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Task related stress and cognitive control in patients with schizophrenia

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Summary

Introduction: Working memory deficits might be one of the major cognitive impairments in schizophrenia. Some researchers argue, that cognitive control is especially disturbed among schizophrenia patients. It was found, that low working memory capacity in schizophrenia may be explained by the fact that irrelevant stimuli occupy patients' storage space that could otherwise be used to hold relevant information.

Aim: We examined, whether increased distress as well as the tendency to focus on irrelevant information (worry) are related to cognitive control in schizophrenia.

Method: The participants were 28 patients with paranoid schizophrenia and a control group (n=28). The cognitive control was measured with the short version of Attention Networks Test (ANT), and the state of worry and distress was assessed by the short version of the Dundee Stress State Questionnaire (DSSQ) in a Polish adaptation.

Results: The stress states of worry and distress were higher among patients in comparison to controls. Moreover, worry mediated the relationship between group and cognitive control task.

Conclusion: The mediation model suggested that patient's poorer performance on cognitive control task might partially explained by their increased state of worry (focus on task unrelated thoughts) measured just before the task.

Key words: cognitive control, stress, schizophrenia, working memory

Introduction

A growing number of research suggests, that working memory (WM) deficits might be one of the major cognitive impairments in schizophrenia [1, 2]. In the classic model, WM is regarded as consisting of three separable components: two temporary storage units (phonological or visual) and controlling system (central executive system) [3, 4]. Working together, these components form a unified memory system that is responsible

for the performance in complex tasks. As WM is a broad structure, attempts have been made to identify simpler mechanisms that may explain WM impairment in people with schizophrenia. Some researchers argue, that cognitive control is especially disturbed among schizophrenia patients [e.g. 5, 6]. Research exploring central executive and cognitive control systems show that these concepts cover a wide range of functions. Miyake et al. [7], for instance, identified three specific processes underlying central executive system. The authors suggested that: 1) it inhibits dominant and irrelevant responses interfering with the contents of memory, 2) the central executive system is responsible for shifting between various tasks and 3) the central executive system monitors the information currently being held in memory and updates the contents that is no-longer relevant.

As regards patients with schizophrenia, it was found, for instance, that they usually have difficulties with tasks that require inhibition of response, such as the cognitive control aspect measured by Attention Network Test (ANT) [8, 9]. In these tasks, subjects have to inhibit their prepotent response, in order to react correctly. In other studies, it was found that, for people with schizophrenia, it was difficult to select non-salient over salient stimuli for storage in WM [5]. Hahn et al. hypothesized that low WM capacity in schizophrenia may be explained by the fact that irrelevant but salient stimuli occupy patients' storage space that could otherwise be used to hold relevant information. In that way, they explain a relatively small capacity of WM among people with schizophrenia. This is consistent with the findings in healthy subjects, suggesting that high WM capacity individuals more efficiently represent only the relevant information, while low capacity subjects inefficiently encode and maintain the irrelevant content of the task [10].

The hypothesis that irrelevant information occupies the WM of people with schizophrenia and this may be the reason for the observed cognitive deficits in schizophrenia can be framed within the processing efficiency theory [11]. This theory postulates that worry is the component of state anxiety that influences the cognitive performance. It is stated that worrisome thoughts interfere with the function of processing and storing the information connected with the task. Moreover, irrelevant thoughts for the task influence the self-regulatory processes (inhibition) consuming that way some portion of the resources in the WM.

In the present study we examined, whether increased distress as well as the tendency to focus on irrelevant information are related to cognitive control in schizophrenia. We measured the subjective state of participants before solving a task measuring cognitive control. Specifically, we used the Dundee Stress State Questionnaire (DSSQ) developed by Matthews et al. [12, 13] to measure the multiple dimensions of subjective stress state related to cognitive performance. Matthews et al. [13] present psychometric and experimental evidence based on studies with the DSSQ that identify three broad factors, task engagement, distress, and worry. Task engagement integrates state constructs that relate to task interest and focus: energetic arousal, motivation, and concentration. Distress appears to integrate unpleasant mood and tension with lack of confidence and

perceived control. Worry is a cognitive factor primarily composed of self-focused attention, self-esteem, and cognitive interference. Matthews et al. [12, 13] validated this taxonomy by showing that the state factors were differentially related to task stressors, personality factors and situational cognitions.

Basing on previous research, we hypothesized, that 1) patients will exhibit higher level of worry than healthy individuals, 2) the focus on task unrelated thoughts, might be distractive in the process of task solving [13]. On the other hand, it was shown, that patients with schizophrenia have problems trying to overcome irrelevant information [5]. Moreover, one can also expect, that patients will have higher level of distress, because many data suggest, that patients reported to experience negative affect more frequently than healthy individuals [14].

Material

The research was approved by Ethic Committee at the Faculty of Psychology, University of Warsaw.

Participants

The participants were 28 ICD-10 diagnosed inpatients (20 males) with paranoid schizophrenia, who had been screened in order to rule out neurological disorders, mental retardation or substance abuse. Their mental state was stable and they stayed in the hospital mainly due to the impact of rehabilitation and psychotherapy. Mean severity of psychopathological symptoms, assessed using the Brief Psychiatric Rating Scale (BPRS), was 31.6 points (SD = 7.6), which should be interpreted as mildly ill [15, 16]. The subjects were also examined in order to exclude neurological disorders, mental retardation, and addictions. Their mean age was 29.5 years old (SD = 4.5), the average duration of illness was 3.5 year (SD = 2.5) and the mean number of years of education was 15.3 (SD = 2.22). All of the inpatients had been receiving the same medications and dosages for at least two weeks. Ten subjects were treated with monotherapy, 17 patients were taking two antipsychotics, in the case of one person the data is missing. Patients in the vast majority (n = 25) received second generation antipsychotic medications (ziprasidone, amisulpride, clozapine, aripiprazole, risperidone, olanzapine, sertindole, quetiapine), and two people were treated with first generation antipsychotics (zuklopenthixol, flupentixol). 28 healthy control participants were recruited who matched the group of patients in terms of age (M = 27.4, SD = 4.5), gender (20 males) and number of years spent in education (M = 15.9, SD = 1.8).

Method

Cognitive control

The cognitive control was measured with the short version of Attention Network Test (ANT) designed by Fan, McCandliss, Sommer, Raz and Posner [17] in the Polish version made by Zajenkowski [18]. The authors' starting point was the assumption that the attentional system can be divided into three functionally and anatomically independent networks: alerting (allows for maintenance of a vigilant and alert state), orienting (responsible for selection of space region to be attended), and executive control (the monitoring and resolution of conflict between expectation, stimulus, and response). In the present study we were focused on the latter network as an index of cognitive control. In the ANT task, on each trial, the participant has to decide, by pressing a button, whether a central arrow stimulus (the target) points left or right. The target is flanked by distractor stimuli – four arrows. The flankers which may be congruent with the target (arrow points in same direction) or incongruent (arrow points in opposite direction). In each case, two flankers are presented on either side of the target. In each trial participants see central fixation cross 400 ms, followed by target until participant responds. The executive control index is calculated by subtracting the response time (RT) median of the congruent flanking conditions from the RT median of incongruent flanking conditions. In the present study we were mainly interested in the executive control.

Stress states

The short version of the Dundee Stress State Questionnaire (DSSQ) in a Polish adaptation by Zajenkowski [19] was used to assess three subjective state factors: task engagement (energy, task motivation, concentration; e.g. item "I am determined to succeed on the task"), distress (tension, unpleasant mood, lack of confidence; e.g. item "I feel tense"), and worry (self-focused attention, low self-esteem, cognitive interference related to task and personal concerns; e.g. item "I feel concerned about the impression I am making") [13]. There are 24 items, with 5 − point response scales. The internal consistency of the Polish version is high (task engagement $\alpha = 0.80$; distress $\alpha = 0.76$; worry $\alpha = 0.84$).

Results

First, we compared the results of people with schizophrenia and controls on all variables used in the study (see table 1). Patients had higher score on the cognitive control, the indicator of which was ANT result. This means that the patients were less effective inhibiting prepotent responses (a higher score means a longer reactions in terms of non-compliance of the central stimulus and distractors). Moreover, people

with schizophrenia exhibited higher level of all stress states, task engagement, distress and worry, in comparison to healthy controls.

Table 1. **Cognitive control and stress states in the group of patients and the control group – descriptive statistics and between groups difference test**

	Statistic	Patients	Controls	Group difference
Alerting	Mean (SD)	17.50 (25.21)	14.70 (21.33)	t(54) = 0.44; p = 0.670; d = 0.12
	Skewness	0.45	-0.02	
	Kurtosis	-0.46	-0.05	
Orienting	Mean (SD)	56.42 (41.85)	56.90 (23.96)	t(54) = – 0.05; p = 0.960; d = 0.01
	Skewness	-0.40	-0.75	
	Kurtosis	0.73	0.26	
Control	Mean (SD)	118.02 (53.73)	92.32 (30.56)	t(54) = 2.20; p = 0.033; d = 0.60
	Skewness	1.00	0.99	
	Kurtosis	0.67	1.01	
Task engagement	Mean (SD)	22.11 (3.70)	19.43 (5.90)	t(54) = 2.04; p = 0.046; d = 0.54
	Skewness	1.10	-0.53	
	Kurtosis	0.80	-0.68	
Distress	Mean (SD)	12.00 (4.16)	9.05 (4.80)	t(54) = 2.50; p = 0.020; d = 0.66
	Skewness	-1.10	1.12	
	Kurtosis	1.23	1.76	
Worry	Mean (SD)	14.53 (6.30)	10.32 (5.30)	t(54) = 2.73; p = 0.009; d = 0.72
	Skewness	-0.39	-0.27	
	Kurtosis	-0.43	-0.50	

SD – standard deviation, p – level of significance, t – Student's t-test, d – Cohen's d

Next we correlated all variables (see table 2). Most important, we found, that cognitive control is positively associated with worry, which means, that the increased level of worry resulted in poorer performance on cognitive control. Moreover, the three factors from DSSQ were intercorrelated.

Table 2. **Pearson's r correlations between the study variables**

	Orienting	Control	Task engagement	Distress	Worry	Age	Years of education	Duration of illness
Alerting	-0.39**	-0.23	0.25	-0.18	-0.18	-0.16	0.16	0.13
Orienting		0.01	-0.01	0.00	-0.15	-0.06	-0.12	-0.06
Control			-0.19	0.14	0.36**	0.21	-0.18	-0.11
Task engagement				-0.51**	-0.28*	0.17	0.19	-0.02
Distress					0.62**	-0.08	-0.10	0.06
Worry						0.05	-0.13	0.19
Age							0.19	0.04
Years of education								0.09

* $p < 0.05$; ** $p < 0.001$ Note. For all variables used in the study n = 56, except the correlation for the duration of illness (n = 28).

To test whether cognitive control mediate a relationship between a group and the level of ANT performance, a series of regression analyses were performed (see figure 1). Mediation model was analyzed using the method we used the method suggested in the paper [20] which tests mediation effect (indirect) using bootstrapping (it does not require assumptions as to the shape of the distribution of the variables and it is recommended especially for small samples). The direct effect between group and cognitive control (beta = 0.29, $p < 0.05$) was significantly reduced upon the inclusion of the mediator (worry) to the model (beta = 0.18, $p > 0.05$). The indirect effect was – 9.32, $p < 0.05$, (based on the bias corrected 95% confidence interval not spanning zero, between – 24.26 and – 1.43) and was statistically significant [20]. The obtained result suggests that the lower result obtained by patients in the task measuring the efficiency of cognitive control may be partially explained by their tendency to focus on the information that is irrelevant to the task.

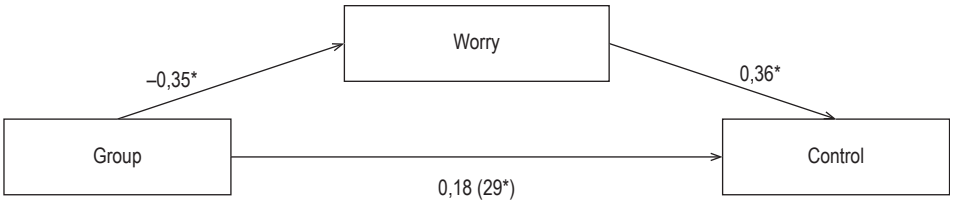

Figure 1. **The mediating effect of worry between "group" and "cognitive control" variables**

Note: "Group" variable is coded as follows: 0 = patient; 1 = control group

Discussion

In the present study we compared the differences between patients with schizophrenia and healthy subjects in cognitive control and stress states levels associated with solving cognitive tasks. We found that patients were less efficient in the cognitive control task. This result is consistent with previous findings, indicating, that patients with schizophrenia, compared to healthy individuals, deal worse with response inhibition tasks, such as ANT [8, 9]. Moreover, this study showed that patients with schizophrenia experienced higher task engagement, distress and worry in comparison to controls. These results are consistent with the results of studies conducted so far. Higher task engagement means higher motivation to succeed on the task, but also higher energetic arousal. According to some researchers, patients are characterized by a tendency to experience increased level of physiological arousal [21]. The patients also experienced higher level of distress than the control group. This result is also consistent with previous findings showing that schizophrenia spectrum individuals experienced more anxiety and fear than healthy subjects as a reaction to daily events [14, 22]. These results are consistently repeated in numerous evocative tests and daily-life studies [23]. High distress is frequently linked to symptoms such as paranoid ideation and persecutory delusions [21, 24]. The studies also show that the intensity of worry is similar among the patients with schizophrenia and patients diagnosed with generalized anxiety disorder, and higher than in the healthy control group [25] what was confirmed in the present research.

In the present study we showed that there is a significant relation between the worry and poor functioning of the working memory. This result is in accordance with processing efficiency theory, that postulates, that thoughts that appear when worrying interfere with the functions of processing and storing the information concerning the task [11]. Moreover, the worrisome thoughts influence the self-regulation processes (the cognitive inhibition) and therefore they consume some portion of the available resources of the working memory [11]. The result received in the present research is also congruent with many correlational studies (for review see: [11]) and with an experiment conducted in the healthy population [26].

Most interesting, we found that worry mediated the relationship between "group" and "cognitive control", suggesting, that patients had problems with the cognitive performance due to increased level of worry. The latter represents a tendency to focus on personal concerns, that is information irrelevant to the task. It is possible, that these thoughts distracted patients with schizophrenia and took their cognitive resources. This is consistent with Hahn et al. [5], who noticed that distracting factors in schizophrenia may originate from sources outside the task, such as external or internal stimuli. It seems to be confirmed in a recent neurocognitive study which showed that patients with schizophrenia have difficulties with unwanted thoughts suppression [27]. It is also worth noting, that the reduced performance in WM in schizophrenia may be similar to the behaviour of non-schizophrenic low WM capacity individuals. Such

persons have difficulty in focusing solely on information related to the cognitive task they performed [10].

The interpretation of the result, that worry is a mediator of the relationship between the variables "group" and "cognitive control", can also be completely different because of the correlational nature of this study. Cognitive theory of pathological worry postulates that the deficits in working memory are the cause for the elevated levels of worry because of the lack of resources to control unwanted thoughts [28]. Therefore, we can put an alternative hypothesis that individuals with schizophrenia are people who have reduced levels of working memory functioning and therefore they experience a higher level of worry when performing a cognitive task. This thesis is also confirmed by the results of the experiment conducted by Freeman et al. [29]. The study included 67 psychotic patients with increased tendency to worry who were randomly assigned to one of the three groups: (1) subjected to a procedure of worry induction, (2) subjected to a worry reduction procedure, and (3) neutral condition. In this study no significant effect of the experimental condition on the working memory was found. However, it should be noted that the authors indicated that there were crucial methodological shortcomings concerning the efficiency of the experimental manipulation. In order to determine the cause-and-effect relationship between worry and working memory functioning among psychotic patients it is necessary to conduct further studies in experimental scheme.

The results of the studies conducted among psychotic patients must be interpreted in the context of the characteristics of the group (e.g. phase of the illness, pharmacological and psychological methods of treatment, the intensity of psychopathological symptoms). Patients that participated in this study were relatively young (the mean age was 30 years), suffering from psychosis for a relatively short period of time (on average 3.5 years), receiving mostly second generation antipsychotic drugs and in a stable phase of the illness. Generalization of the results on the entire population of psychotic patients should be done very cautiously.

Our study has also practical application. We know that different cognitive trainings indeed improve cognitive functions in patients with schizophrenia, but the overall effect is not fully satisfactory (for example a meta-analysis summarizing 26 randomized, controlled trials of cognitive rehabilitation of patients with schizophrenia showed that the average size of the impact of cognitive training on the improvement of cognitive functions is low [30] (Cohen's d for the change before and after the training was 0.41 which is considered as low [31]). Moreover, over the last 40 years no progress in effectiveness of new training methods has been observed [30]. There are two big groups of cognitive trainings (training programs to enhance cognition and compensatory rehabilitation programs) and none of them stress the importance of the relationship between the anxiety and cognitive performance [32]. Taking into account the results suggesting that worry may be an important source of some cognitive deficits (e.g. cognitive control) in patients with schizophrenia work aimed at increase in the ability to inhibit thoughts unrelated to the task being performed and

focused on reducing the negative affect could be a valuable complement to existing training proposals.

Conclusions

The study presented above revealed that people with schizophrenia were less efficient in the cognitive control task than health subjects. Moreover, patients also experienced higher level of task related stress, namely task engagement, distress and worry, compared to healthy controls. Further analysis showed that patient's cognitive deficits in the area of cognitive control might be partially explained by their increased level of worry (focus on task unrelated thoughts) during task performing.

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