False Identification of Humour in Schizophrenia

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Abstract. Background: Patients with schizophrenia are impaired in humour processing. However, it is not clear for the cognitive mechanism underlying these deficits and its associations with clinical symptoms. Methods: Sixty-five patients with schizophrenia and 52 healthy controls completed a behavioural task based on the signal detection theory to explore the humour processing deficits in schizophrenia. Results: Patients with schizophrenia falsely identified more non-humour stimuli as humour stimuli, and showed a larger within-group incoherence than the healthy controls. In patients with schizophrenia, the false alarm rate during humour processing as such was found to have a positive correlation with negative symptoms. Conclusion: These findings suggest that patients with schizophrenia exhibit humour processing deficits, in terms of an elevated false identification of humour which is associated with the severity of negative symptoms.

Keywords: signal detection theory (SDT), humour processing, false alarm, schizophrenia, negative symptoms.

1. Introduction

Humour processing is essential for interpersonal interaction and social function [1,2]. The current cognitive theory for humour processing has proposed that it involves at least two basic phases, i.e., the comprehension phase and the appreciation phase[3-6]. Comprehension refers to the applications of recognitive pattern to resolve expectation violations after discriminating inconsistency information [7], whereas appreciation involves elaborative and affective processing on comprehended information to reach conclusions [6]. Prior evidence suggests that patients with schizophrenia are impaired in humour processing [8-12].

However, it remains unclear whether patients with schizophrenia have deficits in the comprehension phase or the appreciation phase of humour processing. Some studies have found that humor processing deficits in schizophrenia [13-18] involves in the impaired ability to distinguish humourous from non-humourous signal [16,18], i.e., impaired comprehension phase but intact appreciation phase [18]. On the other hand, some studies found altered appreciation phase in patients with schizophrenia, in terms of decreased [19,20] or increased [12,21] appreciation of humour.

To reconcile these controversies, it is important to differentiate the comprehension phase and the appreciation phase of humour processing using a behavioural task [22]. By conceptualizing humour as signal and non-humour as noise, signal detection theory offers an appropriate method to tackle thi issue. Judging humorous signal as a funny report is ‘hit’, and non-humorous signal judged as funny is ‘false alarm’. Hit rate is the correct detection of humourous signal whereas false alarm rate

is the proportion of false identifying non-humourous noise as humourous signal. The d' is computed as the difference value between Z score of 'hit rate' and Z score of 'false alarm rate' to evaluate one's humour-nonhumour discrimination. It reflects the comprehension phase of humour processing. The β is calculated by the ratio of the ordinate of 'false alarm rate' to that of the 'hit rate'. It measures one's inner criteria which reflects the appreciation phase of humour processing.

To-date, from the perspective of the signal detection theory, only a limited number of studies have investigated both comprehension and appreciation phases of humour processing in patients with schizophrenia. Notably, the appreciation phase is mainly characterized by pleasure experience [3,4,23,24]. The inability to feel pleasure, anhedonia, is one of the core negative symptoms in schizophrenia [25]. Close associations have been found between humor processing and social and nonsocial cognition in patients with schizophrenia [15,17]. Thus, investigating the humour appreciation deficits in patients with schizophrenia would be helpful to elucidate the cognitive mechanism underlying anhedonia of schizophrenia.

Comprehension, the other phase in humor processing, consists of incongruity detection and resolution stage that individuals found a stimulates of violative expectation and provide a stable cognitive rules to solve [5]. The actual time interval between detection and resolution stages is very short and difficult to distinguish. In the context of the signal detection theory, efforts have been made to capture how patients with schizophrenia exhibit their deficits in humour processing. For instance, Tsoi et al. distinguished humour comprehension and appreciation in patients with schizophrenia [18]. Ji et al. found that first episode patients with schizophrenia would falsely identify non-humourous stimuli as humourous stimuli [26]. Given these earlier findings, the present study aims to explore how patients with schizophrenia were impaired during humour processing via the signal detection theory.

In addition, it has been found that impaired humour processing has been correlated with negative symptoms [26]. More negative emotions, decreased pleasure-seeking behaviours and low pleasure beliefs, which constitute one of the core negative symptoms---anhedonia [27-34], may contribute to the humour processing deficits. Here we proposed that anhedonia refers not only to the inability to experience positive emotion but also to the incoherence of hedonic experience moment with others. Incoherence means the various understanding or experience of humour stimulation within groups, so that it may impede the social communication in the clinical populations. Because of emotional and social dysfunction in schizophrenia, they may have a discreteness of humour processing with other individuals. We aim to explore whether patients with schizophrenia would show more incoherence of humourous moments detection within group in this study.

Based on these current findings, we investigated the cognitive mechanisms underlying humour processing among patients with schizophrenia, and explored their associations with clinical symptoms. We aimed to (1) investigate the defects of humour processing in stages, (2) explore the incoherence of humour processing in schizophrenia group, and (3) discover the correlation in humour processing and clinical symptoms.

2. Method

2.1 Participant

We recruited 65 patients with schizophrenia (outpatients 51/inpatients 14) from Beijing Anding Hospital, China, and 52 healthy controls from the communities or universities in Beijing, China. The criteria for the clinical group inclusion were set as follows: (1) schizophrenia diagnosis via DSM-IV (American Psychiatric Association, 1994); (2) aged 18-55; and (3) estimated IQ of > 70. The criteria for the clinical group exclusion included (1) a history of alcohol or substance dependence; (2) a history of head trauma or neurological disorders; (3) a treatment record of transcranial magnetic stimulation or electroconvulsive therapy within the last three months; (4) comorbid bipolar disorder, major depressive disorder and other mental disease; and (5) a history of

perinatal trauma. The same eligibility criteria applied to healthy controls, except that they should not have any personal or family history of psychiatric disorders.

In our clinical group, inpatient and outpatient participants only differed in age [t (1,63) = -2.973, p<0.01; outpatients: 29.69±9.48 (mean±SD), inpatients: 38.43±10.44 (mean±SD)], but not IQ, education year, comedy frequency and preference (ps > 0.05), supporting our use of the combined inpatient and outpatient samples in this study. Ethics Committee of the Institute of Psychology, the Chinese Academy of Sciences and Beijing Anding Hospital approved this study. Written informed consent were obtained from all participants.

2.2 Measures

2.2.1 Experimental tasks and procedure

We used the Humour Processing Task (HPT) to assess participants' humour processing. This task was developed on the basis of signal detection theory. In the pictorial version of HPT (HPT-p), 40 pairs of humorous and non-humorous pictures are presented to participants after a 1000ms fixation on the computer screen. Participants would indicate whether the picture appears funny or not to them by pressing buttons on the keyboard. The pictures were presented on screen until the participants pressed buttons. Figure 1 illustrates the HPT-p.

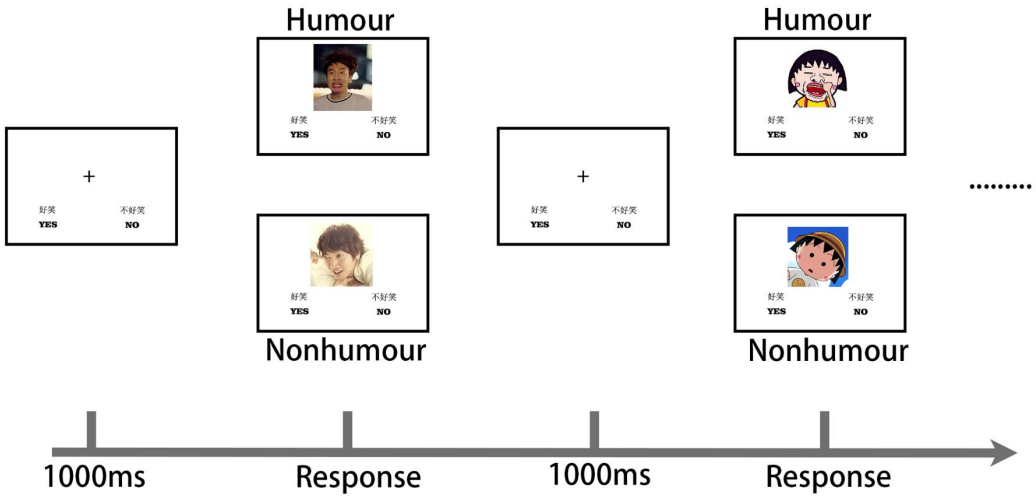

Figure 1. The illustration of picture humour processing task.

In the video version of HPT (HPT-v), the participants would rate on the funniness of the videos on the five-point Likert scale, ranging 1 (not funny at all) to 5 (extremely funny). The HPT-v contains 13 humourous videos, each would be presented twice. In the first viewing, participants rated on the levels of funniness; but in the second viewing, they were asked to report the "humorous moments". The traditional analysis approach in the context of SDT requires both humourous and non-humourous videos. Due to the absence of matched non-humorous videos, a novel analysis approach was developed. This novel approach calculated false alarm rate in HPT-v by the incoherence of reported humorous moments within each group, serving as a substitute for the traditional signal detection method in HPT-p. Detailed information please see section 2.2.4 Statistical Analysis.

Estimated IQ score was tested by the Chinese short form version of WAIS-R [35]. The short version includes four tests of common sense, calculation, similarity, and numerical breadth.

2.2.2 Self-reported scales and clinical assessment

We administered the Revised Chapman Social Anhedonia Scale (CSAS) [36-38] and Revised Chapman Physical Anhedonia Scale (CPAS) [36,37] to measure social and physical anhedonia. Higher CSAS and CPAS cores indicate higher anhedonia. Moreover, the Chinese version of the Temporal Experience of Pleasure Scale (TEPS) [39,40] was employed to evaluate hedonic experience. The TEPS generates four factors, including contextual anticipatory, contextual consummatory, abstract anticipatory and abstract consummatory, and. The TEPS Chinese version comprises 19 items which is rated on six-point Likert scale (1 very false to me -6 very true to me). Higher scores of TEPS indicate higher pleasure experience.

The Beck Depression Inventory (BDI) with 21 items [41] was employed to assess a self-reported depressive symptom. Each item is rated on a four-point (0-3) Likert scale. Higher scores of BDI indicates more depressive symptoms.

The Anticipatory and Consummatory Interpersonal Pleasure Scale (ACIPS) [42] was used to assess hedonic ability of social and interpersonal pleasure experience. The ACIPS generates three factors, including (1) group social interactions, (2) intimate social interactions, (3) social bonding and making connections. Higher scores of ACIPS indicate better pleasure experience.

The Sense of Humour Scale (SHS) [43] was used to measure sense of humour. It has three subscales: ability of humour processing, ability of humour processing in social situation and ability of humour coping. Each individual item is scored on a five-point Likert scale with 1 indicating ‘very false to me’ and 5 indicating ‘very true to me’. Higher scores indicate higher sense of humour.

The 24-item Multidimensional Sense of Humour Scale (MSHS) [44,45] assesses participants’ self-reported sense of humour. Each item is scored on a five-point Likert scale. High scores indicate a better sense of humour.

The Humour Style Scale (HSS) [46] was used to measure four types of humour style, including self-defeating, self-enhancing, affiliative and aggressive. The HSS contains 25 items, each scored on a seven-point Likert scale with 1 indicating ‘disagreement’ and 7 indicating ‘agreement’. High scores indicate higher frequency of using humour style to cope with humorous situation.

The Positive and Negative Syndrome Scale (PANSS) was employed to evaluate the positive, negative and general symptoms of psychopathology in schizophrenia [47].

2.2.3 Statistical analysis

In the HPT-p task, hit rate and false alarm rate within the context of signal detection theory were computed. Hit rate (HIT) represents the proportion of the correct responses to humour stimulations. False alarm rate (FA) denotes the instances where the participants have misjudged non-humorous stimuli as humorous ones among the presented non-humourous distractors. MISS rate (MISS) indicates the instances where the participants have misjudged humourous stimuli as non-humorous ones. Then we estimated the d’ value (indicating sensitivity of humour-nonhumour discrimination) and β value (representing inner criteria of humour elaboration) using the HIT and FA rates.

For the HPT-v task, we devised a novel method to calculate the FA rate. Specifically, we divided each video into several five-seconds periods. We designated the humorous periods that the participants reported as humourous as “1” and the non-humourous period as “0”. Subsequently, we calculated the coherence value (Co) within each group. In each period, we first calculated the percentage of humour moments in each group (n/N=M%) (e.g., Table 1). The coherence value (Co) for each period was calculated as the difference between M% and the recorded binary values (1/0). In each period, the coherence values below zero (Co<0) signify the FA rate (FA_Co) while those greater than zero (Co>0) denote the MISS rate (MIS_Co). The average coherence value calculated across all videos serves as an indicator of the consistency in detecting humourous moments within each group.

Table 1. The novel method to calculate FA rates in video humour processing task.

Periods	0-5	6-10	…	X’
Sub01	0	0	…	1
Sub02	1	0	…	1
…	…	…	…	…
SubN	0	0	…	0
M%	n1(recorded)/N	n2(recorded)/N	…	n’(recorded)/N

M% = n(recorded)/N; Co = M% - recorded(1/0); FA_Co = Co<0; MIS_Co = Co>0

An independent-samples *t*-test was performed to examine the disparity between the clinical group and the healthy control group. We conducted bivariate correlation analyses to examine the associations between task performance (‘HIT’,’FA’,d’, β) and PANSS scores. All statistical analyses were carried out by SPSS software. The significant level was set at *p* values of 0.05.

3. Results

3.1 Demographical and scales data

Table 2 summarizes participants’ demographics and the ratings on self-report scales. Schizophrenia participants and the healthy controls were comparable in education, gender and age, but the clinical group had lower IQ than the healthy control group [$t(1,115)=-4.943$, $p<0.001$]. We found significant difference in social anhedonia [$t(1,115)= 2.993$, $p<0.01$], physical anhedonia [$t(1,115)= 4.082$, $p<0.001$], pleasure experience[$t(1,115)=-2.248$, $p<0.05$], sense of humour[$t(1,115)=-2.146$, $p<0.05$], ability of humour processing [$t(1,115)=-2.084$, $p<0.05$] and humour processing in social situation [$t(1,115)=-3.317$, $p=0.001$] between schizophrenia participants and the healthy controls. Therefore, schizophrenia participants showed poorer pleasure experience and humour processing.

Table 2. Demographic information and scales scores comparison between SCZ and HC.

	SCZ(65)		HC(52)				
	mean	SD	mean	SD	t/x^2	*p*	Cohen’s *d*
IQ	106.91	14.72	120.21	13.23	-4.943	<0.001	0.95
Gender (male:female)	36:29		30:22		0.063	0.802	
Age	31.63	10.29	29.13	10.37	1.292	0.199	
Education	13.59	3.69	14.21	3.01	-0.966	0.336	
PANSS_NE	15.95	7.125					
PANSS_PO	12.30	5.05					
PANSS_GE	26.81	7.96					

CSAS	12.13	5.95	8.87	5.33	2.993	0.003	0.58
CPAS	20.89	8.26	14.33	8.35	4.082	<0.001	0.79
BDI	10.05	11.26	8.42	8.48	0.847	0.399	0.16
TEPS	74.52	14.89	81.00	15.06	-2.248	0.027	0.43
MSHS	82.02	18.89	88.75	13.59	-2.146	0.034	0.41
ACIPS							
ACIPS-1	32.55	6.39	34.39	6.18	-1.51	0.134	0.29
ACIPS-2	16.02	4.10	18.10	3.28	-2.879	0.005	0.56
ACIPS-3	21.25	4.46	23.20	4.02	-2.364	0.02	0.50
HSS							
HSS-1	31.24	5.84	28.29	5.50	2.761	0.007	0.52
HSS-2	23.45	6.06	24.40	5.12	-0.896	0.372	0.17
HSS-3	17.56	6.98	16.58	6.26	0.788	0.432	0.15
HSS-4	13.05	5.64	13.85	5.39	-0.767	0.444	0.15
SHS	91.84	18.69	100.00	15.03	-2.535	0.013	0.48
SHS-1	11.65	2.44	12.52	1.95	-2.084	0.039	0.39
SHS-2	39.21	10.86	45.48	9.00	-3.317	0.001	0.63
SHS-3	40.98	8.08	42.00	7.14	-0.705	0.482	0.13

SCZ: Patient with schizophrenia; HC: Healthy controls.
PANSS: The Positive and Negative Syndrome Scale, NE: Negative symptoms, PO: Positive symptoms, GE: General psychopathology symptoms; CSAS: Chapman Social Anhedonia Scale; CPAS: Chapman Physical Anhedonia Scale; BDI: The Beck Depression Inventory; TEPS: Temporal Experience of Pleasure Scale; MSHS: Multidimensional Sense of Humour Scale; ACIPS: Anticipatory And Consummatory Interpersonal Pleasure Scale, 1: Intimate social interactions, 2: Group social interactions, 3: Social bonding and making connections; HSS: The Humour Style Scale, 1: affiliative, 2: self-enhancing, 3: aggressive, 4: self-defeating; SHS: Sense of Humour Scale, 1: ability of humour processing, 2: ability of humour processing in social situation, 3: ability of humour coping.

3.2 Behavioural performance

3.2.1 Humour processing task-picture version (HPT-p)

Table 3 summarizes the results. Patients with schizophrenia showed significantly higher FA rate [$t(1,114)=2.226$, $p<0.05$]. But no significant group differences were found in d', β, HIT rate and the number of reported humourous signal (n*p*s>0.05).

Table 3. Performances of patients with schizophrenia and the healthy controls in HPT-p.

	SCZ (65)		HC (51)				
	mean	SD	mean	SD	*t*	*p*	Cohen's *d*
d'	1.47	1.25	1.65	0.93	-0.873	0.385	0.16
β	1.88	1.67	2.19	1.78	-0.963	0.338	0.18
FA	0.26	0.30	0.16	0.15	2.226	0.028	0.42
HIT	0.64	0.31	0.64	0.24	-0.06	0.952	0
Num(h)	35.8	19.82	32.14	12.32	1.22	0.225	0.22

SCZ: Patient with schizophrenia; HC: Healthy controls; FA: False alarm rate; HIT: Hit rate; Num(h): The number of reported humourous signal

3.2.2 Humour processing task-video version (HPT-v)

No significant group differences were found in humour rating (n*p*s>0.05) [t (1,112) =-0.436, p= 0.663; Mean±SD: -3.00±0.79 (SCZ, n=62), 3.07±0.70 (HC, n=52)]. Patients with schizophrenia had significantly higher FA rate (FA_Co) than the healthy controls during watching the humourous videos [t(1,112)=-6.061, p<0.001; Mean±SD: -0.75±0.05(SCZ, n=62), -0.70±0.04(HC, n=52)]. Since patients with schizophrenia reported various humourous moments, they exhibited lower group coherence in comprehending the humourous moments than the healthy controls.

3.2.3 Correction between HPT-p performance and negative symptoms

Among the patients with schizophrenia, bivariant correlations between task performance ('HIT', 'FA', d', β) and three PANSS scores were conducted. FA in HPT-p were significantly correlated with negative symptoms (r=0.312, p<0.05) and general psychopathology symptoms (r=0.296, p<0.05), but not correlated with positive symptoms (r=0.259, p>0.05).

4. Discussion

Our study on humour processing in schizophrenia have two main findings. First, deficits in humour processing among patients with schizophrenia seem to be characterized by higher false alarm rate and incoherence during appreciation of humour. Second, false alarm rate of humour processing is closely related to negative symptoms and general psychopathology in patients with schizophrenia.

Consistent with previous studies, the present study suggested patients with schizophrenia have impairments in humour processing [12,14,15,19]. Patients with schizophrenia misidentified the unfunny stimuli as funny stimuli. This result was partially in line with previous study showing that patients with schizophrenia rated stimuli funnier than those healthy controls did in both correctly and incorrectly completed trails [12]. The higher false alarm of humour signal suggested that patients with schizophrenia exhibit deficits not only in the comprehension but also in the appreciation phase of humour processing. That patients with schizophrenia judge more non-humourous stimulates as humourous signal may also imply their confused comprehension that they understand humourous signal as 'ridiculous' but not 'funny'. This result should not be interpreted as their more positive emotion experience but their disorganized social cognition [12,26,48]. To our knowledge, patients with schizophrenia have impairments in emotion recognition [33,49-51]. Especially, patients with schizophrenia have higher false alarm rate to recognize happy and anger emotion [51]. Our results of higher false alarm of humour signal in patients with schizophrenia were consistent with their emotion recognition deficits. It is possible

that the confused comprehension and disorganized appreciation underlying both the humour processing and emotion recognition were the main dysfunction of social cognition in schizophrenia.

Among patients with schizophrenia, deficits in humour processing are manifested not merely as a higher rate of falsely detected humourous stimuli but also as their higher incoherence of humour signal detection. This situation may potentially hinder the social interactions of these clinical populations. The ample evidence showed patients with schizophrenia have less social interaction and reduced cooperation behaviour [52-55]. Humour processing is foundation of social behaviour and social function [6,7,55]. Each patient with schizophrenia recognized different humour signals with others, which leads to a larger group incoherence. This may be reflected a potential reason of worse social function in schizophrenia. The inconsistence of humour detection among the clinical individuals provides a new perspective to understand hedonic deficits and social cognitive dysfunction in schizophrenia.

In addition, it should be noted that humour processing is related to clinical symptoms. Similar findings reported in other studies [17,18]. The false alarm of humour processing was found correlated with negative symptom. A higher false alarm rate is particularly prevalent among those patients with severe negative symptoms. False alarm rate reflected an abnormal humour comprehension and appreciation. It could be the potential cognitive mechanism underlying social anhedonia, the core feature of negative symptom. Therefore, the close correlation inspired that humour processing could be a perspective to investigate pathological mechanism of negative symptom in schizophrenia.

Our study has several limitations. First, our clinical samples include outpatients and inpatients. Humour processing could be affected by external environment. But there were no significant correlations between comedy preference and humour processing. Our results also showed no significant difference in frequency and preference between outpatients and inpatients. Second, the present study elucidated the cognitive mechanism underlying humour processing through a behavioural approach. Future study adopting more kinds of data is needed to explore the neural mechanism of humour processing. Third, the innovative and clinical user-friendly task based on SDT enables the exploration of separate stages of humour processing and serves as a mean to study humour. Future studies could incorporate a broader range of clinical groups, for instances, those with major depression disorder, which is also associated with social cognition and emotion deficits.

To conclude, our findings demonstrated that the patients with schizophrenia more falsely identified nonhumourous stimuli as humourous stimuli than the controls, which suggest their deficits in both humour comprehension and appreciation. Such false identification of humour was associated with the negative symptoms. A novel conceptual framework was proposed to advance the perspective for future research in humour processing.

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