Running title: Affective forecasting and schizotypal traits

Subclinical psychopathology and affective forecasting: Role of in-the-moment feelings

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Abstract

It is important for positive well-being and social engagement to understand how people predict future emotions, an ability known as affective forecasting. However, mechanisms underpinning the change to affective forecasting are not well understood in people with subclinical psychiatric symptoms. The current study differentiated components that comprise affective forecasting and investigated how non-clinical features relate to these. We recruited 319 participants to complete the social affective forecasting task and respond to questionnaires that captured schizotypal and autistic traits as well as depressive symptoms. Associations between affective forecasting and subclinical features were investigated using correlations, regression and structure equation modelling. Results showed that interpersonal features of schizotypal traits negatively predicted anticipated emotions in positive social conditions via in-the-moment feelings but not via mental simulation. Findings highlight in-the-moment feelings may be an intervention target to help people who have difficulties with social interactions to anticipate more pleasure for future social events.

Keywords: anticipated emotions, in-the-moment feelings, schizotypy, depressive symptoms, autistic traits

1. Introduction

Imagine that you are invited to attend your friend's birthday party, you may think about how the party will be. What will you wear? Who else will be going? What else do you have on that day? Will you need to be up early the following day? You will construct the scenario of how the birthday party will be based on previous parties with this friend. At the same time, your constructed scenarios may induce your in-the-moment feelings. How you feel and your imaginings of the party will be used as information to predict how you will feel when at the party; whether you will enjoy the party or not. If you predict that you would feel excited and enjoy the party, you will feel motivated to attend the birthday party, even if it is time consuming and takes time away from study, work or family. This is a simple every day example of affective forecasting (AF), the ability to predict one's emotions in the future (Gilbert & Wilson, 2007).

Previous studies report that individuals tend to forecast stronger emotions than they really experience, which is known as "impact bias" (Gilbert & Wilson, 2009). We tend to overestimate the impact future events will have on our emotional state. Many studies have investigated "impact bias", trying to understand why it exists and how it influences our daily life (Arditte et al., 2018; Buechel, Zhang, & Morewedge, 2017; Lench et al., 2019). In contrast, only few studies on AF has focused on the role of anticipated emotions, i.e. the forecasted emotions, how individuals think they would feel in the future (e.g., "I will feel excited at the party"). In fact, anticipated emotions are stars by which we navigate our future events and lives (Ellis et al., 2018;

Hoerger, Quirk, Lucas & Carr, 2010). For instance, we will be motivated to devote efforts to prepare for examinations because we know we would be “cheerful” when we get good grade. We also avoid making mistakes because we know we will feel “upset” if we change a right answer to a wrong one during an exam. More importantly, anticipated emotions could interact with clinical features of psychiatric disorders, such as anhedonia and amotivation (Frost & Strauss, 2016; Gard, Kring, Gard, Horan, & Green, 2007; Raffard, Esposito, Boulenger, & Van der Linden, 2013), and contribute to both the development and maintenance of these disorders. Therefore, anticipated emotions are significant to individuals’ well-being, daily functioning and personal growth. In the current study, we seek to investigate how anticipated emotions are produced by teasing apart AF into how people imagine future events and how they feel as they imagine these events, following the constructive episodic simulation hypothesis (Schacter & Addis, 2007; Gilbert & Wilson, 2007).

1.1 Constructive Episodic Simulation Hypothesis

In order to understand the AF process, Schacter and Addis proposed the “Constructive Episodic Simulation Hypothesis” (Schacter & Addis, 2007), which was further developed by Gilbert and Wilson (Gilbert & Wilson, 2007). According to this hypothesis, remembering past experiences and imagining future ones, involve similar neural and cognitive processes. When individuals consider a future event, they first construct future scenarios in their mind based on similar past experience (mental

simulation, e.g., how was the last party I went to, how will the next party be). These past experiences are retrieved from their episodic and semantic memory (Gilbert & Wilson, 2007, 2009). Simultaneously, mental simulation induces emotional experience (in-the-moment feelings, e.g., how I feel right now when I am imagining attending the party) so that individuals may feel happy or disappointed in response to their constructed scenarios. On the basis of the mental simulation and in-the-moment feelings, anticipated emotions are then forecast: individuals imagine how they will feel when/if that event happens in the future (e.g., how I will feel during the party?).

1.2 AF and subclinical psychopathology

AF deficits are closely associated with subclinical psychopathology, being especially characterized by anhedonia or amotivation (Frost & Strauss, 2016). From the theoretical perspective, AF is regarded as one component of anticipatory pleasure and therefore impaired AF is associated with the level of anhedonia (Frost & Strauss, 2016). Meanwhile, given that AF impacts the motivation level (e.g., people may be less motivated to join in social activities if they did not anticipate pleasure for social activities; Szpunar et al., 2014), impaired AF may lead to the dysfunction of motivation, or amotivation. From the perspective of empirical studies, AF deficits are reported in patients with anhedonia and amotivation, such as schizophrenia, major depressive disorder and autism (Hanson & Atance, 2014; Thompson et al., 2017; Yang et al., 2018). More importantly, AF deficits is believed to contribute to the

development of mental health disorders (Szpunar et al., 2014; Wenze, Gunthert, Ahrens, & Taylor Bos, 2013). For instance, previous studies reported that people with depressive symptoms anticipated more negative emotions than controls (Wenze et al., 2013). Their abnormal anticipated emotions may guide them to decide to avoid activities, and thus their social withdrawal behaviors may bring them more negative emotions, higher levels of anhedonia and amotivation (Wenze et al., 2013). Therefore, it is important to investigate the pattern of AF in individuals with subclinical symptoms, before illness onset. Understanding the relationship between AF deficits and subclinical symptoms will assist in the development of early intervention programs aiming to reduce the impact or delay the onset of mental health disorders. Therefore, the current study considers the associations between subclinical features (schizotypal traits, depressive symptoms and autistic traits) and AF deficits.

Schizotypal traits are regarded as subclinical features of schizophrenia spectrum disorders (Kwapil & Barrantes-Vidal, 2015). The three-factor model (cognitive-perceptual, interpersonal and disorganization features) of schizotypal traits corresponds to positive, negative and disorganized symptoms of schizophrenia spectrum disorders (Fonseca-Pedrero et al., 2018). Individuals with schizotypal traits have altered AF, particularly in social contexts (Engel, Fritzsche, & Lincoln, 2015; Moore, Chan, Huang, & Martin, 2019; Xie et al., 2014; R.-t Zhang et al., 2019a). For instance, Xie et al. (2014) found that schizotypal individuals anticipated reduced positive emotion in response to cues with social but not monetary information, in

comparison to controls. Moreover, schizotypal individuals have impaired AF in social but not non-social conditions, with altered functional connectivity detectable for anticipated emotions in social but not non-social conditions (R.-t Zhang et al., 2019a). Previous studies have also reported that individuals with depressive symptoms anticipate lower levels of positive emotions, than controls (Hoerger, Quirk, Chapman, & Duberstein, 2012). In an experimental task, individuals with depressive symptoms anticipated less pleasure than controls in conditions that involved winning money (Yuan & Kring, 2009). Moreover, Colombo et al (2020) found individuals with higher levels of depressive symptoms anticipated fewer positive emotions in general for the coming weeks, compared with individuals with lower levels of depressive symptoms, (Colombo et al., 2020). Therefore, unlike individual with schizotypal traits, for those with depressive symptoms, decreased anticipated pleasurable is detectable for both social and non-social events. As for individuals with autistic traits, although no study has directly examined AF in this group of subclinical individuals, it has been found that individuals with autistic traits have anhedonia and the reduced pleasure experience is more likely to occur in social conditions (Novacek, Gooding, & Pflum, 2016; Shi et al., 2017), suggesting that they may have social-specific impairment in experiencing pleasure. Taken together, previous studies have found that subclinical psychopathology is associated with AF alterations, but little is known about the underlying working mechanisms and how subclinical features affect AF capacity.

1.3 The present study

The purpose of the present study was to investigate the relationship between AF and subclinical psychopathology (including schizotypal traits, depressive symptoms and autistic traits). Our first objective was to examine the relationship between anticipated emotions and subclinical features in social and non-social conditions. Since individuals with schizotypal and autistic traits display social-specific deficits (Novacek et al., 2016; R.-t Zhang et al., 2019a), we hypothesized that schizotypal traits and autistic traits would be associated with altered anticipated emotions (lower levels of anticipated valence), especially in social conditions. Moreover, we hypothesized that depressive symptoms would be associated with altered anticipated emotions (lower levels of anticipated valence) in both social and non-social conditions. Our second objective was to examine the process pathway of AF. Based on the "Constructive Episodic Simulation Hypothesis", we hypothesized that both mental simulation and in-the-moment feelings would predict anticipated emotions; and, in-the-moment feelings would mediate the relationship between mental simulation and anticipated emotions (Figure 1A). Our third objective was to examine the effect of subclinical features on AF capacity. Since both impaired mental simulation and reduced anticipatory pleasure have been found in individuals with schizotypal traits, depressive symptoms and autistic traits (Li et al., 2015; Shi et al., 2017), we hypothesized that both mental simulation and in-the-moment feelings could be predicted by subclinical features (Figure 1B).

2. Method

2.1 Participants and Procedure

Since young adults are under high risk of developing psychiatric disorders (Kessler et al., 2005; Fusar-Poli et al., 2021), the present study targeted young adults and on-line advertisement was used to recruit participants aged from 18 to 30 years. Participants answered self-report items to evaluate 1) whether they were diagnosed with any psychiatric disorders; 2) whether they have neurological disorders; 3) whether they have medication exposure and 4) whether they have brain injury. Participants who met the abovementioned exclusive criteria were not involved in the present study.

The sample size for the present study was estimated by two sources. First, a sample size above 200 is regarded as a reliable sample size for structural equation modeling analysis (Barrett, 2007). Second, the sample sizes (e.g., n=119; n=339) which were adopted in previous AF studies (Marroquín, Nolenhoeksema, & Miranda, 2013; Hoerger et al., 2012, respectively). Therefore, we aimed to recruit around 300 participants and also ensuring at least 200 valid participants.

A total of 319 participants were recruited. All participants completed the behavioural task and self-report checklists in a face to face setting. The questionnaires were all completed in the same order. This study was approved by the Ethics Committee of the Institute of Psychology, the Chinese Academy of Sciences (certification number: H15031). All participants gave written informed consent. The present study has no pre-registration.

2.2 Social affective forecasting task

The Social Affective Forecasting (SAF) task is a behavioural task that assesses AF, including the features of mental simulation, in-the-moment feelings and anticipated emotions, in both social and non-social conditions (R.-t Zhang et al., 2019a). There are four conditions in the SAF task (positive social, positive non-social, negative social and negative non-social) and each condition has two events people might encounter in day-to-day life. AF variables for each condition were the mean rating score of two daily events. The general anticipated emotions for positive events and negative events were the average score of four positive or four negative events (collapsed across social and non-social events), respectively.

The SAF task contained a practice session and a formal session. In the practice session, experimenters helped participants to learn to make a distinction between anticipated emotions and in-the-moment feelings and respond to stimuli. Anticipated emotions and in-the-moment feelings were measured by valence ratings. For anticipated emotions participants were ask: “Please predict how you will feel when you are invited to your friend’s wedding? (1-9: very unhappy-very happy)”; while for in-the-moment feelings, participants were instructed: “Please rate how you feel right now after imagining being invited to your friend’s wedding; (1-9: very unhappy-very happy)”. After ensuring that the participants reacted correctly to stimuli, the formal session commenced. In each trial, the daily event was presented in writing on the computer screen first (e.g., you are invited to attend your best friend’s wedding) and participants were required to imagine the presented event

with their eyes closed. Participants opened their eyes when completed the imagination and then described what they have imagined. Afterwards, they were asked to report their anticipated emotions and then in-the-moment feelings. They then rated features of mental simulation on sensory information (visualization, voice, smell, taste, touch; e.g., “How much visualization was contained in your imagination?”) and social interaction (self-referential thoughts, others-referential thoughts, communication; e.g., “How many self-referential thoughts were contained in your imagination?”), with 7-point Likert scales (1-7: none-many). The presentation sequence of eight events was counterbalanced across participants. The SAF task has been used in the Chinese population and has been shown to possess good validity (R.-t Zhang et al., 2019a).

2.3 Measurements

2.3.1 Schizotypal Personality Questionnaire

The Chinese version of the Schizotypal Personality Questionnaire (SPQ) was used to measure schizotypal traits (Chen et al., 1997). The SPQ has a three-factor structure (cognitive-perceptual, interpersonal and disorganization) and includes 74 items (Chen et al., 1997). Participants answered “yes” or “no” to each item and the score could range from 0 to 74, with higher scores indicating more schizotypal traits. Both the original version (Cronbach's alpha = 0.91, test-retest reliability = 0.81) and the Chinese version (Cronbach's alpha = 0.90, test-retest reliability = 0.86) of the SPQ have been shown to possess good reliability and validity (Chen et al., 1997; Raine,

1991). The SPQ has been applied in Chinese samples successfully (Li et al., 2015; Shi et al., 2017). The internal consistency (Cronbach's alpha) of the SPQ in this study is 0.937.

2.3.2 Autism-Spectrum Quotient

The Chinese version of the Autism-Spectrum Quotient (AQ) was used to measure autistic traits (R.-t Zhang et al., 2016). The AQ comprises five subscales (social skills, attention switching, attention to detail, communication and imagination) from 50 items, with a possible score ranging from 0 to 50. A higher score indicates more autistic traits. The original version (Cronbach's alpha = 0.62-0.77, test-retest reliability = 0.70) and the Chinese version of the AQ (Cronbach's alpha = 0.82, test-retest reliability = 0.79) have both been shown to possess good reliability and validity (Baron-Cohen et al., 2001; L. Zhang et al., 2016). The AQ has been used to assess autistic traits in the Chinese population (Shi et al., 2017; R.-t Zhang et al., 2019b). The internal consistency (Cronbach's alpha) of the AQ in this study is 0.775.

2.3.3 Patient Health Questionnaire-9

The Chinese version of the Patient Health Questionnaire-9 (PHQ-9) was used to measure depressive symptoms (Wang et al., 2014). The PHQ-9 contains nine items and each item captures one depressive symptom such as depressed mood or anhedonia (Kroenke, Spitzer, & Williams, 2001). Participants were asked to report the frequency of the described symptom on a four-point Likert scale (0: not at all; 3:

nearly every day). The PHQ-9 has a possible score ranging from 0 to 27, with higher scores indicating more severe depressive symptoms. The original version (Cronbach's alpha = 0.89, test-retest reliability = 0.84) and the Chinese version of the PHQ-9 (Cronbach's alpha = 0.83, test-retest reliability = 0.93) have both been shown to possess good reliability and validity (Kroenke et al., 2001; Wang et al., 2014). The Chinese version of the PHQ-9 has been widely applied in Chinese samples (Wang et al., 2014; R.-t Zhang et al., 2019b). The internal consistency (Cronbach's alpha) of the PHQ-9 in this study is 0.922.

2.4 Data analysis

Descriptive information including demographic information, AF variables and subclinical features were analyzed using the Statistical Package for Social Science (SPSS; version 23.0). Next, correlation analysis was conducted to explore the relationship between anticipated emotions and subclinical features. Based on results from the correlation analysis, regression analysis was used to test which subclinical features predicted anticipated emotions.

We further constructed structure equation models in two steps. First, based on the constructive mental simulation hypothesis (Gilbert & Wilson, 2007), we explored the working pathway of AF without subclinical features. To test the mediating role of in-the-moment feelings (Figure 1A), we ran the structure equation models with mental simulation as the predictor, in-the-moment feelings as the mediator and anticipated emotions as the outcome. Secondly, subclinical features were added to

the model. Based on the AF process model (Figure 1A), subclinical features were added as predictors of mental simulation, in-the-moment feelings and anticipated emotions (Figure 1B). Bootstrapping with 1000 iterations was used to test the significance of the mediation effect. Structural equation modeling analysis was conducted using Mplus (Muthén & Muthén, 2013). We report all manipulations, measures, and exclusions in the present study.

3. Results

3.1 Descriptive information

A total of 319 participants (male: 104; female: 215) completed the behavioural measurements. Their mean age was 21.94 (SD=2.55) years and the mean duration of education was 15.27 (SD=2.26) years. Some participants (n=22) anticipated positive events negatively (e.g., anticipated valence < 5 for positive social events) or anticipated negative events positively (e.g., anticipated valence > 5 for negative social events). We excluded them for subsequent analysis, leaving 297 participants in the final valid sample. The mean age of the valid sample was 21.81 (SD=2.46) years and the mean duration of education was 15.19 (SD=2.23). Analysis based on the original sample (n=319) were also conducted and results showed the same pattern with the final valid sample (see Supplementary Materials).

Demographic information, subclinical features and scores of AF variables of the valid sample are described in Table 1. Distribution of subclinical features and social effects on AF variables were presented in Supplementary Information.

(Please insert Table 1 here)

3.2 Relationship between anticipated emotions and subclinical features

Given that anticipated emotions were not normally distributed, Spearman's correlation analysis was used to analysis the relationship between anticipated emotions and subclinical features (Table 2). Results revealed that SPQ total score was negatively correlated with the general anticipated emotions for positive events (r=-0.165, p=.004) but not for negative events (r=0.011, p=.851). However, no significant correlations were found between anticipated emotions and AQ scores (general positive emotions: r=-0.107, p=.067; general negative emotions: r=-0.012, p=.835) or PHQ-9 scores (general positive emotions: r=-0.051, p=.385; general negative emotions: r=-0.091, p=.118). We also examined the relationship between in-the-moment feelings and subclinical features and the result was shown in Table S2.

(Please insert Table 2 here)

Since AQ and PHQ-9 scores were not significantly correlated with anticipated emotions, these were not pursued in subsequent analysis. Given that the exploratory correlation analysis revealed the association between SPQ scores and positive anticipated emotions, we further investigated the predictive role of subdimensions of the SPQ (cognitive-perceptual, interpersonal, disorganization features) on anticipated emotions in the social and non-social condition using regression analysis.

Correlation analysis between subdimensions of SPQ and anticipated emotions was conducted before regression analysis, and results are shown in Supplementary information (Table S3). We found that interpersonal features of the SPQ negatively predicted anticipated emotions only in the positive social condition (*unstandardized β*=-0.031, 95% Confidence intervals = [-0.055, -0.007], *standardized β*=-.186, *p*=.012, adjust R^2 = 0.046, f^2=0.058), but not in the positive non-social condition (*unstandardized β*=-0.020, 95% Confidence intervals = [-0.044, 0.003], *standardized β*=-0.125, *p*=.094; adjust R^2 = 0.014, f^2=0.025). Results are shown in Table 3.

(Please insert Table 3 here)

3.3 Structure equation modeling results

The normality of the variables included in the hypothesized models was tested before running the structure equation models. Variables were transformed using Blom's Formula to meet the normality assumption (Z-score of skewness < 3).

Before including subclinical features, the model of AF process in social conditions was run first. Since we were targeting AF in social conditions, mental simulation features associated with social interaction (i.e., self-referential thoughts, others-referential thoughts, communication) were included as indicators of social mental simulation. Moreover, because visualization is regarded as a key feature of mental simulation (Barsics, Van der Linden, & D'Argembeau, 2016) and has strong correlations with anticipated emotions (Yang et al., 2019), visualization was also

included as an indicator of social mental simulation.

Structure equation modeling revealed that the observed data fitted the hypothesized model (model fitting indices: χ^2=22.41, *df*=8, *p*=0.004; CFI: 0.977; TLI: 0.958; RMSEA: 0.078; See Figure 1A). Bootstrapping calculation indicated that in-the-moment feelings had a significant mediation effect in the model (*β*=0.113, 95% Confidence intervals = [0.064, 0.169], *p*<.001).

On the basis of the AF process model in social conditions and the results from the correlations and regression model, we added interpersonal features from the SPQ to see how it predicted anticipated emotions. Observed data fitted the hypothesized model well (model fitting indices: χ^2=29.04, *df*=11, *p*=0.002; CFI: 0.973; TLI: 0.948; RMSEA: 0.074; See Figure1B). There were three indirect paths from interpersonal features to anticipated emotions. Two indirect paths via in-the-moment feelings were significant:

1) interpersonal features –> in-the-moment feelings –> anticipated emotions (*β*=-0.054, 95% Confidence intervals = [-0.108, -0.012], *p*=.026);

2) interpersonal features –> social mental simulation –> in-the-moment feelings –> anticipated emotions (*β*=-0.017, 95% Confidence intervals = [-0.036, -0.004], *p*=.025).

However, the indirect path via social mental simulation but without in-the-moment feelings was not significant (*β*=-0.027, 95% Confidence intervals = [-0.064, -0.005], *p*=.068).

(Please insert Figure 1 here)

4. Discussion

In this study, we examined the relationship between AF and subclinical features, and the effect of subclinical features on the AF process. The subclinical features which were the most significant were SPQ Interpersonal. The task we devised separated AF process into imaging an event (mental stimulation), experiencing in the moment emotions while imaging (in-the-moment feelings) and predicting future emotions if the event happened (anticipated emotions). Our results revealed both mental simulation and in-the-moment feelings predicted anticipated emotions, and in-the-moment feelings mediated the relationship between mental simulation and anticipated emotions. Neither autistic traits, nor depressive symptoms were related to anticipated emotions. In line with our hypothesis, interpersonal features of schizotypal traits predicted anticipated emotions only in social conditions. In addition, in-the-moment feelings plays a central role in the relationship between interpersonal features of schizotypal traits and anticipated emotions.

We found that interpersonal features of schizotypal traits predicted anticipated emotions in social conditions. Specifically, individuals with more interpersonal features anticipated lower levels of positive emotions, compared with individuals with less interpersonal features, for future social events. Interpersonal features of schizotypal traits are characterized by anxious feelings in social activities and lacking close friends (Raine, 1991). This finding is in line with previous research showing that individuals with schizotypal traits have social-specific impairment when anticipating

emotions (Engel et al., 2015; Moore et al., 2019; Xie et al., 2014). As schizotypal traits are a dimensional structure (cognitive-perceptual features, interpersonal features, disorganization features), teasing apart predictive effects of different sub-dimensions may help us to better understand which particular features of schizotypal traits are important for the reduced emotional and rewarding experiences during social environments. Our findings extended previous results by highlighting the impact of interpersonal features (but not cognitive perceptual features or disorganization features) on the AF process. Thus, future studies aiming at investigating social-specific impaired AF in schizotypal individuals could focus on interpersonal features and perhaps start to tease apart the different elements of this dimension i.e. social withdrawal, social anxiety, social anhedonia, valuing of friendships. The findings are intuitive since much emotional engagement with the social world comprises off-line mental social imagery, where cognitive biases and internal capacities shape perceptions (Bell, Mills, Modinos, & Wilkinson, 2017).

Complementary to this, in the AF process, we found that in-the-moment feelings mediated the relationship between mental simulation and anticipated emotions, suggesting that both mental simulation and in-the-moment feelings could predict anticipated emotions. Moreover, mental simulation could predict in-the-moment feelings. This relationship supports the “constructive episodic simulation hypothesis” (Gilbert & Wilson, 2007). Specifically, mental simulation of future scenarios would be shaped by how people recall their feelings from past events, and, how people constructed the future scenarios induces their in-the-moment feelings. Together with

in-the-moment feelings, mental simulation of future scenarios further feed into how individuals forecasted their future emotions. Moreover, this finding also helps to explain why impact bias exists. Gilbert and Wilson (2009) proposed that dissimilar context and dissimilar content may contribute to the impact bias. Specifically, people anticipate their emotions based on what they have imagined (content) and how they feel (context) during forecasting, but their experienced emotions are influenced by what they have experienced and how they feel in the real environment. Anticipated emotions that people imagine may not reflect actual emotional experiences, either due to how they feel at the time when they consider past and future experiences; or, in trying to surmise emotions for a future experience based on past experiences which are too dissimilar from their future anticipated event. These factors ensure that people are less likely to predict their future emotions accurately. Our findings provide empirical evidence to support that anticipated emotions are influenced by both content (social mental simulation) and context (in-the-moment feelings) factors.

We also found that the mediating path from interpersonal features of schizotypal traits to anticipated emotions could not be significant without in-the-moment feelings, highlighting the key role of in-the-moment feelings in the altered AF process in individuals with schizotypal traits. How we feel at the time is important for our anticipation of future emotions: current emotions not only color past reminiscing but also our projections for possible upcoming experiences. We found that interpersonal features negatively predicted social mental simulation, but this pathway did not further predict anticipated emotions directly. This suggests that individuals with

more interpersonal features may have reduced ability in mental simulation of social events, or they find it difficult to simulate social events, but the abnormal mental simulation is less likely associated with their reduced anticipated emotions (reduced anticipated valence) directly. Indeed, individuals with more interpersonal features may experience less pleasantness during mental simulation since they have trouble in simulating the positive qualities of future social events, and the reduced in-the-moment feelings may be associated with lower anticipated emotions. Since individuals with more interpersonal features (e.g., interpersonal problems) tend to have fewer close friends and have problems in emotion expression or communications (Raine, 1991), they might experience less pleasure from social activities in the past and thus less likely to feel happy when simulating social activities. Indeed, reduced pleasurable experience during anticipation has been reported in previous studies, in individuals with schizotypal traits (Chan et al., 2012; Li et al., 2015).

However, we did not find any correlation between anticipated emotions and autistic traits. Previous studies have reported that individuals with autistic traits have social anhedonia and reduced anticipatory pleasure (Novacek et al., 2016; Shi et al., 2017), but no previous studies have directly demonstrated AF impairment in individuals with autistic traits. Therefore, the impaired anticipatory pleasure found in individuals with autistic traits may not be due to impaired AF, rather it may be related to other components of anticipatory pleasure, such in-the-moment feelings or associative conditioning (Frost & Strauss, 2016). In fact, we found AQ scores were

negatively correlated with in-the-moment feelings in social and non-social conditions. Moreover, we did not find any correlation between anticipated emotions and depressive symptoms, which is contrary to previous findings (Marroquín & Nolen-Hoeksema, 2015; Wenze et al., 2013). One possible reason is that we adopted the PHQ-9 to measure depressive symptoms. Most previous studies have used the Beck Depression Inventory to measure depressive symptoms (Marroquín & Nolen-Hoeksema, 2015; Marroquín et al., 2013; Yuan & Kring, 2009), which has more items that measure depressive symptoms from different perspectives and focuses heavily on anhedonia. The relationship between anticipated emotions and depressive symptoms needs to be further investigated in future studies to different mood (feeling down) from anhedonia (reduced pleasure/reward). Another potential reason is that we considered anticipated emotions to specific future events. Previous studies which found significant association between depressive symptoms and anticipated emotions captured anticipated emotions as general emotions, without specific events (Colombo et al., 2020). In contrast, studies failed in reporting the association between depressive symptoms and anticipated emotions to specific future events (Murphy et al., 2018). Therefore, depressed individuals may anticipate more negative emotions in general but they may anticipate similar levels of pleasure in response to specific future events. There may be an important role for mental simulation as a point of intervention. Perhaps in people with depressive symptoms, recalling the specific features of an experience how to anchor them emotionally to positive attributes. Under more general imaginings, cognitive biases may more readily exert

influence in the absence of contextual cues. However, this potential reason needs to be further clarified in future studies.

This study has several limitations. First, contents of the SAF task were devised based on young adults and our participants were college students. This may affect the generalization of our findings to other populations, such as children or the elderly. Moreover, the sample in this study showed relatively high depressive symptoms, which may bring bias to the current findings. Our findings should be further replicated in diverse samples and future studies should explore the developmental trajectory of the AF process and explore how the relationship between AF and subclinical features changes over time. Secondly, we did not measure the level of anhedonia or amotivation of participants, we were unable to provide the direct evidence showing the relationship between AF deficits and anhedonia or amotivation. Future studies should adopt longitudinal design to investigate the relationship between AF and negative symptoms of psychosis. Thirdly, whether the SPQ interpersonal factor could or could not predict non-social anticipated emotion needs to be further verified and replicated. Given that the AF process is informed by personal experience, it would also be beneficial to capture recent experiences with the scenarios being captured during AF tasks.

5. Conclusion

To conclude, we found that interpersonal features of schizotypal traits predicted altered anticipated emotions (lower anticipated valence) in social conditions.

Moreover, in-the-moment feelings may play a vital role in the AF process and may connect interpersonal features of schizotypal traits with impaired AF. Our findings suggest that in-the-moment feelings might be a possible treatment target to improve pleasure anticipation and pleasure experience in individuals with schizotypal traits, which may further help to intervene the development of psychosis. Future intervention programs can adopt mindfulness strategies to help individuals to aware and feel their in-the-moment feelings during mental simulation.

Disclosure of conflict of interest

The authors declare there are no conflicts of interest.

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Table1. Descriptive information of demographic characters, subclinical features and AF variables

		Mean	SD	Min	Max
Gender			Male/Female：96/201		
Age (years)		21.81	2.46	18	31
Years of education		15.19	2.23	0.0	22.0
SPQ total score		31.34	14.07	1.0	68.0
	Cognitive-perceptual	13.84	6.98	0.0	32.0
	Interpersonal	10.79	5.56	0.0	25.0
	Disorganization	6.57	4.21	0.0	16.0
AQ total score		22.24	6.84	7.0	39.0
	Social skills	4.88	1.98	0.0	10.0
	Attention switching	4.34	1.71	0.0	9.0
	Attention to details	4.45	2.02	0.0	10.0
	Communication	4.19	1.83	0.0	9.0
	Imagination	4.33	1.99	0.0	10.0
PHQ-9 total score		8.19	5.65	0.0	27.0
Anticipated emotions	General Positive	7.74	0.78	5.0	9.0
	Positive Social	7.76	0.93	5.00	9.00
	Positive Non-social	7.73	0.90	5.5	9.0
	General Negative	2.17	0.76	1.0	4.5
	Negative Social	2.30	0.92	1.0	5.0
	Negative Non-social	2.04	0.93	1.0	5.0
In-the-moment feelings	General Positive	6.73	1.00	3.5	9.0
	Positive Social	6.71	1.18	3.5	9.0
	Positive Non-social	6.75	1.14	3.0	9.0
	General Negative	3.49	1.00	1	6.25
	Negative Social	3.53	1.10	1.0	6.0
	Negative Non-social	3.45	1.19	1.0	6.5

Note: n=297; SPQ: Schizotypal Personality Questionnaire; AQ: Autism-Spectrum Quotient; PHQ-9: Patient Health Questionnaire-9.

Table 2. Correlations between subclinical features and anticipated emotions

	AQ	SPQ	PHQ	General_AE_P	General_AE_N
AQ	1.000	.451***	.197**	-.107	-.012
SPQ		1.000	.471***	-.165**	.011
PHQ			1.000	-.051	-.091
General_AE_P				1.000	-.413***
General_AE_N					1.000

Note: **: p<.01, ***: p<.001. n=297; SPQ: Schizotypal Personality Questionnaire; AQ: Autism-Spectrum Quotient; PHQ-9: Patient Health Questionnaire-9; General_AE_P: General positive anticipated emotions; General_AE_N: General negative anticipated emotions.

Table 3. Regression analysis on the association between positive anticipated emotions and subdimensions of schizotypal traits

Outcome variables	Predictor	R^2	*Adjust* R^2	*F*	*Standardized β*	*p*
Social AF	Cognitive-perceptual	0.055	0.046	5.71**	0.083	.293
	Interpersonal				-0.186	.012
	Disorganization				-0.116	.204
Non-social AF	Cognitive-perceptual	0.024	0.014	2.41	0.097	.228
	Interpersonal				-0.125	.094
	Disorganization				-0.087	.347

Note: **: *p*<.01; n=297; Social AF: anticipated emotions in social conditions; Non-social AF: anticipated emotions in non-social conditions.

Figure legends

Figure 1. (A). The model of AF process. The in-the-moment feelings mediated the relationship between social mental simulation and anticipated emotions (n=297). Standardized path coefficients are displayed with paths. (B). The effect of interpersonal features on AF process. Mediating paths from interpersonal features to anticipated emotions via in-the-moment feelings were significant (interpersonal features – in-the-moment feelings – anticipated emotions: β=-0.054, 95% Confidence intervals = [-0.108, -0.012], p=.026; interpersonal features – social mental simulation – in-the-moment feelings – anticipated emotions: β=-0.017, 95% Confidence intervals = [-0.036, -0.004], p=.025). Mediating path from interpersonal features to anticipated emotions without in-the-moment feelings was not significant (interpersonal features – social mental simulation – anticipated emotions: β=-0.027, 95% Confidence intervals = [-0.064, -0.005], p=.068). Standardized path coefficients are displayed with paths.

Note: *: p<.05; **: p<.01; ***: p<.001.

Fig 1.

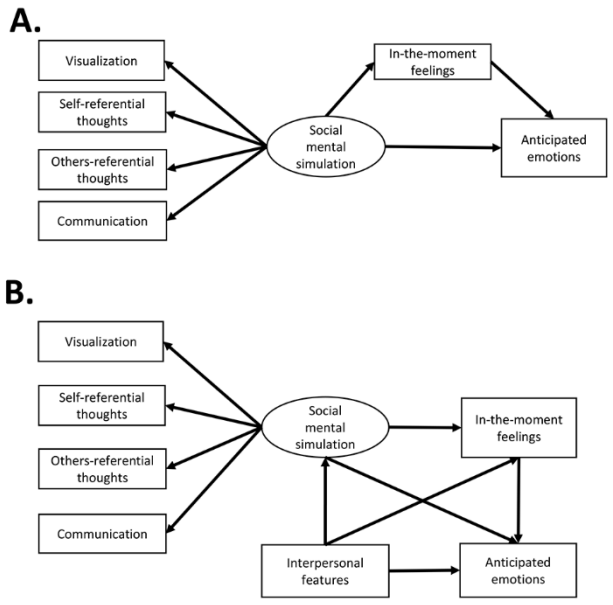
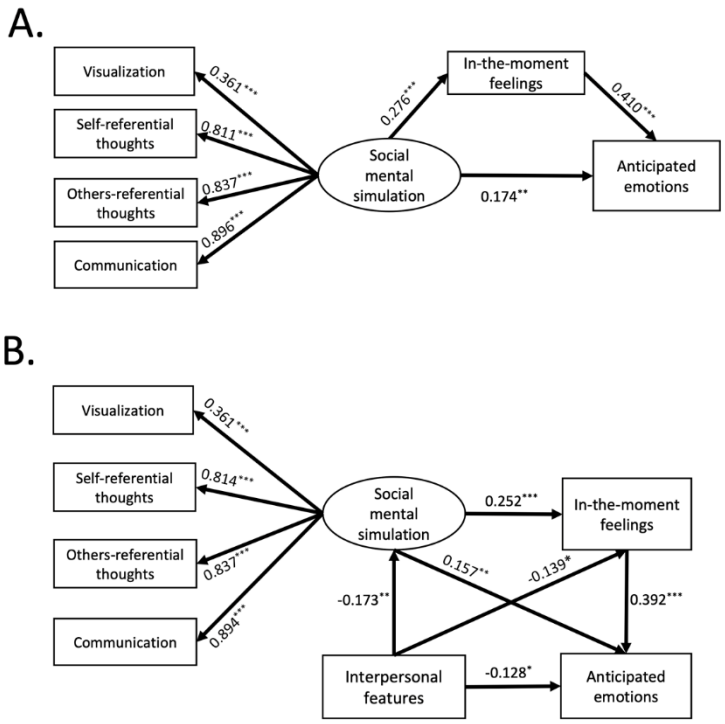

A.
Visualization
Self-referential thoughts
Others-referential thoughts
Communication
Social mental simulation
In-the-moment feelings
Anticipated emotions
B.
Visualization
Self-referential thoughts
Others-referential thoughts
Communication
Social mental simulation
In-the-moment feelings
Interpersonal features
Anticipated emotions

Fig 2.


A.
Visualization
Self-referential thoughts
Others-referential thoughts
Communication
0.361***
0.811***
0.837***
0.896***
Social mental simulation
0.276***
In-the-moment feelings
0.410***
Anticipated emotions
0.174**
B.
Visualization
Self-referential thoughts
Others-referential thoughts
Communication
0.361***
0.814***
0.837***
0.894***
Social mental simulation
0.252***
In-the-moment feelings
0.157**
-0.139*
-0.173**
0.392***
Interpersonal features
-0.128*
Anticipated emotions

Supplementary information

1. Social effects on affective forecasting

Table S1 Social effects on affective forecasting

	Social		Nonsocial		*T*	*df*	*p*	Cohen'd
	Mean	SD	Mean	SD				
Anticipated emotions_P	7.76	0.93	7.73	0.90	0.53	296	0.598	0.04
Anticipated emotions_N	2.30	0.92	2.04	0.93	4.18	296	<0.001	0.34
In-the-moment feelings_P	6.71	1.18	6.75	1.14	-0.60	296	0.552	0.05
In-the-moment feelings _N	3.53	1.10	3.45	1.19	1.22	296	0.222	0.10
Visualization_P	5.89	1.09	5.35	1.27	7.24	296	<0.001	0.60
Visualization_N	5.25	1.34	5.47	1.26	-3.49	296	0.001	0.29
Self-referential thoughts_P	4.89	1.50	4.80	1.57	1.08	296	0.279	0.09
Self-referential thoughts_N	5.15	1.32	5.07	1.46	1.35	296	0.177	0.11
Others-referential thoughts_P	4.42	1.60	3.15	1.68	13.25	296	<0.001	1.09
Others-referential thoughts_N	4.40	1.52	3.30	1.70	11.75	296	<0.001	0.97
Communication_P	4.65	1.55	3.39	1.67	13.21	296	<0.001	1.09
Communication_N	4.73	1.44	3.70	1.76	10.41	296	<0.001	0.86

Note: n=297; P: positive; N: negative.

Participants reported less unhappy anticipated emotions in social than non-social conditions for negative events (*T*=4.18, *df*=296, *p*<0.001; Cohen's d=0.34). No significant difference in anticipated emotions was found between non-social and social conditions for positive events (*T*=-0.53, *df*=296, *p*=0.598; Cohen's d=0.04).

For social conditions, compared to non-social, participants reported more visualization for positive events (T=7.24, df=296, p<0.001; Cohen's d=0.60) but less visualization for negative events (T=-3.49, df=296, p=0.001; Cohen's d=0.29). Moreover, participants reported more others-referential thoughts (positive events: T=13.25, df=296, p<0.001, Cohen's d=1.09; negative events: T=11.75; df=296, p<0.001, Cohen's d=0.97) and communication details (positive events: T=13.21, df=296, p<0.001, Cohen's d=1.09; negative events: T=10.41; df=296, p<0.001,

Cohen’s d=0.86) in social conditions than non-social conditions.

2. Relationships between in-the-moment feelings and subclinical features

Table S2 Correlations between in-the-moment feelings and subclinical features

	SPQ	AQ	PHQ-9	Positive Social IF	Positive Nonsocial IF	Negative Social IF	Negative Nonsocial IF
SPQ	1.00	.451**	.471**	-0.10	-0.11	0.03	0.06
AQ		1.00	.197**	-.166**	-.122*	0.00	0.01
PHQ-9			1.00	-0.03	0.01	0.02	-0.02
Positive Social_IF				1.00	.466**	-.436**	-.400**
Positive Nonsocial _IF					1.00	-.463**	-.443**
Negative Social_ IF						1.00	.532**
Negative Nonsocial_IF							1.00

Note: n=297; *: p<0.05; **: p<0.01; ***: p<0.001; IF: in-the-moment feelings; SPQ: schizotypal traits scores; AQ: autistic traits scores; PHQ-9: depressive symptoms scores.

3. Relationship between subdimensions of schizotypal traits and anticipated emotions

Table S3 Correlations between subdimensions of schizotypal traits and anticipated emotions

	AE_PS	AE_PN	Cognitive-perceptual	Interpersonal	Disorganization
AE_PS	1	.461***	-0.07	-.212***	-.143*
AE_PN		1	-0.034	-.141*	-0.096
Cognitive-perceptual			1	.453***	.691***
Interpersonal				1	.644***
Disorganization					1

Note: n=297; *: p<0.05; **: p<0.01; ***: p<0.001; AE_PS: anticipated emotion in positive social conditions; AE_PN: anticipated emotion in positive non-social conditions.

4. Results based on the original sample (n=319)

4.1 Correlations between anticipated emotions and subclinical features

Table S4 Correlations between in-the-moment feelings and subclinical features

	AQ	SPQ	PHQ	General_AE_P	General_AE_N
AQ	1.000	.460**	.218**	-.100	-.022
SPQ		1.000	.483**	-.180**	.016
PHQ			1.000	-.058	-.071
General_AE_P				1.000	-.378**
General_AE_N					1.000

Note: **:p<0.01, ***: p<0.001. n=319; SPQ: Schizotypal Personality Questionnaire; AQ: Autism-Spectrum Quotient; PHQ-9: Patient Health Questionnaire-9; General_AE_P: General positive anticipated emotions; General_AE_N: General negative anticipated emotions.

4.2 Predictive effects of interpersonal features on positive social anticipated emotions

Table S5 Regression analysis on the association between positive anticipated emotions and subdimensions of schizotypal traits

Outcome variables	Predictor	R^2	*Adjust* R^2	*F*	*Standardized β*	*p*
Social AF	Cognitive-perceptual	0.055	0.046	6.12***	0.098	0.199
	Interpersonal				-0.149	0.038
	Disorganization				-0.165	0.065
Non-social AF	Cognitive-perceptual	0.024	0.015	2.58	0.139	0.073
	Interpersonal				-0.092	0.206
	Disorganization				-0.132	0.145

Note: **:p<0.01; n=319; Social AF: anticipated emotions in social condition; Non-social AF: anticipated emotions in non-social condition.

4.3 Structure equation modeling

AF process model.

Structure equation modeling revealed that the observed data fitted the hypothesized model well (model fitting indices: χ^2=25.94, *df*=8, *p*=0.001; CFI: 0.975; TLI: 0.954; RMSEA: 0.084; See Figure S1A). Bootstrapping calculation indicated that in-the-moment feelings had a significant mediation effect in the model (*β*=0.138, 95% Confidence intervals = [0.082, 0.201], *p*<0.001).

Effects of Interpersonal features on AF process

Model fitting indices of Model B: χ^2=30.13, *df*=11, *p*<0.001, RMSEA=0.074, CFI=0.974, TLI=0.951 (See Figure S1B). The indirect effect from interpersonal features to anticipated emotions via in-the-moment feelings was significant (*β*=-0.068, 95% Confidence intervals = [-0.117, -0.020], *p*=0.007). The indirect effect from interpersonal features to anticipated emotions via mental simulation and in-the-moment feelings was significant (*β*=-0.017, 95% Confidence intervals = [-0.039, -0.005], *p*=0.038). The indirect effect from interpersonal features to anticipated emotions via mental simulation was not significant (*β*=-0.021, 95% Confidence intervals = [-0.058, -0.004], *p*=0.084).

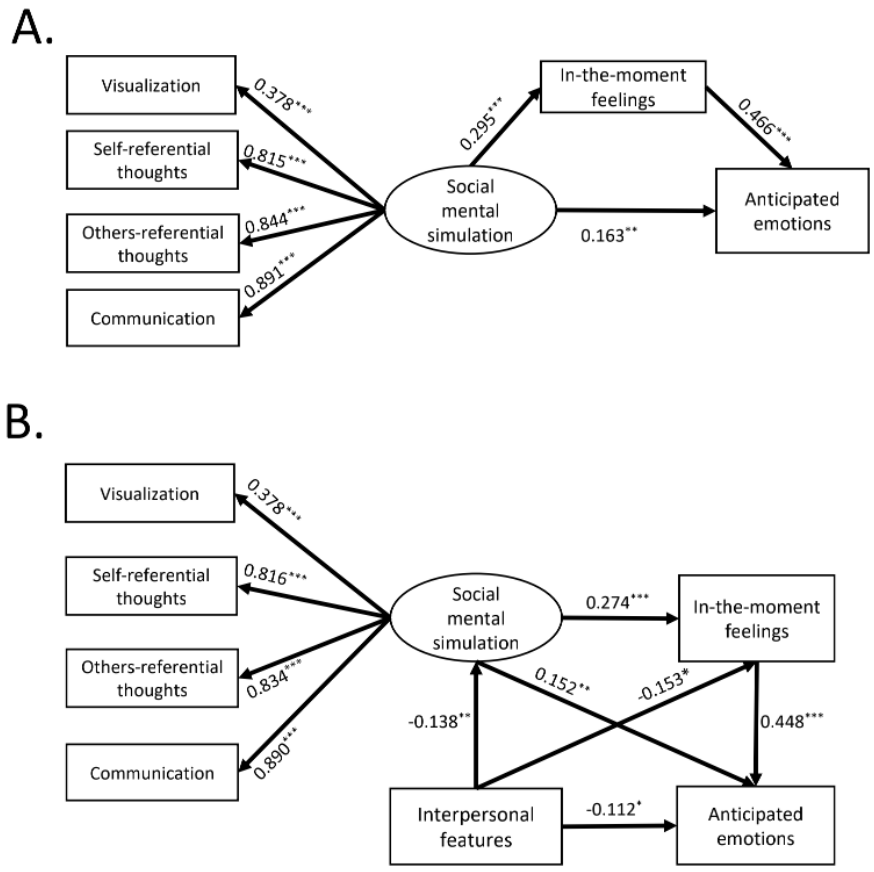


Figure S1. (A). The model examining the mediating effect of in-the-moment feelings on the relationship between the social mental simulation and anticipated emotions (n=319). Standardized path coefficients are displayed with paths. (B). The effect of interpersonal features on AF process. Mediating paths from interpersonal features to anticipated emotions via in-the-moment feelings were significant (interpersonal features – in-the-moment feelings – anticipated emotions: β=-0.068, 95% Confidence intervals = [-0.117, -0.020], p=0.007; interpersonal features – social mental simulation – in-the-moment feelings – anticipated emotions: (β=-0.017, 95% Confidence intervals = [-0.039, -0.005], p=0.038). Mediating path from interpersonal features to anticipated emotions without in-the-moment feelings was not significant (interpersonal features – social mental simulation – anticipated emotions: β=-0.021, 95% Confidence intervals = [-0.058, -0.004], p=0.084).

Note: *:p<0.05; **:p<0.01; ***:p<0.001.

5. Distribution of subclinical features

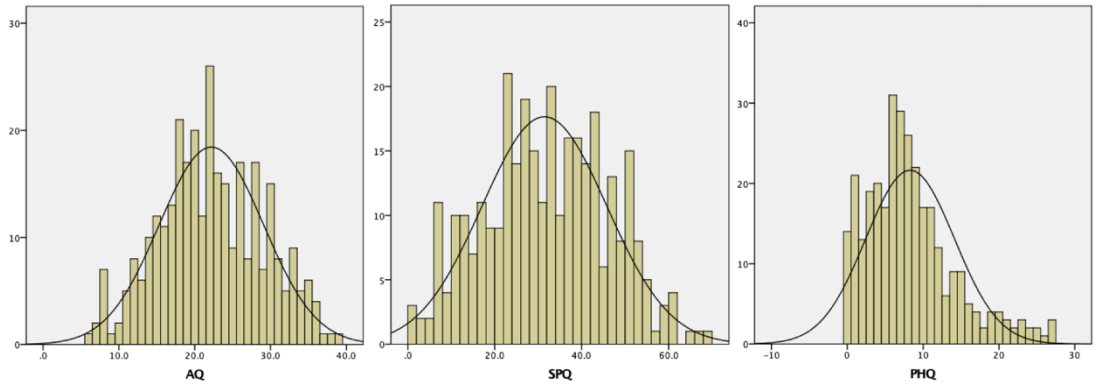


Figure S2. Distribution of subclinical features. AQ: scores of autistic traits; SPQ: scores of schizotypal traits; PHQ: scores of subclinical depressive symptoms.