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ORIGINAL PAPER

Subjective emotional over-arousal to neutral social scenes in paranoid schizophrenia

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Abstract From the clinical practice and some experimental studies, it is apparent that paranoid schizophrenia patients tend to assign emotional salience to neutral social stimuli. This aberrant cognitive bias has been conceptualized to result from increased emotional arousal, but direct empirical data are scarce. The aim of the present study was to quantify the subjective emotional arousal (SEA) evoked by emotionally non-salient (neutral) compared to emotionally salient (negative) social stimuli in schizophrenia patients and healthy controls. Thirty male inpatients with paranoid schizophrenia psychosis and 30 demographically matched healthy controls rated their level of SEA in response to neutral and negative social scenes from the International Affective Picture System and the Munich Affective Picture System. Schizophrenia patients compared to healthy controls had an increased overall SEA level. This relatively higher SEA was evoked only by the neutral but not by the negative social scenes. To our knowledge, the present study is the first designed to directly demonstrate subjective emotional over-arousal to neutral social scenes in paranoid schizophrenia. This finding might explain previous clinical and experimental data and could be viewed as the missing link between the primary neurobiological and secondary psychological mechanisms of paranoid psychotic-symptom formation. Furthermore, despite being very short and easy to perform, the task we used appeared to be sensitive enough to reveal emotional dysregulation, in terms of emotional disinhibition/hyperactivation in paranoid schizophrenia patients. Thus, it could have further research and clinical applications, including as a neurobehavioral probe for imaging studies.

Keywords Paranoid schizophrenia · Emotional arousal · Emotional experience · Emotional salience misattribution · Social cognition

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Introduction

Emotional experience is a very important factor for social adjustment [1, 2] and for the functional outcome [3] in

schizophrenia. Social-cognitive functioning is another factor predicting the social outcome in schizophrenia patients [4]. Social-cognitive deficits [5, 6] and emotional under-arousal in response to affect-laden social stimuli [7–14] are among the most robust findings in schizophrenia. Clinically, the flat or blunted affect, emotional withdrawal, apathy and anhedonia, i.e., the symptoms of *decreased* emotional experience within the negative syndrome dimension, have been regarded as a hallmark of the fundamental disease process [15–17].

Relatively neglected in the literature is the opposite pole of emotional dysregulation in schizophrenia—the abnormally *increased* emotional experience. Its basic role in paranoid psychosis has been pointed out as early as the beginning of the last century within the classical psychodynamic models of psychotic-symptom formation in "paranoia" [18], "dementia praecox" [19] and "schizophrenia" [15]. Actually, these models have assumed that *strong* affects divert associations from the laws of logic and lead to the so-called emotionally charged or affect-laden complexes that determine delusion formation and hallucinogenesis [15, 18–21].

A more recent model of paranoid psychosis, presuming persecutory delusions to arise from an interaction between psychotic and emotional processes, has been developed within the framework of cognitive psychology [22, 23]. It assumes psychotic social anxiety as a key emotion, leading to a search for meaning and explanation, thus contributing to the creation of threat beliefs. Accordingly, persecutory delusions are regarded as explanations of the *increased* anxious *arousal*.

Other biological and psychological models also emphasize the role of emotional *over-arousal* for the formation and maintenance of paranoid delusions and hallucinations [24–26]. In general, they consider the positive symptoms to result from a rapid search for meaning, due to intolerance of ambiguity, caused by the *increased* anxiety and *over-arousal* [27–29]. Some of them implicitly admit that emotional over-arousal might underlie cognitive biases (e.g., meaning assignment or jumping to conclusions), thus contributing to psychotic-symptom formation [24, 25, 28, 30–32].

Consistent with these theoretical models, abnormally *increased* emotional experience has been reported in studies using a variety of approaches. In the context of daily life, schizophrenia patients find social interactions more activating [33] and react with more intense emotions to subjective appraisals of stress [34]. Standardized clinical measures have revealed high levels of negative affect like hostility, guilt, anxiety and fear in schizophrenia [35]. Abnormally high levels of negative emotion have been reported also from studies employing trait emotion instruments [3, 36]. Furthermore, schizophrenia patients compared to healthy controls appear to have greater arousal and higher levels of ambivalence in response to auditory and visual stimuli [37]. Moreover, a meta-analysis of laboratory studies of emotional experience in schizophrenia has revealed that patients experience relatively stronger aversion to positive and *neutral* stimuli [38].

Despite the fact that in the recent years more evidence has been accumulated of *increased* emotional *experience* (but not increased emotional *expression*) in paranoid schizophrenia, the findings are still controversial and there is a lack of studies especially designed to explore this phenomenon. In general, most controlled laboratory studies to date fail to find a significant difference between the emotional experience of patients and controls [39–41]. Besides, little attention is paid to the spontaneous subjective experience, as most studies focusing on emotional experience in schizophrenia use mood induction paradigms. The spontaneous subjective emotional experience is important to be examined as it is closer to what happens and what matters in real-life situations. Another aspect that has not gained enough attention in the empirical studies on emotional experience in schizophrenia is the social relevance of the stimuli. It is worthy to be considered as most patients with schizophrenia are particularly vulnerable to social stimuli [6, 7, 22, 42] and have prominent impairments that are clinically manifested in social contexts. Patients exhibit profound deficits in social functioning that severely impact the quality of their lives [43]. Besides, social stimuli compared to non-social ones are processed differently in their brain [44]. Sociality affects also the subjective and physiological responses to emotional valence [45]. That is why the social relevance of the stimuli appears to be a necessary parameter in designing experimental paradigms. The social stimuli that are most widely used represent photographs of facial expressions [12, 13, 46]. However, they are usually out of context and lack real-life complexity. The use of complex social scenes that represent real-life situations seems to be particularly appropriate but still unexplored direction for schizophrenia research. Until now, laboratory studies focusing on the subjective emotional arousal (SEA) to complex social scenes in paranoid schizophrenia patients are still lacking.

A very closely related phenomenon of *affective* misattribution bias has been recently demonstrated together with the accumulating body of evidence of *increased* emotional experience in paranoid schizophrenia patients. This affective cognitive bias denotes misattribution of emotional salience (e.g., threat assignment) to different types of non-salient *neutral* stimuli. For example, emotionally neutral human faces [46], words [42] and non-structured (projective) visual and auditory rhythms [29] were misperceived (misinterpreted) by paranoid patients as affective, emotionally salient ones. Although the observed aberrant

cognitive bias has been conceptualized to result from *emotional over-arousal* associated with the positive symptoms of paranoid psychosis [47], the subjective emotional arousal level has not been *measured* directly in the prior studies. This explanatory concept was based on the clinical observations that a pre-existing anxious delusional *mood* contributes to the psychotic patients' tendency to assign emotional salience to non-salient emotionally *neutral* events and situations [16, 17, 29]. Hence, it could be predicted that such non-salient emotionally neutral stimuli would be of great importance for the discrimination of paranoid patients from healthy controls, since an *increased* SEA could be expected in response to *neutral* social stimuli in paranoid schizophrenia.

The goal of the present study was to *quantify* the level of SEA, evoked by non-affective (emotionally neutral) and affect-laden (negative) social scenes in patients with paranoid schizophrenia, compared to healthy controls. With the use of socially relevant stimuli, we aimed to shed more light on the emotional mechanisms of aberrant social cognition in paranoid psychoses. Our approach to emotional arousal, using self-report measures, seemed satisfactorily reliable, because recently it has been demonstrated that schizophrenia patients are capable to relatively well evaluate their own emotional states [48]. The basic hypothesis was that patients would have a *higher* SEA level, more specifically for the non-salient *neutral* stimuli, as compared to the control subjects.

Materials and methods

Subjects

Thirty inpatients with paranoid schizophrenia (hospitalized for acute psychosis or psychotic exacerbation) and 30 healthy control subjects, pairwise matched on gender (all males), age and years of education, participated in the experiment. There was no difference also between the parental education of the patients and the controls. Only males were studied in order to reduce variability introduced by potential gender differences in emotional responding [49]. Inclusion criteria for the patients were diagnosis of paranoid schizophrenia (F20.0), according to the ICD-10 criteria [50], based on the ICD-10 symptom checklist [51]. Exclusion criteria for patients and controls comprised history of or current (concomitant) psychiatric or neurological disorders, alcohol or substance abuse, mental retardation (IQ below 85), and lack of ability or desire to provide informed consent. Patients had moderately severe positive and negative symptoms as assessed by the positive and negative syndrome scale (PANSS) for schizophrenia [52]. They all were with actual paranoid symptoms, participated in an open post-marketing clinical trial and were on a standard antipsychotic treatment with aripiprazole as monotherapy (daily dose 26 ± 4.23 mg), started immediately after the admission in the acute psychiatric clinic. None of them have taken other psychotropic drugs such as anxiolytics or mood stabilizers. The previous treatment has been traditional (with different atypical antipsychotics in various dosing strategies). Eleven of the patients were already on aripiprazole treatment before the admission, and seven other patients have stopped their maintenance antipsychotic treatment before the actual psychotic relapse. There were no patients on long-acting or depot antipsychotics. The included patients were with predominantly remitting forms of the illness with relatively few previous episodes (5.46 ± 1.23). They were tested as soon as possible (after 14.38 ± 3.12 days) when their psychotic state permitted them to understand and follow instructions and to give informed consent. Demographic and some other clinical characteristics of the participants are presented in Table 1.

Table 1 Demographic and clinical characteristics of the participants

Gender	Controls ($n = 30$) only males M ± SD	Patients ($n = 30$) only males M ± SD	T	*P*
Parental education (years)	13.36 ± 4.18	12.73 ± 3.47	.64	.53
Education (years)	13.6 ± 3.22	13.6 ± 3.22	.00	1
Age (years)	38.03 ± 12.57	38.03 ± 12.57	.00	1
PANSS-P	NA	17.9 ± 7.18		
PANSS-N	NA	19.3 ± 7.46		
Duration of episode (days)	NA	35.27 ± 6.6		
Duration of illness (years)	NA	14.23 ± 10.09		

NA not applicable, *PANSS-P* positive and negative syndrome scale-positive subscale, *PANSS-N* positive and negative syndrome scale-negative subscale

The study was approved by the local ethical committee of the University Hospital of Neurology and Psychiatry "St. Naum" (Sofia, Bulgaria) and has been carried out in accordance with the latest version of the Declaration of Helsinki. Written informed consent was obtained from all subjects before inclusion in the study and after the nature of the procedures and all details had been fully explained.

Apparatus

The experiment was carried out in a quiet laboratory examination room on a laptop with a 14" diameter of the screen, resolution of 1,024 × 768 pixels, 96 dpi and a refresh rate of 60 Hz. The task was administered on a Presentation Software (www.neurobs.com). The stimuli were projected onto the display. Subjects were placed in

normal viewing distance from the monitor, and the responses were given by mouse click. There were standardized lighting conditions.

Stimuli

Stimuli were colored photographs depicting emotionally neutral and affect-laden aversive (negative) scenes. All of them were chosen to be with socially relevant content with at least one person presented. They were selected from the International Affective Picture System [53] and the Munich Affective Picture System [54]. The MAPS is a standardized database similar to the IAPS, consisting of photographs that vary in terms of emotional valence and arousal. We have included scenes from MAPS, as this database is compiled especially to tap socially relevant phenomena—for use in studies about emotional experience and perception in settings and/or in clinical populations in which the social aspects are particularly prominent or of interest. One great advantage of MAPS for such studies is that it consists only of photographs, depicting complex scenes with social content for all dimensions of valence and arousal. For the purposes of the present study, ten emotionally neutral social scenes were chosen, which have been previously found to be with low arousal and medium valence. The values of the ratings of the neutral scenes in the normative MAPS study have been determined with the SAM 9-point rating scales and are 4–6 on a valence scale (1–3 = negative valence and 7–9 = positive valence) and below three on an arousal scale (1 = lowest arousal and 9 = highest arousal).

To avoid habituation, in addition to the ten neutral scenes, we included ten affective ones. The affective stimuli were ten *aversive* social scenes, with low valence and medium arousal. The values from the normative study were 2–3 for the valence and 4–5 for the arousal. The neutral scenes presented persons attending public events or engaged in work, hobbies or everyday tasks, while the negative scenes presented people in situations of loss, grief, abuse, poverty, physical threat, injuries and disaster.

The neutral and the negative scenes were matched on size, color brightness, picture complexity, number of depicted persons and format. In addition to the 20 social complex scenes, there were 20 non-social and non-arousing baseline pictures, introduced to neutralize the impression of the scenes by masking their psychological effects.

Design and procedure

Each subject was tested individually. Written and oral instructions were provided together with practice trials prior to the actual experiment with individual feedback to assure comprehension also in patients. Before the experimental task, there was a preliminary task for training with the rating scale. As the rating in the main task was on a scale that was designed to be conveniently used in functional magnetic resonance imaging (fMRI) studies, it was an increasing in size bar. Thus, it required a button press within a certain time span. That is why we have included training with the scale, so that participants get used to it and can practice working with it as long as they needed. Only after participants have mastered the scale and it was clear, they manage to give their intended responses in time the experiment proceeded to the main task.

Training with the scale

The preliminary task for training with the rating scale that was performed at the very beginning of the experiment was a task for pressing a button at a particular moment. Participants were told random numbers from 1 to 9 that corresponded to particular positions of horizontally increasing in size rectangular bar. They were required to press the button at the appropriate moment, before the bar reaches the next position. In this task, a horizontally increasing bar was included, which was the same as the rating scale used in the main part of the experiment. Proceeding to the major task only after it was assured that participants manage to press a button fast enough to record their desired response excluded possible artefacts due to the scale, motor slowing and motor coordination deficits of the patients. The reason for constructing the rating scale as a moving bar was to be in accordance with other studies [55, 56] and easily applicable in fMRI.

Experimental task

In the experimental task, participants were asked to rate their SEA after seeing a social scene presented on the screen. While a scene was shown, subjects had to view it passively and be prepared to rate the evoked level of SEA. The ratings had to be given on a nine-point scale. The scale was designed to be similar to the self-assessment manikin (SAM) scale [57] and was programmed as a ninefold sliding scale. It consisted of a display of a green horizontal rectangular bar labeled "level of subjective emotional arousal" with anchors of 1 = low and 9 = high. The bar was increasing in size from one side to another for 8 s, stopping at nine positions. The first position was corresponding to the lowest level of SEA and the last to its highest level. Subjects were instructed to press the mouse button when the bar had grown to a size that corresponds to the level of SEA they experience. The bar provided a continuous index of participants' subjective experience of emotional arousal. The two ends of the emotional arousal scale represented two opposite states of the subject: calm/sleepy/drowsy versus excited/panicked/aroused state in

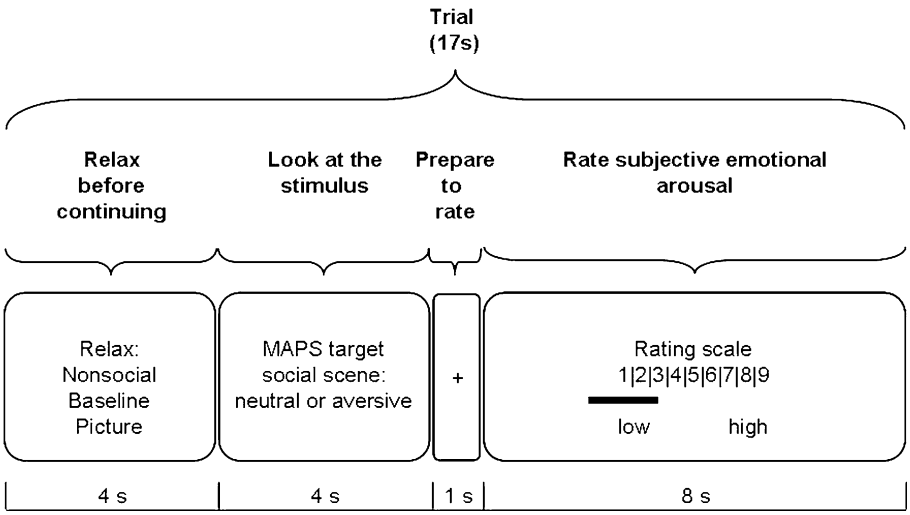

Fig. 1 Schematic representation of a single trial from the experimental task

response to the target scene. The task consisted of 20 trials, randomized across two conditions—negative and neutral. The procedure within a single trial with the timings is presented in Fig. 1.

Data analysis

The study was cross-sectional, and we did both within- and between-subject comparisons. To examine whether the SEA differed across affective categories, depending on diagnosis, a 2 × 2 repeated measures ANOVA was used with affective category (neutral vs. negative) as a within-subject factor and group (schizophrenia patients vs. healthy controls) as a between-subject factor. Planned independent-samples *t*-tests were also performed. All analyses were done with the SPSS software (version 14.0, SPSS Inc., 2000).

Results

There was a significant group X affective category interaction ($F(1,58) = 88.77$, $P = .000$). Planned independent-samples *t*-tests revealed a significant over-arousal for all stimuli (the whole picture set) ($t(50) = -3.64$, $P = .001$) in schizophrenia patients (4.96 ± 1.45) compared to the healthy controls ($3.81 \pm .95$). When the comparison between the groups was done for each affective category separately, it was revealed that the difference was only for the neutral scenes ($t(45) = -6.67$, $P = .000$), but not for the negative scenes ($t(58) = -.16$, $P = .87$). The mean level of the SEA to the neutral stimuli in the schizophrenia group was 4.77 ± 1.61, while in the control group, it was $2.53 \pm .88$. For the negative stimuli, the patient group had a mean SEA level of 5.14 ± 1.53, and the control group, 5.08 ± 1.32 (Fig. 2).

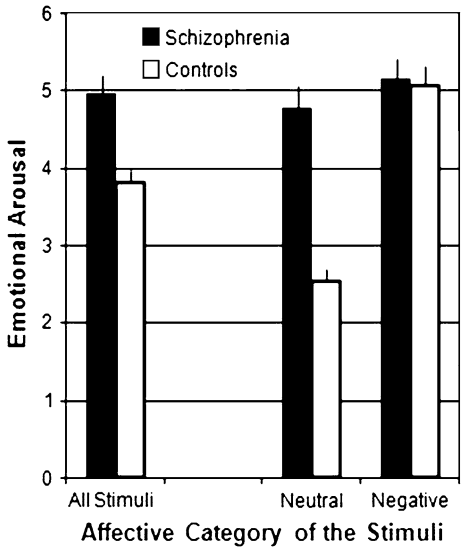

Fig. 2 Subjective emotional over-arousal to neutral stimuli in schizophrenia. The responses of the schizophrenia patients indicate an increased subjective arousal for social scenes in comparison with healthy subjects. Only the neutral social scenes evoked higher ratings on the subjective arousal scale in the schizophrenia patients, compared to the healthy controls. The *error bars* represent the standard error of the means

Discussion

The main finding of the study was the discrimination between paranoid schizophrenia patients and healthy controls, on the basis of their SEA ratings, particularly for the *neutral* stimuli. As could be seen in Fig. 1, the overall SEA level for the whole picture set was higher in the schizophrenia group relative to the controls. This is in line with previous findings, which have revealed an increased level of objectively recorded autonomic arousal in paranoid schizophrenia [41, 58]. However, when we distinguished the SEA level evoked by the non-affective, non-salient

neutral scenes from that evoked by the affect-laden, more salient negative scenes, the role of affective category of the stimuli became apparent. The emotional over-arousal of the schizophrenia group turned out to be evoked only by the *neutral* and not by the negative scenes. Such a finding is compliant with the preliminary hypothesis and the results of prior studies that have demonstrated a tendency in paranoid schizophrenia patients to misattribute affective meaning to a range of *neutral* stimuli such as human faces [46, 59], words [42], simple visual stimuli [60], and non-structured "projective" visual and auditory rhythms [29]. However, these studies have not employed direct measures for SEA level. Likewise, studies measuring visual attention to pictures of social scenes in schizophrenic patients with persecutory delusions have revealed increased visual attention to emotionally *neutral* but not to overtly threatening components of these scenes [61]. Analyses of such experimental findings suggest that the reality distortion dimension (i.e., the positive symptoms) in schizophrenia may be associated with an increased perception of threat from inappropriate stimuli, e.g., those classified as *neutral* by healthy individuals [29, 62]. On this background, the finding of a higher SEA level to neutral social scenes in paranoid schizophrenia patients might be extrapolated to any kinds of *neutral* stimuli provided they have some ambiguous social significance or hidden social meaning.

One possible explanation of our finding could be the hypothesis that in paranoid schizophrenia, a valence-independent emotional over-arousal might be "projected" to neutral social stimuli (as they are more ambiguous and predisposing to misperception and/or misinterpretation), thus leading to aberrant assignment of emotional salience to them [25]. Such an explanation is in agreement with the *cognitive* model postulating that schizophrenic patient's overwhelming sense of importance and meaning to *neutral* events in the environment can lead to the development of delusions in an attempt to make sense of these subjective experiences [62]. Findings from recent neuroimaging studies in schizophrenia reveal an over-activation of some mesolimbic structures, like amygdala [64, 65], hippocampus [66] and parahippocampal gyrus [63], which all take part of the so-called emotional brain [64, 67]. The same structures are normally activated in case of external danger [65, 67], and their abnormal over-activation evoked by otherwise insignificant and neutral stimuli is largely believed to underlie psychotic-symptom formation in schizophrenia [47, 63–65, 68]. Such mesolimbic activations could be related to our results of the patients' emotional over-arousal in response to non-salient neutral social scenes that are in line with those data. Indirect support for such a hypothesis could be found in the fMRI data that reveal over-activation of some mesolimbic structures ("fear systems") in response to *neutral* faces in schizophrenic patients [63, 65] and individuals at risk of psychosis [66]. Importantly, this functional *over-activation* has been interpreted as contributing to the development of psychotic symptoms [65], associated with reality distortion [63] and indicating a biological risk of psychosis [66]. Our finding of emotional over-arousal to *neutral* social scenes is consistent also with the *concept* of psychosis as a state of aberrant salience [68, 69] and the related model of emotional dysregulation in schizophrenia [64], both postulating that a stimulus-independent mesolimbic dopamine release may lead to increased anxiety and over-arousal, and the assignment of emotional salience to insignificant *neutral* stimuli in psychosis. In fact, according to these theoretical *hypotheses*, the psychotic symptoms of paranoid schizophrenia are due to non-selective mesolimbic hyperdopaminergia leading to endogenous anxiety and emotional over-arousal, which in turn results in misattribution of emotional salience to neutral (non-salient) stimuli (see [16, 25, 29]). The opposite direction of causality is also possible, i.e., alternatively, the patients might *cognitively* misperceive or misinterpret the neutral scenes as emotionally salient and therefore experience higher SEA levels to them. These two explanations are not mutually exclusive. Although from the present data it is not possible to make a firm conclusion and further research is required, in our view, the emotional over-arousal to neutral social scenes might be the missing link between the basic biological factors (e.g., mesolimbic hyperdopaminergia, functional over-activation of the "emotional" limbic structures or the "fear systems"), on the one hand, and the *psychotic* symptoms of paranoid schizophrenia [16, 25, 29], on the other hand. At the same time, this phenomenon could be regarded as being on the interface between affective and cognitive *production* at a psychological level of psychotic-symptom formation [16, 25, 29, 70, 71]. In such a way, the subjective emotional over-arousal to neutral social scenes in paranoid schizophrenia patients could be viewed as a misattribution of emotional salience to non-salient stimuli. This *affective* production in non-affective psychoses [16, 25, 47] corresponds to the current tendency for convergence between affective and non-affective psychoses into a new dimension called "salience syndrome" [71] or "salience dysregulation syndrome" [72].

A related and equally important issue is whether the antipsychotic medication may have an impact on the SEA level and to what extent our findings could be related to this medication. In order to minimize the possible confounding factors of the treatment, we have selected only patients on a standardized monotherapy. Nevertheless, since the normal controls were not on medication, a role of the antipsychotic treatment for our results could not be rejected without further studies. However, our preliminary investigations [16, 25, 29] demonstrated that the atypical antipsychotics

do not increase but rather *decrease* the SEA level. On the other hand, from the experimental and theoretical data cited above, it may be concluded that the increased EA to neutral stimuli is associated with increased mesolimbic dopamine (DA) levels and/or over-activation of the "emotional brain", which both underlie psychotic symptoms. Since the antipsychotic treatment theoretically *decreases* the mesolimbic DA levels and *reduces* the misattribution of salience to neutral stimuli, thus *suppressing* the psychotic symptoms [68, 69], it is logical to expect that it would *decrease* the SEA to the neutral social scenes instead of increasing it. Therefore, we might assume that our finding is not resulting from the treatment but rather is due to the paranoid psychosis itself. We hypothesize that the potential effects of psychosis (toward increasing the SEA level) are confronted with the antipsychotic treatment effects (toward decreasing the SEA level). In any case, the best way to directly test the possible role of medication is to include unmedicated patients. If our hypothesis is true, they will have even greater levels of SEA to the neutral social scenes. It is worthy to note here that at the moment of the SEA testing, some of the patients investigated by us have been still actively psychotic (partial responders or non-responders), while others have been already influenced therapeutically (treatment responders). According to our hypothesis, the psychotic patients would be with higher SEA levels than the remitted ones. That is, another way to dissect the role of antipsychotic treatment from that of paranoid psychosis itself is to compare patients who are still psychotic to clinically improved (at least to some extent) post-psychotic patients. This is an issue with great theoretical and clinical impact. For that reason, we have focused on it in our next article, which is currently in preparation.

Another aspect that is important to be pointed out, relevant to the discussion of the treatment effects, is that (contrary to our expectations) we did not find a significant *deficit* of SEA in response to the emotionally salient (negative) scenes. This could be explained by the fact that all patients in our study were in a state of acute psychosis either currently or recently. Probably for that reason, they do not present with reduced affective reactions (see [16, 25]). Concerning the role of aripiprazole as a confounding variable, it is well known that almost all antipsychotics reduce affective reactions (especially in healthy controls). As already said, most probably the drug should *reduce* the higher SEA levels to the neutral social scenes in the patients. It remains unclear why these levels are not normalized (i.e., returned to the normal) in spite of the current treatment and why the antipsychotic treatment does not significantly reduce the SEA levels to the emotionally salient social scenes. A possible answer of the first question is that without treatment the SEA levels to the neutral scenes would be even *higher* and they, in fact, are relatively reduced by the drug, though remaining higher as compared to the norm. The answer of the second question could be related to the possibility that the short-term treatment is not enough to cause reduction in the reactivity to *affective* (aversive) stimuli. In any case, further studies are needed to give a more definite answer to these important questions.

The present study is just an initial step in the process of understanding the SEA in schizophrenia. Further investigations and their analyses would be important to deepen our knowledge in this promising direction. One of the limitations of the study is related to the fact that we have investigated only males, aiming to prevent the confounding role of the gender. Therefore, further studies including female populations would be necessary. Another issue that should be considered is that the responses were given by motor reaction, and an ability to press a button with a certain minimum pace was required. Thus, clumsiness, motor and cognitive slowness characteristic of schizophrenia patients might be a potential confounder, although such a probability is minimal, having in mind that the timescales are quite different (milliseconds vs. seconds). Nevertheless, in order to overcome this potential problem, a practice task was introduced to assure that patients are able to give their responses as they want. Furthermore, the rating scale was designed in such a way, so that it unfolds slowly enough to enable even patients with motor retardation to give their responses in time. Thus, slowness of patients does not have an impact on the results. Besides, retrospective debriefing confirmed that patients managed to record their intended SEA values.

In the present study, we have measured only the subjective arousal, without including objective measures such as skin conductance response (SCR), because we were interested primarily on the subjective emotional experience and not so on the objective autonomic-arousal level in response to the social scenes. However, in future studies, parallel measurements of the autonomic-arousal level would allow assessing the objective correlates of the self-rated SEA level in response to the non-salient and non-affective stimuli.

As a next step, it would be interesting to explore to what extent the heightened SEA level to *neutral* social scenes is associated with misattribution of *threatening* significance to them, by additional examination of their perceived emotional valence (together with or after the SEA ratings). In the present study, we have not investigated this emotional parameter because we have focused on the arousal as a valence-independent measure in order to reveal the emotional salience misattribution to neutral social stimuli, irrespective of the valence of the misattributed emotion. Certainly, the role of the valence is also very interesting, and in future studies, we plan to analyze it by adding

valence ratings of all stimuli and including not only negative (aversive) but also positive (pleasurable) social scenes. The valence rating would also allow us to check to what extent the SEA depends on the type of emotion that is experienced—positive versus negative, i.e., whether there is an interaction between arousal and valence.

Furthermore, direct fMRI recordings during the execution of the task (which is especially designed for functional neuroimaging research) by paranoid schizophrenia patients would help to reveal the brain mechanisms that underlie the emotional over-arousal in response to neutral [65, 66] but not to affect-laden social stimuli [63]. As the effect sizes appear to be quite large, our study proves to be a good basis for future functional neuroimaging research.

Conclusion

To our knowledge, the present study is the first designed to directly demonstrate the emotional over-arousal to non-salient emotionally neutral complex social scenes in paranoid schizophrenia patients. This finding might explain previous clinical and experimental data and could be viewed as the missing link between the neurobiological and psychological mechanisms of psychotic-symptom formation (reality distortion). More specifically, based on these findings, we might assume that the paranoid misattribution of emotional salience to neutral social stimuli could result from increased SEA. Further studies are necessary to test this hypothesis directly. Finally, it could be concluded that the simple task for SEA ratings appeared to be sensitive enough to reveal emotional dysregulation, in terms of emotional disinhibition/hyperactivation in paranoid schizophrenia patients. Thus, it could have further research and clinical applications. As the task was especially designed for use in fMRI, it could serve as a neurobehavioral probe for neuroimaging studies.

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Conflict of interest The authors declare that they have no conflict of interest.

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