

Humor processing and its relationship with clinical features in patients with first-episode schizophrenia

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ABSTRACT

Humor, a higher-order social cognitive process unique to humans, is commonly impaired in patients with chronic schizophrenia. However, humor processing and its association with the clinical characteristics in the early stage of the illness remain unknown. In this study, we investigated humor processing and its relationship with clinical features in patients with first-episode schizophrenia (FES). We recruited 45 patients with FES and 44 healthy controls matched for age, sex, and education level. The participants completed the Picture Humor Processing Task (HPT-p) and Video Humor Processing Task (HPT-v), which evaluated humor comprehension and appreciation, and a questionnaire assessing their humor styles. Clinical participants also completed clinical and social functioning measurements. Signal detection theory analysis was used to calculate the d' and β values, which represent the detection of humor signals in the comprehension phase and inner criteria of the humor appreciation phase, respectively. In the HPT-p, patients with FES showed a higher false alarm rate ($p = 0.048$) than healthy controls, whereas the hitting rate, signal recognition ability (d' value), and intrinsic evaluation criterion (β value) were comparable between the two participants groups. In the HPT-v, patients with FES showed lower within-group coherence in the funniness rating ($p = 0.023$) than healthy controls. In addition, the false alarm rate in the HPT-p and negative symptoms effectively predicted social functioning in patients with FES ($R^2 = 0.681$, $p < 0.001$). Our results indicate that impairment of humor comprehension in patients with schizophrenia is generated in the first episode and contributes to social functioning deficits, which require early recognition and intervention.

1. Introduction

Humor is a complex social cognitive process that is unique to human beings (Wild et al., 2003; Lefcourt, 2000) and is believed to represent complex higher-order emotional processing (Lefcourt and Martin, 1986). Humor processing comprises comprehension and appreciation phases (Wyer Jr and Collins 2nd, 1992; Campbell et al., 2015). In the

comprehension phase, one detects incongruous content and reorganizes coherence through reinterpretation, which can be further divided into the cognitive processes of expectation, incongruity detection, and resolution (Chan et al., 2013). Consequently, this reinterpretation evokes feelings of amusement in the appreciation phase, namely, the component of emotional experiences (Chan et al., 2012; Tsoi et al., 2008). Humor can be categorized into four types relative to target (self or other)

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and motivation (benign or detrimental). Affiliative humor aims to amuse others and promote relationships, whereas self-enhancing humor is typically used to cope with stress and maintain an optimistic mindset. Aggressive humor refers to the mocking and belittling of others to create laughter. Self-defeating humor refers to excessive self-deprecation or defensive negativity (Chan et al., 2018). Liking or disliking different types of humorous stimuli are closely related to the individual's personality traits, age, and sex (Chan et al., 2018; Vrticka et al., 2013; Zhang et al., 2021). Humor has multiple psychosocial and physiological benefits (van der Wal and Kok, 2019), including building and maintaining relationships and enhancing emotional health and cognitive function (Martin, 2007; Wilkins and Eisenbraun, 2009). Moreover, humor is a natural stress antagonist that can enhance the cardiovascular, immune, and endocrine systems (Bennett et al., 2003; Berk et al., 1989; Fry Jr., 1992).

Evidence has consistently shown that patients with schizophrenia (SCZ) have difficulty comprehending humor (Tsoi et al., 2008; Polimeni et al., 2010). However, the results from previous studies on humor appreciation in SCZ are inconsistent, as lower, higher, and comparable ratings of humor stimuli have been reported in patients with SCZ compared to healthy controls (Berger et al., 2018; Marjoram et al., 2005; Polimeni and Reiss, 2006; Tu et al., 2019). These inconsistent results may be attributable to the use of a single and different type of humor material that may not fully reflect the patients' humor-processing ability. Patients may process humor differently for different types of material (Chan et al., 2012). Additionally, previous studies focused on patients with chronic SCZ with an average disease duration >10 years (Tsoi et al., 2008; Polimeni et al., 2010; Berger et al., 2018; Marjoram et al., 2005; Polimeni and Reiss, 2006; Tu et al., 2019). Thus, whether humor-processing impairment appears in the first episode of the illness remains unknown, although the early stage of the illness is considered a critical period for complete symptom remission and the restoration of social functioning.

Social cognition is strongly associated with clinical symptoms and social functioning in patients with SCZ. However, previous reports on the relationship between humor and clinical characteristics of SCZ showed inconsistent results. Tsoi et al. found that humor processing was negatively correlated with delusions, apathy, depression, and neuro-cognitive function in patients with SCZ (Tsoi et al., 2008), whereas Polimeni et al. reported that humor impairment was only significantly correlated with cognitive impairment in patients with SCZ (Polimeni and Reiss, 2006). Daren et al. found that humor comprehension was negatively correlated with positive and disorganized symptoms but not with negative symptoms (Daren et al., 2020). Hence, while humor impairment in patients with SCZ may negatively impact their social functioning, existing evidence supporting this notion remains insufficient. Only one study has assessed the relationship between humor and social functioning. Polimeni et al. found that the greater a patient's ability to recognize humor, the better their social adjustment (Polimeni et al., 2010). Adamczyk et al. also found that compared with unemployed patients, those with stable jobs had better social skills, including better humor comprehension (Adamczyk et al., 2016). Examining the relationship between humor processing and clinical characteristics (especially social functioning) in patients with first-episode SCZ (FES) might reveal the clinical implications of humor processing and provide a novel perspective on functional recovery in SCZ.

In previous studies, humor appreciation has generally been represented by funniness ratings of the stimuli. Compared to the funniness rating paradigm, signal detection theory (SDT) provides a novel and more suitable approach to evaluate humor processing and has been applied in previous humor studies in SCZ (Tsoi et al., 2008). SDT explains how the individuals make decisions based on given evidence quantitatively via d' and β values. d' represents one's sensitivity to appropriate signals and ability to distinguish target signals from undesired signals. β represents one's inner criteria of objective judgment, which depends on cognition appraisal, motivation, and emotions.

In this study, we aimed to investigate impairment in humor processing and its relationship with clinical features (especially social functioning) in patients with FES. Based on a systematic review of previous studies, we hypothesized that patients with FES would show impaired humor comprehension but intact humor appreciation, and humor processing would be significantly associated with social functioning in SCZ.

2. Material and methods

2.1. Participants

Overall, 45 patients with FES and 44 healthy controls matched for age, sex, education level, and handedness were recruited for this study. The patients with FES met the following inclusion criteria: (1) aged between 16 and 35 years; (2) demonstrated an IQ >80 (assessed using the short form of the Wechsler Adult Intelligence Scale-Revised); (3) met the diagnostic criteria for SCZ in the Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition (DSM-IV); (4) disease duration ≤ 5 years; (5) Positive and Negative Syndrome Scale (PANSS) total score ≤ 60 ; and (6) stable treatment regimen in the last month. Participants were excluded if they had (1) other Axis I diagnoses according to the DSM-IV; (2) a history of head injuries, neurological disorders, or substance dependence; (3) serious somatic illness; or (4) received modified electroconvulsive therapy in the last 6 months. The healthy controls were also excluded if they had a lifetime history of psychotic disorder or a first-degree relative with a psychotic disorder. The mean antipsychotic dose was calculated as chlorpromazine equivalents. All participants provided written informed consent before participating in the study. This study adhered to the Declaration of Helsinki and was approved by the Ethics Committee of Peking University Sixth Hospital.

2.2. Clinical and neuropsychological measures

The PANSS was used to assess the patients' clinical symptoms (Kay et al., 1987), which were divided into positive symptoms (P1, G9, P3, P6, P5), negative symptoms (N2, N1, N4, N6, N3, G7, G16), disorganization (P2, G11, N5, G13, N7, G5, G15, G10), affect (G2, G6, G3, G4, G1), and resistance (P7, G14, P4, G8) (Shafer and Dazzi, 2019). Negative symptoms are further divided into two factors: expressive (N1, N3, N6, G7) and experiential (N2, N4, and G16) (Khan et al., 2017). The Negative Symptom Assessment scale (NSA) was used to comprehensively assess the patients' negative symptoms (Alphs et al., 1989; Huang et al., 2020). The Chinese version of the brief cognitive assessment for SCZ (C-BCAS) was used to measure patients' neurocognitive function (Shi et al., 2019). The Social Skills Checklist (SSC) was used to evaluate the patients' social function (Bellack et al., 2004).

2.3. Humor processing task

We used the Picture Humor Processing Task (HPT-p), Video Humor Processing Task (HPT-v), and Humor Style Questionnaire (HSQ) to comprehensively assess humor processing. The HPT-p and HPT-v were designed and presented using E-Prime 2.0 (e-prime.software.informer.com). The HPT-p comprised 40 humorous and non-humorous pairs of pictures. In the HPT-p, the pictures were presented one at a time in a random sequence, and the participants were instructed to judge whether the image was humorous by pressing a button. The HPT-v comprised 11 movie clips from the animated movie "Despicable Me"; each video was no longer than 1 min in length. The participants were instructed to rate the videos based on their level of humor and identify any moments they found amusing. The effectiveness of the HPT-p and HPT-v has been validated in previous studies (Liu et al., 2019). The HSQ comprised four subscales (affiliative, self-enhancing, aggressive, and self-defeating) and measured how people use humor in their social interactions.

2.4. Data analysis

Statistical analysis was conducted using SPSS Statistics for Windows, version 17.0 (SPSS Inc., Chicago, Ill., USA) with two-sided test. Statistical significance was set as $p < 0.05$. Between-group comparisons of demographic characteristics, neurocognitive functioning, social functioning, and humor processing abilities were performed using independent samples t -tests, Mann-Whitney rank sum tests, or chi-square tests, as appropriate. Correlations between humor processing ability and disease characteristics, clinical symptoms, neurocognitive functioning, and social functioning of patients with FES were assessed using Pearson or Spearman correlation analysis. Linear regression analysis was used to explore predictive models of FES social functioning.

For the HPT-p, hit rates (the number of correct judgments of humorous pictures divided by the total number of humorous pictures) and false alarm rates (the number of misjudgments of non-humorous pictures divided by the total number of non-humorous pictures) were calculated. Based on SDT, d' and β were calculated as follows: $d' = Z$ -transformed hit rates – Z -transformed false alarm rates; and $\beta = \frac{Y - \text{transformed hit rates}}{Y - \text{transformed false alarm rates}}$. Higher d' values indicated higher sensitivity to humor signals, whereas greater β values indicated more restrictive inner criteria. Independent-samples t -tests were used to compare between-group differences in d' and β values. For the HDT-v, we calculated the intragroup evaluation consistency of the video according to a previous study (Shi et al., 2019); the larger this value, the higher the intragroup evaluation consistency.

3. Results

3.1. Demographic and clinical data

Table 1 summarizes the demographic information and neuropsychological characteristics of the study participants. No significant differences in demographic characteristics were observed between the two groups. The cognitive test scores of patients with FES in the Trail Making Test A, Symbolic Encoding, Sustained Operant Attention, and Digit Breadth were significantly lower than those of healthy controls. All patients with FES were administered second-generation antipsychotics, including risperidone, ziprasidone, olanzapine, paliperidone, blonanserin, aripiprazole, and amisulpride.

3.2. Humor processing in patients with FES

Table 2 shows humor processing of patients with FES and healthy controls. Compared to healthy controls, patients with FES used less self-enhancing humor but used comparable affectionate, aggressive, and self-defeating humor. In the HPT-p, patients with FES had a significantly higher false alarm rate (effect size = 0.41) than healthy controls, although the hitting rate, signal recognition ability (d' value), and intrinsic evaluation criterion (β value) were not significantly different between the two groups. In the HPT-v, the total number of humorous moments identified by patients with FES and their funniness score were similar to that identified by healthy controls. However, the within-group coherence in evaluating humorous moments of patients with FES was significantly lower than that of healthy controls (effect value = -0.98 , $p = 0.023$) (Fig. 1).

3.3. Correlations between humor processing and clinical characteristics in patients with FES

In patients with FES, HPT-p false alarm rate was significantly correlated with negative symptoms ($r = 0.328$ – 0.343 , $p < 0.05$), disorganized symptoms ($r = 0.322$, $p < 0.05$), and social functioning ($r = 0.326$, $p < 0.05$). Among the multiple dimensions of negative symptoms, HPT-p false alarm rate correlated with the communication factor of the

Table 1

Demographic and clinical characteristics of patients with FES and HC.

	Patients with FES (n = 45)		HC (n = 44)		t/χ^2	sig(p)
	Mean	SD	Mean	SD		
Age (years)	23.13	3.92	23.07	4.49	0.07	0.942
Male:Female	24:21		22:22		0.10	0.753
Education years	13.89	2.58	13.59	3.05	0.50	0.619
C_BCAS						
TMT-A	45.60	3.75	47.83	2.74	−3.15	0.002
Symbol coding	45.18	7.54	53.60	10.07	−4.43	<0.001
Continuous performance	47.22	5.26	50.19	3.45	−3.09	0.003
Digit sequencing	46.64	7.71	52.07	7.59	−3.31	0.001
Duration of illness (months)	21.76	13.57				
Chlorpromazine equivalence (mg/day)	659.54	453.64				
PANSS						
Total	46.64	9.12				
Expressive factor	8.31	3.37				
Experiential factor	6.53	2.52				
Positive symptom	7.29	3.53				
Disorganized	10.36	1.91				
symptom						
Depressed	7.16	2.24				
symptom						
Excited symptom	4.40	1.21				
NSA						
Total	38.04	10.90				
Communication	12.29	4.67				
factor						
Affective flattening	7.11	1.82				
factor						
Motivation factor	15.91	5.15				
SSC	17.36	8.04				

FES: First-episode schizophrenia; HC: Healthy control; C_BCAS: Chinese version of brief cognitive assessment for schizophrenia; TMT-A: Trail Making Test Part A; PANSS: Positive and Negative Syndrome Scale; NSA: Negative Symptom Assessment; SSC: Social Skill Checklist.

Table 2

Between-group comparison of humor processing.

	Patients with FES (n = 45)		HC (n = 44)		t	sig(p)
	Mean	SD	Mean	SD		
HSQ						
Affiliative	30.60	5.88	28.71	5.69	1.52	0.133
Self-enhancing	21.04	6.62	23.79	6.35	−1.97	0.052
Aggressive	15.38	8.44	14.17	6.43	0.75	0.456
Self-defeating	13.42	6.37	12.17	6.25	0.93	0.357
HPT-p						
Hit rates	0.62	0.30	0.70	0.26	−1.35	0.181
False alarm rates	0.15	0.19	0.09	0.08	2.01	0.048
d' value	1.60	1.16	1.91	1.13	−1.28	0.204
β value	2.94	3.79	2.66	2.74	0.39	0.695
HPT-v						
Total number of humorous moments	11.91	9.65	13.84	8.58	−0.99	0.326
Funniness score	3.38	1.01	3.37	1.02	0.03	0.979
Within-group coherence	0.23	0.08	0.33	0.12	−2.46	0.023

FES: First-episode schizophrenia; HC: Healthy control; HSQ: Humor Style Questionnaire; HPT-p: The Picture Humor Processing Task; HPT-v: The Video Humor Processing Task.

Bold font indicates a statistically significant difference or trend.

NSA ($r = 0.343$, $p < 0.05$) and expressive factor of the PANSS ($r = 0.328$, $p < 0.05$), which similarly assessed speech quantity, interaction with the interviewer, and activity speed. HPT-p false alarm rate was not significantly correlated with positive symptoms, neurocognitive function, or

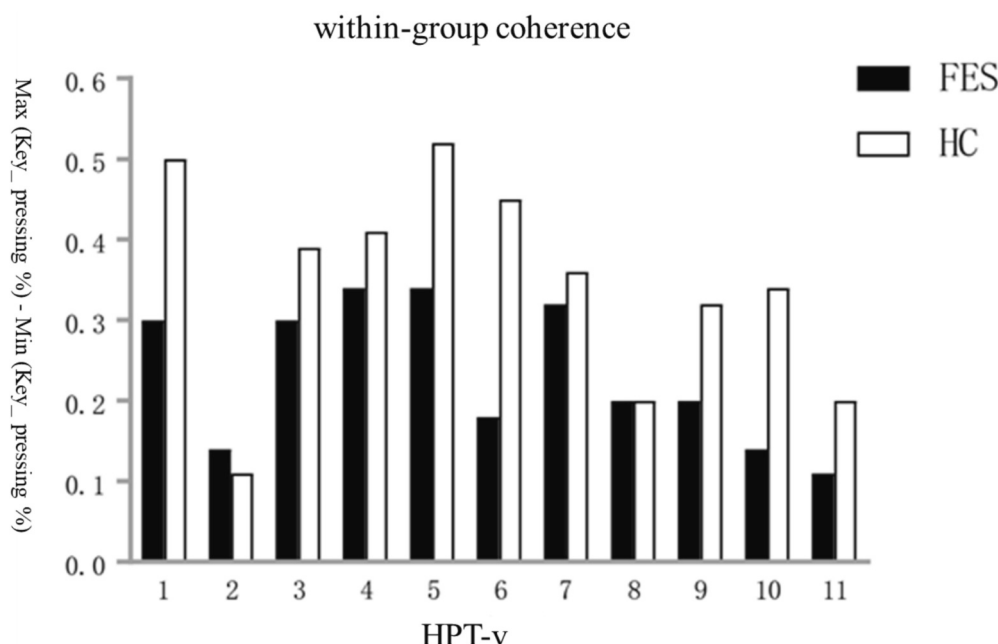


Fig. 1. Within-group coherence of judgment on funniness moment in the HPT-v. FES: First-episode schizophrenia; HC: Healthy control.

chlorpromazine equivalence. We performed further regression analysis based on the results of the correlation analysis, and factors significantly associated with social functioning in patients with FES were included in the stepwise regression model. The PANSS experience factor was entered into the regression model first ($R^2 = 0.560, p < 0.001$), followed by the HPT-p false alarm rate ($R^2 = 0.644, p < 0.001$), and finally the PANSS expression factor ($R^2 = 0.681, p < 0.001$).

4. Discussion

In this study, we used picture and video stimuli to comprehensively investigate impairment in humor processing and its relationship with clinical features in patients in the early stage of SCZ. We found that compared with healthy controls, patients with FES had a higher false alarm rate in the HPT-p, indicating that they more frequently misjudged non-humorous stimuli as humorous. Their within-group coherence in the judgment on funniness moment in the HPT-v was significantly lower than that of healthy controls, indicating a higher degree of dispersion in their judgments. In addition, the false alarm rate in the HPT-p and negative symptoms effectively predicted the social functioning of patients with FES. Our results suggested that humor impairment is present in the early stages of the illness and primarily marked by reduced discrimination of humorous signals and inconsistent evaluation, while humor appreciation remains largely intact. This provides a possible breakthrough in understanding the pathological impairments of patients with SCZ and facilitating their functional recovery.

4.1. Humor processing impairment in FES

Consistent with our finding of a higher false alarm rate in patients with FES, Adamczyk et al. used humorous cartoons with text captions in their study and found that individuals with SCZ rated neutral and odd pictures as funny more often (Adamczyk et al., 2018; Adamczyk et al., 2019). Moreover, Polimeni et al. found that patients with SCZ were worse at recognizing humor signals than patients with anxiety-depressive disorders or healthy controls (Polimeni et al., 2010). These results suggest that patients with SCZ may have a cognitive processing bias in the inconsistent information awareness and resolution stage, leading them to misidentify irrelevant signals as humorous signals. We

found that FES patients' judgments of humorous moments had a higher degree of dispersion, consistent with the findings of Tu et al. (Tu et al., 2019). In another study, Tsoi et al. found that while the number of humorous moments rated by patients with SCZ and healthy controls did not differ, the clips that patients with SCZ found funny were significantly different from those of healthy controls (Tsoi et al., 2008). These results reflect a deviation from the norm in the perceptions of humor in patients with FES. FES patients' high rate of false alarms and low consistency in humor processing may result in their inability to achieve a consistent understanding of humor with others in their social interactions. Consistent understanding of humor is essential for engaging in effective social interactions, and fostering social relationships or alliances is critical. Individuals with SCZ exhibit significant reductions in both social interactions and cooperative behaviors (Campellone and Kring, 2018; Hanssen et al., 2018), which may be related to their inconsistent understanding of humor. Considering that humor comprehension corresponds to the cognitive component of humor processing and humor appreciation is the emotional component (Vrticka et al., 2013), our findings may lead to new insights into the pathological damage in SCZ.

We also found that subjective ratings of humorous stimuli in FES patients were not significantly different from those in healthy controls, which were similar to the findings of some previous studies (Tsoi et al., 2008; Dominic et al., 2005) but differ from some others. Berger et al. found that the difference in SCZ patients' funniness ratings of humorous and non-humorous comics was not as pronounced as that of healthy controls (Berger et al., 2018). Adamczyk et al. found that SCZ patients' funniness ratings of absurd stories were significantly higher, whereas their funniness ratings of humorous stories were significantly lower (Adamczyk et al., 2017). In contrast, Tu et al. found that compared with healthy controls, SCZ patients tended to rate humorous videos as funnier (Tu et al., 2019). These inconsistencies may be caused by the use of different types of humor materials and slightly different evaluation metrics. For example, the present study and the study by Tu et al. focused on the funniness ratings of humorous videos, whereas the other two studies focused on differences in funniness ratings between humorous and non-humorous materials. This evidence suggests that FES patients can experience funniness from humorous stimuli; however, the source from which they derive funniness may differ from that of healthy controls. In future studies, both FES patients' funniness scores and

overall funniness scores for different stimulus materials should be collected to provide a more nuanced picture of their humor appreciation function.

4.2. Relationship between humor processing capacity and clinical characteristics in FES

We found that in patients with FES, humor processing ability was significantly associated with negative symptoms, which is consistent with previous findings (Tsoi et al., 2008; Dominic et al., 2005). However, Daren et al. and Polimeni et al. found no such correlation in patients with SCZ (Polimeni and Reiss, 2006; Daren et al., 2020). The probable reason for this inconsistency is that these studies placed insufficient emphasis on negative symptoms and did not use specialized negative symptom assessment tools with good reliability and validity. Consistent with earlier findings in patients with SCZ (Tsoi et al., 2008; Polimeni et al., 2010; Dominic et al., 2005), humor processing ability in patients with FES was not significantly associated with positive, disintegrative, and anxiety-depressive symptoms. However, other studies found that SCZ patients' humor processing was significantly associated with delusions (Tsoi et al., 2008) and thought form disorders (Daren et al., 2020). This inconsistency may be caused by the distinct sample characteristics among the different studies. We patients in the stable phase to reduce the influence of acute phase symptoms on humor processing, in which the patients' positive and disintegrative symptoms were largely in remission and might fail to reflect the correlations between these symptoms and humor processing. Additionally, we found no significant correlation between humor processing and neurocognitive functioning in patients FES, whereas Daren et al. and Polimeni et al. reported significant correlations between humor processing and neurocognitive functioning (Polimeni et al., 2010; Daren et al., 2020). The humor materials used in these two studies were either written stories or picture stimuli with textual captions, whereas we used pictures without literal illustrations and short films without dialogue as humor materials. These results suggest that the processing of linguistic humor stimuli depends more on neurocognitive functioning than on visual humor stimuli.

Humor processing ability in patients with FES was also significantly associated with social function, and further regression analyses showed that negative symptoms and humor processing ability could jointly predict the patients' social function. Similarly, negative symptoms and social cognition reportedly have important influences on the patients' social functioning (Kalin et al., 2015; Green et al., 2018; Degnan et al., 2018; Uchino et al., 2021; Mancuso et al., 2011), whereas humor processing, as a uniquely human advanced social skill, plays an important role in social interactions (Martin, 2007; Wilkins and Eisenbraun, 2009). Previous studies have also preliminarily confirmed that discrimination of humor signals in patients with SCZ is significantly associated with their social adjustment and social anxiety (Tsoi et al., 2008). Our results suggest that negative symptoms and humor processing are important predictors of the patients' social functioning, and future studies focusing on their social functioning should take both into account. Humor may be a therapeutic target for improving cognitive and emotional functioning, thereby restoring social functioning in patients with schizophrenia.

4.3. Limitations

This study has some limitations. First, because of the large individual differences in humor processing among people of different ages and cultural backgrounds, we only included Han Chinese aged 16–35 years to reduce sample heterogeneity, which may limit the extrapolation of our findings to older age groups or other subcultural backgrounds. Second, the HPT-v we utilized had a limited number of moments that met the criteria for “standard” humorous moments during the pre-test. As a result, we could not establish a gold standard for the HPT-v and calculate d' and β values. This may be due to the difficulty in assessing

individual differences in humor itself, as previous studies using similar video tasks reported large differences in the selection of humorous moments between healthy controls and pre-test populations (Tsoi et al., 2008). Therefore, we used discrete degrees of humorous moment ratings to reflect the participants' ability to process humor. The development of more stable humor assessment tools with better reliability and validity is necessary for future studies. Third, we utilized behavioral paradigms to evaluate humor processing. Future research should extend our work by using techniques with higher temporal resolution, such as electroencephalography, considering that humor processing is a rapid process. Finally, we failed to examine the effects of different drug types on humor processing in patients with FES, which requires further investigation.

In summary, humor impairment occurs in the early stage of SCZ and primarily marked by reduced discrimination of humor signals and inconsistent evaluation, whereas humor appreciation remains largely intact. Our finding provides a possible breakthrough in understanding the pathological impairments of patients with SCZ and facilitating their functional recovery.

CRediT authorship contribution statement

Yunfei Ji: Writing – review & editing, Writing – original draft, Investigation. **Bingjie Huang:** Writing – review & editing, Investigation, Data curation, Conceptualization. **Jia Huang:** Methodology, Conceptualization. **Xiaodong Guo:** Investigation. **Tianqi Gao:** Investigation. **Yue Zheng:** Investigation. **Wanheng Hu:** Investigation. **Xiaolin Yin:** Investigation. **Xianghe Wang:** Investigation. **Xin Yu:** Supervision, Resources, Methodology, Conceptualization. **Chengcheng Pu:** Writing – review & editing, Resources, Project administration, Methodology, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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