Humour processing deficits in individuals with social anhedonia

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ABSTRACT

Humour processing comprises the humour comprehension and the humour appreciation phases. Patients with schizophrenia have impaired humour processing. However, it is unclear whether such deficits affect subclinical populations such as individuals with social anhedonia. Our study recruited forty-eight individuals with high levels of social anhedonia (HSA, screened by the Revised Chapman Social Anhedonia Scale) and 50 individuals with low levels of social anhedonia (LSA). Participants completed behavioural tasks which tapped into humour comprehension and appreciation, and a set of questionnaires assessing their sense of humour, humour styles and subjective experiential pleasure. Using signal detection theory analysis, the d' and β values were generated to measure the detection of humour signal in the comprehension phase and the inner criteria of the humour appreciation respectively. The results showed that the HSA and LSA groups did not differ in humour signal detection (d') but the HSA group had significantly higher inner criteria of humour appreciation (β) than the LSA group. The β value was correlated with experiential anticipatory pleasure in all participants. The HSA group had significantly lower within-group coherence than the LSA group when processing humour. Our findings suggested that individuals with social anhedonia have impaired humour processing.

1. Introduction

Humour processing is a complex social cognitive operation, essential to effective social interactions and interpersonal relationships (Chadwick and Platt, 2018; Vrticka et al, 2013). The ability to appreciate humour is also believed to promote work performance, and physical and mental health (Cai et al., 2014; Tsoi et al., 2008). Humour processing consists of two phases, namely comprehension and appreciation (Campbell et al., 2015). In the comprehension phase, individuals have to identify the inconsistency in the context, and have to figure out a resolution to reconcile such inconsistency (Suls, 1972; Wyer and Collins, 1992). In the appreciation phase, individuals have to appraise the inconsistency and derive pleasure from it (Campbell et al., 2015; Wyer and Collins, 1992; Patrikelis et al., 2017).

Empirical research have shown that many neuropsychiatric disorders are associated with impaired humour processing (Adamczyk et al., 2017, 2018; Clark et al., 2015; Wu et al., 2014). For example, patients with schizophrenia showed less accuracy (Bozikas et al., 2007; Polimeni and Reiss, 2006; Polimeni et al., 2010) and greater individual difference in humour processing (Tsoi et al., 2008) than healthy individuals. The deficits as such could be attributable to the neurocognitive dysfunctions (Bozikas et al., 2007) and negative symptoms in patients with schizophrenia (Andreasen, 1982). Moreover, the underlying cognitive mechanisms of impaired humour processing in patients with schizophrenia may affect both comprehension and appreciation phases (Adamczyk et al, 2017, 2018; Aykan and Nalcaci, 2018). Regarding non-clinical populations who are at risk of developing psychosis, it is unclear whether impaired humour processing could be found in these individuals, albeit in an attenuated form than that found in patients with schizophrenia.

Individuals with social anhedonia have problems in their ability to experience pleasure in social interactions (Blanchard et al., 2011; Wang et al., 2016). Social anhedonia is associated with poor social function (Cohen et al., 2006; Li et al., 2016) and difficulty in enjoying social

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interactions (Gooding and Pflum, 2012). It is possible that impaired humour processing exists in individuals with social anhedonia, and this deficit may contribute to the lack of pleasure in social interactions. Importantly, social anhedonia is one of the negative schizotypy traits (Cohen et al., 2015), which are believed to be risk factors for the development of schizophrenia (Meehl, 1962). Humour processing involves the reward-system of the brain (Berger et al, 2018). Individuals with anxiety trait have difficulty in identifying the humorous components in everyday encounters as healthy people would do (Samson et al., 2012). Evidence also suggested that individuals with schizotypy are impaired in irony-appreciation and theory of mind (Gooding and Pflum, 2011; Humphrey et al, 2010; Langdon and Coltheart, 2004). However, no study to date has investigated both the comprehension and appreciation phases of humour processing in individuals with social anhedonia.

The comprehension phase of humour processing is believed to depend on basic "cool" (non-emotion dependent) cognitive abilities such as conflict detection and processing, while the appreciation phase depends more on "hot" (emotion-dependent) cognitive abilities, such as hedonic capacity. Researches have shown that individuals with social anhedonia have lower hedonic capacity than healthy individuals (Gooding and Pflum, 2012; Heininga et al., 2017), but they apparently have intact basic "cool" cognitive abilities such as sustained attention, conflict detection (Cohen et al., 2006) and working memory (Gooding and Tallent, 2003).

In this study, we aimed to investigate whether individuals with social anhedonia have impaired humour processing, and whether these deficits affect the comprehension, the appreciation, or both phases.

Moreover, previous studies have shown that individuals with social anhedonia have a higher variations in pleasure experience than that of healthy individuals (Gooding and Pflum, 2012; Martin et al., 2011), suggesting a wide individual difference in terms of stimuli appraisal and emotion experience in the former population. This study therefore also aimed to investigate the within-group incoherence during humour processing in a sample with social anhedonia.

To tap into both the comprehension and appreciation phases of humour processing, the use of subjective funniness ratings is considered inadequate (Tsoi et al., 2008; Samson et al., 2012; Ku et al., 2017). On the other hand, the signal detection theory (SDT) (Macmillan and Creelman, 2005) provides a suitable approach to examine both the comprehension and the appreciation phases. The SDT procedure could generate two objective indices, i.e., the d' value to measure one's ability to distinguish humour signals from non-humour signals, and the β value to measure one's inner criteria of funniness judgement. The comprehension phase in humour processing includes incongruity detection and resolution, while the appreciation phase involves one's inner judgement as to how funny the current stimuli are. In view of these, the d' value is a suitable proxy of the comprehension phase, while the β value the appreciation phase. A higher d' value indicates better humour comprehension ability, whereas a higher β value indicates poorer humour appreciation (a higher inner criteria suggest that one can hardly experience pleasure in a humorous moment). This study adopted the SDT method, which is believed to be superior to other traditional rating methods used in previous studies (Bozikas et al., 2007; Polimeni and Reiss, 2006), and could parse humour processing into the two phases more clearly and investigate them properly.

Humour processing is also affected by an individual's current mood, his/her sense of humour, and the humour style preference and hedonic capacity (Schermer et al, 2015; Willinger et al, 2017). Therefore, we aimed to investigate whether better humour processing is associated with more positive mood, a higher sense of humour, and a brighter humour style preference.

Based on the empirical findings on humour processing in schizophrenia patients, we hypothesized that individuals with social anhedonia would exhibit deficits in humour processing. Specifically, they would have higher inner criteria of humour appreciation which would

be associated with their lower pleasure experience. Given the large variations of pleasure experience in individuals with social anhedonia, we hypothesized that individuals with social anhedonia would show greater within-group incoherence than healthy individuals when comprehending humour.

2. Methods

2.1. Participants

Participants were recruited from several universities in Beijing. For screening purposes, university students completed the Revised Chapman Social Anhedonia Scale (RCSAS) (Chan et al., 2015). Using this screening questionnaire, we identified the high social anhedonia group who have a total score on the RCSAS of 17 or above, as well as the low social anhedonia group who have a total score of 11 or less. These cut-off scores were determined by an earlier study (Li et al., 2016), which showed that the RCSAS score of 17 lied above 1.96 standard deviations above the mean, and the RCSAS score of 11 lied 0.5 standard deviations below the mean. To make the handedness be consistent across all participants, left-handed participants were excluded from this study, because handedness is found to be associated with schizotypal thinking (Annett and Moran, 2006), linked to schizophrenia (Brandler and Paracchini, 2014) and psychoic-like symptoms (Barrantes-Vidal et al., 2013). Based on these inclusion criteria, we recruited 48 individuals with high social anhedonia and 50 with low social anhedonia. None of the participants have a personal or family history of neurological or psychiatric disorders, a history of head trauma or alcohol or substance dependence. Table 1 shows the demographics of the participants and their ratings on the different self-reported scales.

2.2. Behavioural tasks

2.2.1. The Picture Humour Processing Task (HPT-p)

Based on the Signal Detection Theory (SDT), we developed a Picture Humour Processing Task in which participants indicated whether each of the 40 humorous or non-humorous pairs of pictures was funny or not. The pictures used in the HPT-p were chosen from the internet, and each

Table 1
Demographic and self-report scale scores in HSA and LSA group.

	HSA(N = 48) Mean ± SD	LSA (N = 50) Mean ± SD	t/χ^2	sig(p)
Age (years)	21.35 ± 3.55	21.36 ± 4.15	− 0.007	0.994
Estimated IQ	127.10 ± 8.82	123.57 ± 9.41	1.907	0.059
Gender (M:F)	17:33	17:31	− 0.022	0.883
Education (years)	14.92 ± 1.93	14.51 ± 2.83	− 0.824	0.412
RCSAS	21.96 ± 3.84	5.46 ± 2.76	24.497	< 0.001
PANAS-PA	26.13 ± 6.44	30.82 ± 5.37	− 3.926	< 0.001
PANAS-NA	19.35 ± 6.12	15.62 ± 4.25	3.519	0.001
TEPS total	79.48 ± 89.14	89.14 ± 10.10	− 4.483	< 0.001
Abs_ant	17.84 ± 3.45	20.70 ± 2.16	− 4.920	< 0.001
Con_ant	15.33 ± 4.30	19.12 ± 4.51	− 4.250	< 0.001
Abs_cons	27.27 ± 4.13	29.04 ± 3.70	− 2.23	0.028
Con_cons	16.50 ± 3.46	18.08 ± 3.33	− 2.304	0.023
HSS				
Affiliative	28.79 ± 4.27	27.72 ± 2.96	1.439	0.151
Self-enhancing	20.23 ± 5.39	24.74 ± 4.53	− 4.523	< 0.001
Aggressive	17.58 ± 6.69	15.88 ± 5.17	1.413	0.161
Self-defeating	15.17 ± 5.36	13.34 ± 4.76	1.784	0.078
MSHS total	81.69 ± 13.03	91.62 ± 10.23	− 4.206	< 0.001

HAS: High social anhedonia; LSA: Low social anhedonia; PANAS: Positive And Negative Affect Scale, PA: Positive affect, NA: Negative affect; TEPS: Temporal Experience of Pleasure Scale, Abs_ant: Abstract anticipatory, Con_ant: Concrete anticipatory, Abs_cons: Abstract consumatory, Con_cons: Concrete consumatory; HSS: Humor style Scale; MSHS: Multidimensional Sense of Humor Scale.
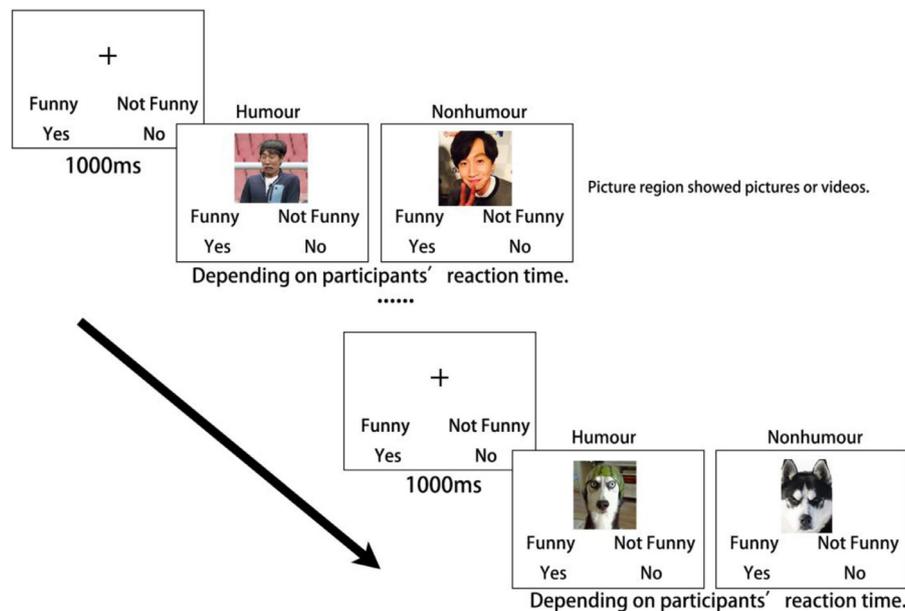
Fig. 1. Trial illustration of the Picture Humour Processing Task (HPT-p).
Note: Max(%): The maximum percentage of key pressing in each video; Min(%): The minimum percentage of key pressing in each video. The y-axis 'Key_pressing%' in the example (Right Panel) is the percentage of key pressing in each 5s-period.

picture is identical in size and resolution.

The funniness of the pictures was validated in a pilot experiment in which an independent group of healthy participants rated the pictures on a Likert scale, which ranged from 1 (not funny at all), 2 (mildly funny), 3 (moderately funny), 4 (funny) to 5 (extremely funny). The mean rating (± SD) of the humorous pictures was 3.19 ± 0.24, whereas the mean rating (± SD) of the non-humorous pictures was 1.58 ± 0.21. The humorous pictures were then considered to signal humour (SN stimuli), while the non-humorous pictures were considered to signal noise (N stimuli). We calculated the d' and β values, according to the SDT, with d' representing the ability to distinguish humour signals from non-humorous signals in the comprehension phase, and β representing the inner criteria of funniness judgement in the appreciation phase (Fig. 1).

2.2.2. The Video Humour Processing Task (HPT-v)

We developed the Video Humour Processing Task, which comprised 11 one-minute humorous clips of *Despicable Me*, distributed only on the internet. Like the method used for developing the HPT-p, we first conducted a pilot experiment in which an independent group of participants rated the humour intensity of each clip on a Likert scale, which ranged from 1 (not funny at all) to 5 (extremely funny), They were also asked to record the humorous moments. The mean (± SD) humour ratings of the videos in the pilot experiment was 3.05 ± 0.40.

In the formal task, participants watched the videos before making the ratings. Participants then watched the videos again and pressed the spacebar whenever they felt the video was funny (funniness judgement).

To examine the within-group incoherence of funniness judgement, each video was divided into several five-second periods. In each period, we recorded any spacebar pressing as 1 and no spacebar pressing as 0. The within-group mean percentage of spacebar key pressing (Key_pressing%) in each period was calculated. For each video, the within-group incoherence of funniness judgement was calculated by Maximum (Key_pressing%) minus Minimum (Key_pressing%). A larger outcome value indicates better funniness-judgement coherence within one group. In order to assess the humour signal detection in this video task, we defined six period as 'standard humorous' in which at least 50% of the participants reported the moment as humorous in the pilot

experiment. In the pilot experiment, the mean percentage of humour report for all periods was 16.05%. The participants in the pilot experiment were all healthy volunteers who did not participate in the formal experiment. The d' and β values were not calculated in this video task, because the number of standard humorous moments was not large enough for estimating the two values. Difference in humour processing between groups was assessed by comparing the identified number of standard humorous moments.

2.2.3. Self-reported measures

We estimated participants' IQ using the short form of the Chinese version of WAIS-R (Gong, 1992).

The Revised Chapman Social Anhedonia Scale (RCSAS) (Eckblad et al., 1982) includes 40 items capturing social anhedonia. The Chinese translation of the scale has been found to have good validity and reliability (Chan et al., 2015; Chan et al., 2012a,b).

The Humour Style Scale (HSS) (Chen and Martin, 2007) was used to measure how people use humour in their social interaction, and comprised four subscales, namely (1) the affiliative subscale, a positive style of using humour to facilitate one's communication with others; (2) the self-enhancing subscale, a positive coping style of using humour to deal with emotion conflict or stress; (3) the aggressive subscale, a negative style of defending oneself by laughing at others; and (4) the self-defeating subscale, a negative style of deprecating oneself to enhance the interpersonal relationship. It contains 25 items evaluating these humour styles on a seven-point Likert scale, ranged from 1 (disagreement) to 7 (agreement). The validity and reliability of the Chinese version have been found to be acceptable (Chen and Martin, 2007).

The Multidimensional Sense of Humour Scale (MSHS) (Thorson and Powell, 1993) was used to measure one's behaviours or attitudes related to humour. Sense of humour is regarded as a personality trait. The Chinese version of the MSHS comprised 24 items, and participants were asked to respond to each item based on a five-point Likert scale, ranged from 1 (strongly disagree) to 5 (strongly agree). The internal consistency and factor structure of the Chinese version have been previously ascertained (Ho et al., 2008). Although the scale can be divided into four subscales, a single total score evaluating sense of humour was adopted in this study.

The Temporal Experience of Pleasure Scale (TEPS) (Gard et al.,

2006) is a self-reported scale measuring pleasure experience. The Chinese version of the TEPS (Chan et al., 2012a,b) has been validated and comprised 20 six-point Likert items to evaluate (1) abstract anticipatory, (2)abstract consummatory, (3) contextual anticipatory, and (4) contextual consummatory pleasure experiences. The subscales were named according to the abstract and concrete properties of the described events in scale items.

The Positive and Negative Affect Scale (PANAS) (Tellegen, 1988) contained 20 items evaluating the positive and negative aspects of current emotional states. The validity and reliability of the Chinese version have previously been established (Huang et al., 2003).

2.3. Data analyses

Hit rates and false alarm values were calculated in the HPT-p paradigm. The SDT value d' (humour signal detection) and β (inner criteria of funniness judgement) were calculated based on the hit rates and false alarm rates. Analysis of variance (ANCOVA) was then used to examine the group difference in the d' and β values, controlling for gender effects. Within-group incoherence of funny moments judgement in the HPT-v was examined by paired t-tests on [Maximum (Key_pressing%) − Minimum(Key_pressing%)] of the two groups in 11 videos. Moreover, in order to ascertain the relationship between humour processing and pleasure experience, we examined the correlation between humour signal detection (d') and inner criteria of funniness judgement (β) and ratings on various self-report scales.

3. Results

3.1. Humour processing in individuals with high social anhedonia

In the HPT-p paradigm, individuals with high social anhedonia reported significantly fewer number of humorous pictures [$t(1,96) = -3.20$, $p < 0.01$; Mean ± SD: 31.04 ± 11.79(HSA), 38.50 ± 11.32 (LSA)] and identified fewer standard humorous pictures [$t(1,96) = -3.225$, $p < 0.01$; Mean ± SD: 25.83 ± 10.14 (HSA), 31.66 ± 7.49 (LSA)] than individuals with low social anhedonia. Although no significant group (high social anhedonia group versus low social anhedonia group) effect was found in d' [$t(1,96) = -0.886$, $p = 0.378$; Mean ± SD: 1.93 ± 1.04 (HSA), 2.09 ± 0.80 (LSA)], the high social anhedonia group (HSA) had a significantly larger β value than the low social anhedonia (LSA) group [$t(1,96) = 2.648$,$p = 0.01$; Mean ± SD: 2.20 ± 1.73(HSA), 1.41 ± 1.18(LSA)].

In the HPT-v task, the total number of humorous moments reported by the HSA group was significantly lower than the LSA group [$t(1,96) = -2.675$, $p < 0.01$; Mean ± SD: 14.29 ± 8.73 (HSA), 18.78 ± 7.88 (LSA)]. A significant group difference was found in the number of standard humorous moments identified [$t(1,96) = -2.523$, $p < 0.05$; Mean ± SD: 2.52 ± 1.52 (HSA), 3.22 ± 1.22 (LSA)]. The HSA group exhibited significantly lower overall humour ratings than the LSA group [$t(1,96) = -2.430$, $p < 0.05$; Mean ± SD: 2.94 ± 0.73(HSA), 3.27 ± 0.89(LSA)].

For within-group coherence in funniness moment judgement, paired t-test on [Maximum (Key_pressing%) − Minimum (Key_pressing%)] of the two groups in 11 videos showed that the HSA group had significantly lower within-group coherence in judging the funniness moments than the LSA group [Mean ± SD: 0.33 ± 0.13(HSA), 0.48 ± 0.12(LSA), $t(10) = 9.239$, $p < 0.001$]. Fig. 2 illustrates the within-group coherence of funniness moment judgement in the two groups.

3.2. Correlation between humour processing performance and scale scores

In order to examine the relationship between humour processing performance in the HPT-p paradigm and the current mood, humour

styles, sense of humour and hedonic capacity, we examined the correlations between the d' and β values and the ratings on the self-reported scales. The data on the HSA and LSA groups were pooled together for examination of relationship between these variables. Table 2 illustrates the results.

The β value in our sample was significantly and inversely correlated with the sense of humour, the two anticipatory subscales scores of the TEPS, and the self-enhancing humour style. Moreover, the β value in our sample was significantly and positively correlated with the aggressive humour style. However, the d' value in the HPT-p task was not correlated with any subscale scores of the TEPS ($ps > 0.05$).

4. Discussion

In this study, we found that individuals with social anhedonia have higher inner criteria of humour signal judgement than individuals without social anhedonia. Moreover, the inner criteria of humour signal judgement are associated with the individual's sense of humour and the ability to anticipate pleasure. Individuals with social anhedonia also appear to vary widely in their judgments of which moments were humorous.

Consistent with earlier findings reported in patients with schizophrenia (Adamczyk et al., 2017; Corcoran et al., 1997), individuals with social anhedonia showed impaired humour processing, as they could not identify as many as humorous pictures and video moments than healthy individuals. Our study also investigated the comprehension and appreciation phases (Suls, 1972; Wyer and Collins, 1992) of humour processing in individuals with social anhedonia, and we found that social anhedonia individuals exhibited deficits in humour appreciation, manifested as their higher inner criteria of humour signal judgement. It is likely that the stimuli in the paradigm used in this study presented humour signals but the intensity of humour signals did not reach social anhedonia individuals' inner criteria, and therefore these risk-risk subclinical subjects failed to derive pleasure from humour stimuli. In view of our findings that the d' value in the high social anhedonia group was comparable to that in the low social anhedonia group, it is likely that individuals with social anhedonia have preserved ability to detect humour signals. This finding is consistent with earlier evidence which support that individuals with social anhedonia have preserved basic "cool" cognitive abilities. In short, although individuals with social anhedonia are able to discriminate humour from non-humour signals, they could not derive emotions and fun from the detected signals, probably because of their higher inner criteria.

Our findings of negative correlation between the β value, the TEPS and the MSHS scores, and self-enhancing humour style appear to suggest that looser inner criteria in judging funniness may be accompanied by more pleasure experience towards future events, higher sense of humour and more self-enhancing use of humour in personality traits. Our findings appear to suggest that more restrictive inner criteria may be an indicator of deficient pleasure experience in humour processing. Individuals with social anhedonia may have more restrictive inner criteria of humour signal judgment. This further suggests that the appreciation phase of humour processing is related to pleasure experience, and the β value is a good proxy for the appreciation phase, a complex high-order cognitive processing with humour signal appraisal and pleasure derivation.

In this study, individuals with social anhedonia had a large incoherence in judging which moments were funny in the HPT-v paradigm. This finding suggests a wide individual difference in the group with high social anhedonia. Previous studies have conceptualised 'anhedonia' as deficits in pleasure experience (Kring and Caponigro, 2010), reward motivation (Kring and Barch, 2014; McCarthy et al., 2015) and beliefs (Strauss and Gold, 2012). Our findings apparently points to another potential important dimension of anhedonia, i.e., an incoherence with others in a group may also be an important factor which impedes a person's pleasure experience during
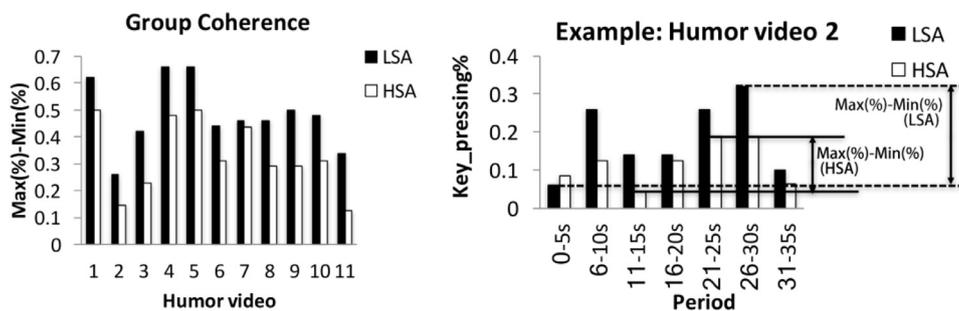
Fig. 2. The within-group coherence of funniness moments judgement and one example illustration in the video Humour Processing Task (HPT-v).

Table 2
Correlations of d' and β in the HPT-p task and scales in all participants.

	Scales MSHS	PANAS Positive	PANAS Negative	TEPS	TEPS Abs_ant	TEPS Con_ant	TEPS Abs_cons	TEPS Con_cons	HSS affiliative	HSS self- enhancing	HSS aggressive	HSS self- defeating
d'	0.03	−0.025	−0.096	0.036	−0.063	0.023	0.062	0.109	−0.075	−0.109	−0.006	0.065
β	−0.258*	−0.052	0.169	−0.182	−0.222*	−0.234*	−0.143	−0.033	0.105	−0.275**	0.218*	0.098

MSHS: Multidimensional Sense of Humor Scale; PANAS: Positive And Negative Affect Scale; TEPS: Temporal Experience of Pleasure Scale, Abs_ant: Abstract anticipatory, Con_ant: Concrete anticipatory, Abs_cons: Abstract consumatory, Con_cons: Concrete consumatory; HSS: Humor style Scale.

* $p < 0.05$.
** $p < 0.01$.

social interactions.

Taken together, our findings demonstrate deficits in humour processing, a complex social cognition, in subclinical individuals with social anhedonia, and suggest possible underlying cognitive mechanisms for diminished pleasure experience in individuals with social anhedonia. Importantly, impaired humour processing in individuals with social anhedonia appears to be attributable to their highly restrictive inner criteria of humorous signal judgement and their wide within-group incoherence.

Our study has several limitations. The gender ratio between high and low social anhedonia groups was not equal. Further study should examine the gender effect on humour processing using more balanced gender ratios. Secondly, we only utilized behavioural paradigms to tap into humour processing, but future research should extend our work to neuroimaging studies on humour processing. Thirdly, although individuals with social anhedonia showed certain attenuated features of patients with schizophrenia, and are believed to be at risk of developing schizophrenia, our study did not examine other at-risk populations, such as psychosis prodromal cases. Our findings in individuals with social anhedonia might not be generalisable to patients with schizophrenia and other at-risk populations. More evidence on clinical and prodromal individuals is needed to address the issues as to whether similar cognitive mechanisms underlie impaired humour processing in schizophrenia spectrum disorders. Notwithstanding these limitations, we have developed a novel SDT-based behavioural paradigm to examine humour processing, and examined the comprehension and appreciation phases of humour processing in individuals with social anhedonia. Our findings generally supported a differential deficit in humour processing in social anhedonia individuals, affecting the emotion-dependent component of humour appreciation, rather than the "cool" cognitive component of humour comprehension.

CRediT authorship contribution statement

Bing-hui Liu: Data curation, Writing - original draft. **Jia Huang:** Supervision, Writing - review & editing. **Hai-di Shan:** Project administration, Writing - original draft. **Ya-fei Liu:** Project administration, Writing - original draft. **Simon S.Y. Lui:** Methodology. **Eric F.C. Cheung:** Writing - review & editing. **Xiao-dong Yue:** Writing - review & editing. **Raymond C.K. Chan:** Writing - review & editing.

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Conflicts of interest

None to be declared.

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