1-back, and 2-back tasks) fMRI scanning to assess participants' working memory performance and brain activity. Furthermore, 80 hours (16 weeks) of adaptive

computerized cognitive training (SZ-AT) (including auditory/verbal, visual, and social-cognitive processes) or computer games control condition (SZ-CG) were used as the exercise module [19]. The results indicated that schizophrenia participants performed significantly less well on the 2-back task before training than healthy participants, and their left middle frontal gyri showed low activation. After undergoing (SZ-AT) training, there was a positive correlation between the schizophrenia participants' 2-back task accuracy and the connectivity between bilateral middle frontal gyri and left inferior frontal gyri. They showed a significant increase in task accuracy and neural system efficiency compared to untrained schizophrenia participants, suggesting that training may have enhanced the prefrontal capacity of schizophrenia participants, allowing their work memory and social functioning to begin to 'normalize' gradually. Furthermore, schizophrenia participants who received (SZ-AT) training also showed better generalized social functioning at follow-up six months later. However, this improvement was not seen in schizophrenia participants who received (SZ-CG) training. Thus, these results suggested that the positive results of condition-specific behavioural level work memory training manifest themselves in patients' relevant brain areas and neural mechanisms and can improve their social functioning.

As has been mentioned, behavioural level interventions can modulate a wide range of working memory capacity of patients, thereby improving their symptoms and social functioning problems. Considering that problem-processing and problem-solving skills play an essential role in social functioning, then direct intervention and stimulation of the neurological level of the patient can also alter their working memory to affect social functioning. Singh and colleagues explored the relationship between enhanced frontal gamma activity and improved working memory in schizophrenia patients, focusing on the cognitive dimension of social functioning, and assessed N-back task (0-back, 1-back, and 2-back task) performance, EEG power, and neuropsychological test performance in schizophrenia patients by using a total of 12 weeks of twice-weekly EEG neurofeedback as a treatment modality [20]. The results indicated that before treatment, participants showed abnormal activity in gamma band responses. Moreover, participants' performance on the 1-back task improved significantly at 4, 8, and 12 weeks of treatment, and that their frontal gamma power began to improve progressively. At the end of the 12th week of treatment, participants showed significant changes in the 2-back task, and they also showed significant improvements in the Speed of Processing, Working memory, and problem-solving domains. In addition, these improvements are still visible 4 weeks after the end of treatment. The results thus demonstrate that EEG neurofeedback is associated with significant gains in frontal gamma power and working memory performance and that improvements in gamma power are also associated with improvements in broad cognitive abilities (including reasoning, problem-processing, and problem-solving). Therefore, these results demonstrate that the use of neurofeedback can indeed improve the working memory of schizophrenia patients, thereby improving their symptoms and social functioning.

6. LIMITATION AND FUTURE DIRECTION

Previous studies were mainly cross-sectional studies. Most studies did not study the two separately due to a lack of technical conditions or difficult experimental measurements. They only studied the relationship between schizophrenia working memory deficit and social function at a certain point in time. The main research method of previous studies is to study the correlation between working memory deficits and social function in schizophrenia through multiple sets of experiments, such as neurocognitive tests, N-back tests, motion perception tests, etc., and infer working memory through these inferences. Defects are indeed related to a social function, but it is impossible to conclude whether working memory deficits have caused social dysfunction in patients with schizophrenia [13]. Since real social scenes are difficult to restore and measurement will be more difficult, previous studies on measuring social function are limited to questionnaires and did not study the performance of schizophrenia in real social scenes.

Some future predictions can be made. For example, future studies could follow up on whether working memory deficits affect social skills to the same extent at different stages of schizophrenia patients going through. Future research can explore whether different levels and aspects of social skills are affected by different levels of training of different types of working memory. Research done in the future could set up social situations that are more like real life to detect social skills in schizophrenia.

7. CONCLUSION

The above discussion suggested that cognitive deficits in schizophrenic patients are related to deficits in auditory working memory and visual working memory. Deficits in auditory working memory can lead to impaired social skills in patients. And deficits in working memory can also affect the patient's ability to control their emotions, leading them to perform aggressive behaviors. It is also possible that working memory deficits may have some role in the emotional regulation of patients. One part of schizophrenic symptoms is related to empathy, which empathy deficits may cause through working memory deficits.

Also, working memory deficits in schizophrenic patients have a negative impact on their processing of facial information about others. Cognitive deficits in

dealing with social problems and performing basic social behaviors can also make it more difficult for patients. Because patients' working memory deficits have already had a significant effect on schizophrenia, then measuring patients' working memory and training them behaviorally might affect their social functioning. Behavioral-level training could then regulate their cognitive deficits, and direct interference with patients' neurological levels should similarly affect their working memory deficits and ultimately regulate social functioning.

On the neurological side, there are some associations between neural mechanisms and working memory deficits, prefrontal and parietal activity in schizophrenic patients. The abnormalities in the neural mechanisms of working memory may be related to the hallucinatory symptoms produced by the patients. However, previous studies have focused only on the correlation between working memory deficits and social functioning and have been limited to an overly monolithic approach to investigation. We believe that future studies will explore the different types of working memory training that causes different effects on social competence and conduct follow-up studies to detect the extent of the effects at different stages.

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