

# Network structure of anticipatory pleasure and risk features: Evidence from a large college sample

## Abstract

Investigating the relationship between anticipatory pleasure deficits and risk features of mental disorders not only theoretically benefits the understanding of anhedonia, but could also facilitate early detection and intervention of mental disorders. Using network analysis, the present study examined the pattern of relationship between anticipatory pleasure and risk features of schizophrenia spectrum, depressive, anxiety, autism spectrum, and obsessive–compulsive disorders in a large sample of college students ( $n = 2152$ ). It was found that interpersonal features of schizotypal personality traits and poor social skills of autistic traits showed strong correlation with low social anticipatory pleasure. Depressive symptoms severity was weakly associated with reduced abstract anticipatory pleasure, while obsessive–compulsive traits were weakly associated with high contextual anticipatory pleasure. No significant correlation was found between anxiety symptoms severity and anticipatory pleasure. Social anticipatory pleasure had the highest strength centrality among all anticipatory pleasure components, while interpersonal features of schizotypal personality traits had the highest strength centrality in the whole network. Our findings suggest that impaired anticipatory pleasure, especially social anticipatory pleasure, is a particular feature of schizotypal personality traits and autistic traits. Our findings may have implications for intervention in that the social component may be a target to improve anhedonia in individuals with schizotypal and autistic traits, while interpersonal features may be a key treatment target given that it was central to the relationship between anticipatory pleasure and risk features.

**Keywords:** anticipatory pleasure; mental health; network analysis; risk features

## Appendix S1. Supporting Information.

High incidence of comorbidity between diagnostic categories and heterogeneity in presentation within disorders (Kotov et al., 2017) suggest that discrete divisions between diagnostic categories may be less welldefined than previously assumed and evidence suggests that symptom expression is continuous between disorders (Lambert et al., 2018; Sharma et al., 2017). One symptom that is present transdiagnostically is anhedonia (Sharma et al., 2017). Anhedonia is characterized by a reduced ability to experience pleasure and is a core symptom of schizophrenia (Strauss & Cohen, 2018) and depression (Yang et al., 2014). It is also reported in autism spectrum disorders (ASD; Chevallier, Grezes, Molesworth, Berthoz, & Happe, 2012; Novacek, Gooding, & Pflum, 2016) and obsessive–compulsive disorder (OCD; Abramovitch, Pizzagalli, Reuman, & Wilhelm, 2014), and is associated with anxiety symptoms (Winer et al., 2017).

Social anhedonia and physical anhedonia are two main components of anhedonia (Chapman, Chapman, & Raulin, 1976). Social anhedonia appears to play a specific role in schizophrenia spectrum disorder (SSD) and ASD. For instance, social anhedonia, but not physical anhedonia, may be a predictor of onset of schizophrenia (Kwapil, 1998). By summarizing studies on social anhedonia and schizophrenia, Cohen, Najolia, Brown, and Minor (2011) proposed that hedonic deficits in schizophrenia may be specific to the social domain. On the other hand, ASD is characterized by social deficits. Studies have reported that adolescents with high-functioning autism experience less pleasure in interpersonal activities than controls (Chevallier et al., 2012). Moreover, autistic traits have been found to be negatively correlated with social and general pleasure experience (Novacek et al., 2016). In light of these findings, it is possible that hedonic experience in individuals with SSD or ASD may have social-specific impairments.

The findings of anhedonia in patients with schizophrenia, however, are less clear: subjective measures reveal diminished hedonic experience, while laboratory-based studies report intact hedonic experience (Cohen et al., 2011). The Temporal Experience of Pleasure Model (Kring & Barch, 2013) proposed that anhedonia can be divided into anticipatory (the prediction of future emotions and the hedonic experience during anticipation) and consummatory components (the in-the-moment hedonic feeling when experiencing pleasurable activities), and previous studies have reported that anticipatory pleasure may be the component of hedonic experience impaired in patients with schizophrenia (Gard, Kring, Gard, Horan, & Green, 2007; Li et al., 2015).

Since anhedonia is present transdiagnostically, it is important to consider whether anticipatory pleasure deficits may also be commonly found in different mental disorders. Apart from the reduced anticipatory pleasure found in people with SSD (Li et al., 2015), diminished anticipatory pleasure is also observed in individuals with subsyndromal and clinical depression (Yang et al., 2014) and in individuals with autistic traits (Novacek et al., 2016; Shi et al., 2017). However, little is known about anticipatory pleasure in OCD and anxiety disorders. Given that most previous studies adopted a case–control design, they were unable to take into account comorbid symptoms in the relationship between symptoms and anticipatory pleasure (Gard, Gard, Kring, & John, 2006; Yang et al., 2014). More importantly, comorbid symptoms may be potential confounding factors themselves.

A method that can be utilized to investigate the relationships between anticipatory pleasure deficits and mental disorder symptoms is network analysis (Borsboom & Cramer, 2013). Network analysis measures the strength of the connection between two nodes directly, while controlling for the effects of all other nodes, which could control for the confounding effect of co-morbid symptoms (Fried et al., 2017). Moreover, network analysis calculates the centrality of each node, which allows inferences of the importance of each node in the network. To date, network analysis has been applied to investigate the structure of schizotypy (Christensen, Kenett, Aste, Silvia, & Kwapil, 2018; Fonseca-Pedrero et al., 2018), psychotic disorder (Isvoranu et al., 2017), major depressive disorder (Bringmann, Lemmens, Huibers, Borsboom, & Tuerlinckx, 2015), and the pattern of connection of highly comorbid symptoms (Choi, Batchelder, Ehlinger, Safren, & O'Cleirigh, 2017).

It is now recognized that prior to meeting diagnostic criteria for a mental disorder, people in the general population present with different severity of mental disorder symptoms (e.g., depressive symptoms), which impact negatively on psychological well-being and social functioning (Wang et al., 2017). Moreover, mental-disorder-related traits (e.g., SP traits) confer heightened risk for the future development of mental disorders (Debbané et al., 2015). Therefore, consideration of continuous symptoms and mental-disorder-related traits, which could be integrated as risk features, could help inform the understanding of factors involved in the development of mental disorders. Moreover, utilizing a non-clinical sample could minimize the impact of confounding factors such as medication exposure and illness chronicity.

In the present study, we adopted a continuum approach and utilized network analysis to examine the relationship between anticipatory pleasure and risk features in a general population sample. Given that anhedonia is associated with SSD, ASD, depression, anxiety, and OCD, we examined the corresponding risk features, including SP traits, autistic traits, depressive symptoms, anxiety symptoms, and obsessive–compulsive traits in this study. We investigated: (1) the correlations among anticipatory pleasure, SP traits, autistic traits, depressive symptoms, anxiety symptoms, and obsessive–compulsive traits; (2) whether SP traits and autistic traits were associated with social-specific anticipatory pleasure; and (3) the centrality of each node to determine which was the key node in the network. We hypothesized that: (1) reduced anticipatory pleasure would be associated with SP traits, autistic traits and depressive symptoms, after controlling for confounding factors; and (2) SP traits and autistic traits would be correlated with social-specific anticipatory pleasure.

# Materials and Methods

## Participants

Participants were recruited through open advertisement with an online link with a set of measures. Participants who completed all questionnaires received 20 RMB (approximately \$US 3). A total of 2,904 college students from 130 cities and 34 provinces in mainland China gave written informed consent and completed the online measures. This study was approved by the Ethics Committee of the Institute of Psychology, the Chinese Academy of Sciences (Ethics number: H15031).

Potential participants were screened based on the following two criteria: (1) native Chinese speaker; and (2) a quality test score greater than 1. The quality test contained five items which described the reverse meaning of five items from the Schizotypal Personality Questionnaire (SPQ; Raine, 1991). Quality test items were scored if the answers of two paired items were inconsistent. This quality test was designed to exclude participants who were distracted or not putting in effort when responding to the questionnaires. Based on these criteria and removing repeated answers, 2,152 participants (611 males) were included in the final analysis.

## Measures

The present study used the anticipatory items of the Temporal Experience of Pleasure Scale (TEPS; Gard et al., 2006) and the anticipatory items of the Anticipatory and Consummatory Interpersonal Pleasure Scale (ACIPS; Gooding & Pflum, 2014) to measure anticipatory pleasure. The TEPS is a self-report scale that measures an individual's trait disposition in pleasure experience (Gard et al., 2006). Nine anticipatory items are included in the TEPS, with a possible score ranging from 9 to 54 (Chan et al., 2012). The ACIPS is a self-report scale which measures disposition in social pleasure experience (Gooding & Pflum, 2014). Seven anticipatory pleasure items are included in the scale and the score range for anticipatory pleasure was 7 to 42. Higher scores indicate a higher capacity to experience pleasure (Chan, Yang, Li, Xie, & Gooding, 2016).

We used the SPQ to measure SP traits (Chen, Hsiao, & Lin, 1997; Raine, 1991), which contains three factors (the cognitive-perceptual, the interpersonal and the disorganization factor). The Patient Health Questionnaire (PHQ-9; Kroenke, Spitzer, & Williams, 2001; Wang, Bian, et al., 2014) was used to measure the severity of depressive symptoms and the Generalized Anxiety Disorder Questionnaire (GAD-7; Spitzer, Kroenke, Williams, & Lowe, 2006; Wang, Ding, Hu, & Li, 2014) was adopted to assess the severity of anxiety symptoms. The Obsessive–Compulsive Inventory–Revised (OCI-R; Foa et al., 2002; Peng, Yang, Miao, Jing, & Chan, 2011) was used to assess obsessive–compulsive traits, which contains six subdimensions (washing, obsessing, hoarding, ordering, checking, and neutralizing). We used the Autism-Spectrum Quotient (AQ; Baron-Cohen, Wheelwright, Skinner, Martin, & Clubley, 2001; Zhang et al., 2016) to measure autistic traits, which contains five subdimensions, including social skills, attention switching, attention to detail, communication, and imagination. Higher scores on these measurements indicated more risk features. All scales showed good psychometric properties and have been widely used in the Chinese population (Chen et al., 1997; Peng et al., 2011; Wang, Ding, et al., 2014; Zhang et al., 2016). Details of the scales can be found in [Appendix S1](#).

## Data analysis

### Descriptive analysis and principal component analysis

SPSS 19.0 was used to carry out the descriptive statistics analysis for demographic information and selfreport measures. To explore the main components of anticipatory pleasure, all anticipatory items of the TEPS and the ACIPS were transformed into Z-scores, which were then used for principal components analysis with promax rotation. Factors with eigenvalues larger than 1.0 were retained to represent anticipatory pleasure components.

## Network analysis

Network estimation was calculated by the qgraph package (Epskamp, Cramer, Waldorp, Schmittmann, & Borsboom, 2012) in R software (Version 3.2.2; <https://www.r-project.org/>). We used the main components of anticipatory pleasure and subdimensions of each questionnaire as nodes, and calculated partial correlations with defined nodes. A network was then constructed with the edge between each two nodes representing the partial correlation coefficients of two connected nodes, while controlling for all other nodes. The present study used the “least absolute shrinkage and selection operator” (LASSO; Epskamp et al., 2012) to regularize the partial correlation network to obtain the optimal network structure. Centrality of each node was calculated (strength, closeness, and betweenness) to represent the importance of each node in the network. Stability analysis was completed to examine the quality of the constructed network using the “bootnet” package (Epskamp, Borsboom, & Fried, 2018). The stability of edge weights was assessed by calculating the 95% confidence intervals (CI) of the cases, using the non-parametric bootstrapping function in bootnet. The Correlation Stability coefficient (CS-coefficient) was used to quantify the stability of networks and the CScoefficient should not be lower than 0.25 and should best be higher than 0.5 (Epskamp et al., 2018). Centrality differences were calculated to determine whether the centrality value of one node was significantly higher or lower than other nodes, using the bootstrapped difference test in the bootnet R-package (Epskamp et al., 2018). Detailed description of network analysis can be found in [Appendix S1](#).

## Results

### Descriptive statistics

Mean scores of the anticipatory items of the TEPS and the ACIPS, as well as the levels of risk features of the sample are shown in Table 1.

**Table 1** Descriptive Information of Sample, Anticipatory Pleasure and Risk Features

	Mean	SD	Min	Max
Age	21.65	2.43	18	30
GenderSex<<Query: Please advise if 'gender' is being used to describe the biological or the psychological state. If the biology is being described, then 'sex' should be used instead, as per APA style. Please change this term throughout the article, if applicable. Ans: We have changed "Gender" into "sex".>>	Male/Female: 611/1541			
TEPS-A	39.28	6.31	15	54
ACIPS-A	31.75	3.93	14	37
SPQ total	24.00	11.94	0	70
Cognitive-perceptual	10.86	5.90	0	30
Interpersonal	8.35	5.24	0	25
Disorganization	4.79	3.54	0	16
PHQ-9	7.21	4.87	0	27
GAD-7	5.80	4.34	0	21
OCI-R total score	21.83	11.14	0	68
Washing	3.15	2.38	0	12
Obsessing	3.52	2.53	0	12
Hoarding	4.24	2.37	0	11
Ordering	4.41	2.49	0	12
Checking	3.47	2.51	0	12
Neutralizing	3.05	2.29	0	12
AQ total score	20.83	5.75	6	40
Social skill	4.31	2.65	0	10
Attention switching	5.54	1.74	0	10
Attention to detail	4.98	2.21	0	10
Communication	2.97	1.98	0	8
Imagination	3.03	1.73	0	10

Note.  $n = 2152$ .

Note. ACIPS-A = anticipatory items of ACIPS; AQ = autism-spectrum quotient; OCI-R = Obsessive–Compulsive Inventory-Revised; GAD-7 = Generalized Anxiety Disorder Questionnaire; PHQ-9 = Patients Health Questionnaire-9; *SD* = standard deviation; SPQ = Schizotypal Personality Questionnaire; TEPS-A = anticipatory items of TEPS.

## Principal component analysis

Principal component analysis revealed three factors with eigenvalues larger than 1.0 and these three factors explained 48.04% of the total variance ( $KMO = 0.915$ , Chi-square = 9726.04,  $p < .0001$ ). Looking at the

wordings and meaning of the terms loaded onto each of the three factors, the factors were labeled *social anticipatory pleasure*, *abstract anticipatory pleasure*, and *contextual anticipatory pleasure*. *Social anticipatory pleasure* (AP1) refers to the anticipatory pleasure of interpersonal activities, *abstract anticipatory pleasure* (AP2) refers to the anticipatory pleasure of general feelings, and *contextual anticipatory pleasure* (AP3) refers to the anticipatory pleasure within some specific contexts. Factor analysis results are presented in Table 2.

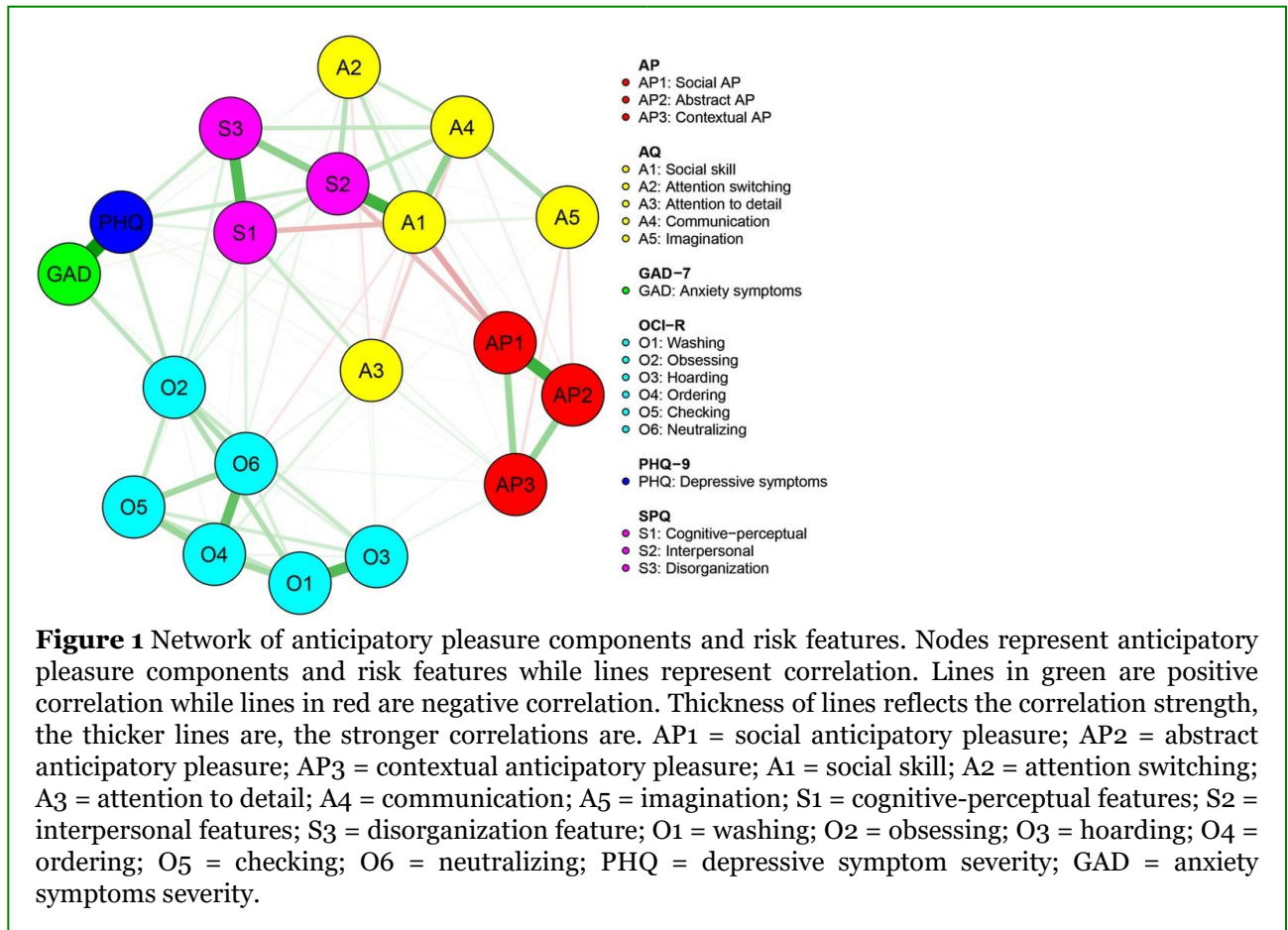
**Table 2** Principle Component Analysis of Anticipatory Items

Items	Factor loadings		
	A	B	C
ACIPS-3. I don't really look forward to family get-togethers or gatherings.	.827		
ACIPS-14. I look forward to watching my favorite TV shows with my friends.	.619		
ACIPS-15. I am excited when a friend that I haven't seen in a while contacts me to make plans.	.674		
ACIPS-7. When something good happens to me, I can't wait to share the news with others.	.56		
ACIPS-8. If I learned of a group where the people shared similar interests as me, I would be interested in joining it.	.486		
ACIPS-10. I imagine how much fun it would be to go on vacation with a friend or someone I love.		.838	
TEPS-4. I look forward to a lot of things in my life		.883	
TEPS-18. When something exciting is coming up in my life, I really look forward to it.		.852	
TEPS-20. On the way to my first date with my beloved, I can hardly wait to see him/her.		.399	
TEPS-10. I get so excited the night before a major holiday I can hardly sleep.			.401
TEPS- 8. When I think of something tasty, like a chocolate chip cookie, I have to have one.			.641
TEPS-5. I love it when people play with my hair.			.563

*Note.* Factors: A, social anticipatory pleasure; B, abstract anticipatory pleasure; C, contextual anticipatory pleasure; ACIPS, Anticipatory and Consummatory Interpersonal Pleasure Scale; TEPS, Temporal Experience of Pleasure Scale.

## Regularized partial correlation network (LASSO)

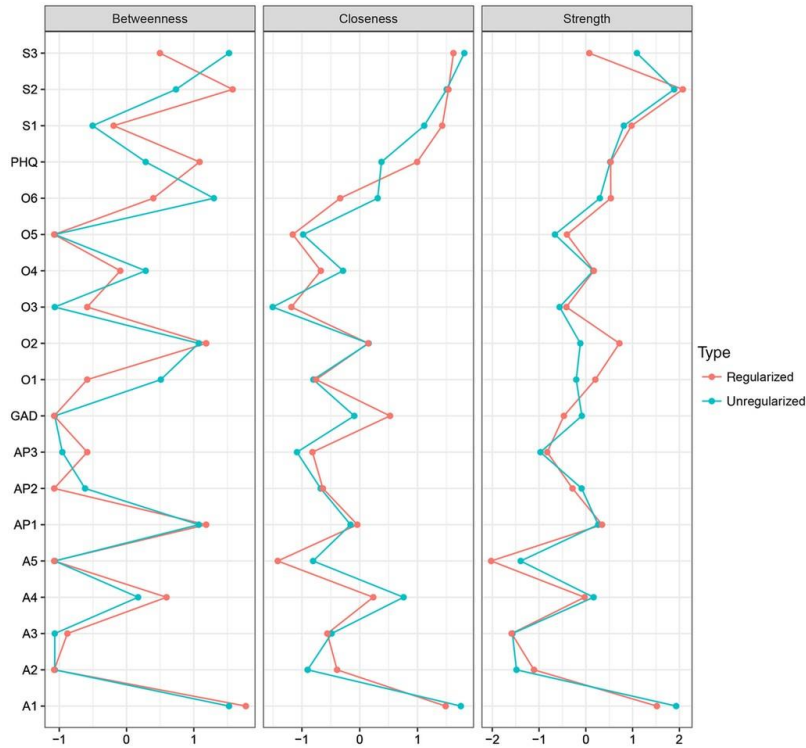
Figure 1 illustrates the regularized partial correlation network. In general, anticipatory pleasure was associated with risk features mainly via social anticipatory pleasure (AP1). In particular, social anticipatory pleasure was significantly and inversely correlated with scores on the Interpersonal subscale of the SPQ (S2;  $r = -.15$ ) and the Social Skills subscale of the AQ (A1;  $r = -.19$ ). Moreover, PHQ-9 score was significantly but weakly correlated with abstract anticipatory pleasure (AP2;  $r = -.03$ ). It was also identified that scores on the Hoarding subscale (O3;  $r = .06$ ) and the Neutralizing subscale (O6;  $r = .03$ ) of the OCI-R were weakly correlated with contextual anticipatory pleasure. No significant correlation was found between GAD-7 score and anticipatory pleasure.  $R$  values of each edge can be found in Table S1 in Appendix S1.



## Centrality of nodes

Figure 2 depicts the centrality plot of each node. Social anticipatory pleasure (AP1) had the highest centrality among all three anticipatory pleasure factors. In addition, scores on the Social Skills subscale of the AQ (A1) and the Interpersonal subscale of the SPQ had the highest betweenness centrality and strength centrality among all nodes in the network.





**Figure 2** Centrality of anticipatory pleasure components and subclinical features. AP1 = social anticipatory pleasure; AP2 = abstract anticipatory pleasure; AP3 = contextual anticipatory pleasure; A1 = social skills; A2 = attention switching; A3 = attention to detail; A4 = communication; A5 = imagination; S1 = cognitive-perceptual features; S2 = interpersonal features; S3 = disorganization feature; O1 = washing; O2 = obsessing; O3 = hoarding; O4 = ordering; O5 = checking; O6 = neutralizing; PHQ = depressive symptom severity; GAD = anxiety symptom severity.

## Stability analysis

We found that the network was stable. For edge strength, stability analysis indicated that the edge value was reliable. For order of node centrality, the CS-coefficient was 0.75 for closeness and 0.75 for strength while the CS-coefficient was 0.28 for betweenness. Details of the stability analysis could be found in the Figure S1 in [Appendix S1](#).

## Centrality differences

Results of centrality differences test showed that strength centrality, closeness centrality and betweenness centrality of social anticipatory pleasure (AP1) were all significantly higher than the other two anticipatory pleasure components. Moreover, the Interpersonal node of the SPQ (S2) showed significant difference from all the other nodes in strength centrality. Details of the centrality difference analysis can be found in Figures S2–S4 in [Appendix S1](#).

## Discussion

The present study examined the relationship between anticipatory pleasure and risk features. First, we found that the anticipatory pleasure items could be reduced to three factors: social, abstract, and contextual anticipatory pleasure. In line with our hypothesis, reduced anticipatory pleasure was correlated with SP traits



(S2: interpersonal features), autistic traits (A1: social skills) and depressive symptoms severity. Increased anticipatory pleasure was correlated with obsessive–compulsive traits (O3: Hoarding; O6: Neutralizing). Anxiety symptoms severity was not correlated with anticipatory pleasure. SP traits and autistic traits were mainly correlated with social anticipatory pleasure. In addition, social anticipatory pleasure was the node with the highest centrality among the three anticipatory pleasure components and interpersonal features had the highest strength centrality among all the nodes.

As anhedonia could be divided into social and physical anhedonia, we in turn classified anticipatory pleasure into social and other categories by principal component analysis. This allowed more in-depth analysis to test whether the social component of anticipatory pleasure was correlated with SP and autistic traits. We found that interpersonal features were negatively correlated with social anticipatory pleasure, suggesting that participants with more interpersonal SP features experienced less anticipatory pleasure, especially in social-related conditions. This is consistent with previous studies, which found that individuals with SP traits report diminished anticipatory pleasure (Li et al., 2015), and that people with social anhedonia anticipated less positive emotions in tasks containing more social information (Chan, Li, et al., 2016; Xie et al., 2014) and tasks including social conditions (Engel, Fritzsche, & Lincoln, 2015) than people without social anhedonia. This finding is corroborated by a recent network study, which reported that social anhedonia was one of the subdimensions of negative schizotypy (Christensen et al., 2018). Collectively, these findings suggest that hedonic deficits of schizotypy may be social-specific.

As a non-current emotion, anticipatory pleasure may be influenced by episodic memory, which is specific to associated events or past experience, or semantic memory, which refers to general knowledge, such as beliefs (Strauss & Gold, 2012). Frost and Strauss (2016) further proposed that prospection and affective forecasting may be key aspects of anticipatory pleasure. Therefore, impaired episodic memory, abnormal beliefs, deficits in prospection, and affective forecasting may contribute to reduced anticipatory pleasure. Interestingly, individuals with SP traits report less thoughts/emotion details and pre-experiencing during prospection (Yang, Xie, et al., 2018) and lower levels of pleasure beliefs than healthy controls (Yang, Yang, et al., 2018). In addition, individuals with interpersonal SP features may have diminished social-pleasurable memories due to social anxiety, negative attitude toward developing friendship, and maladaptive communication skills, which are the main characteristics of interpersonal features (Raine, 1991). As such, deficits in prospection, low pleasure beliefs, and reduced pleasurable social memories may result in reduced social anticipatory pleasure in individuals with SP traits.

We also found that social anticipatory pleasure was inversely correlated with autistic traits through poor social skills, indicating that people with poorer social skills tended to have reduced social anticipatory pleasure. This is consistent with previous studies which showed that individuals with autistic traits report reduced anticipatory pleasure (Shi et al., 2017) and experience less pleasure in social situations (Novacek et al., 2016). According to the social motivation hypothesis (Clements et al., 2018), individuals with ASD may pay little attention to social stimuli, which may impede the development of social cognition and social interests. As a result, social stimuli become less rewarding for individuals with ASD and they may have reduced anticipatory pleasure in social conditions because they do not regard social activities as pleasurable. Another possible reason is that poor social skills may cause difficulties during social activities, which leads to negative feedback from others. Therefore, accumulated negative experiences about social activities in their memories may lead to decreased anticipatory pleasure in social conditions.

The severity of depressive symptoms only showed a weak inverse correlation with anticipatory pleasure. This is consistent with studies that found reduced anticipatory pleasure in people with subsyndromal depression (Yang et al., 2014) and clinically depressed patients (Liu, Wang, Zhao, Ning, & Chan, 2012). Moreover, studies using self-report questionnaires (Marroquín, Nolenhoeksema, & Miranda, 2013), laboratory-based tasks (MacLeod & Salaminiou, 2001), and experience sampling methodology (Thompson et al., 2017) also found that depressed individuals anticipated less pleasure than controls. However, correlations between depressive symptoms severity and anticipatory pleasure nodes were relatively weak. This could be due to differences in the measurement window. Given that the PHQ-9 captures the depressive *state* of an individual, while the SPQ and the AQ both capture *traits*, it is possible that the impairment of anticipatory pleasure is more trait- than

state-like in presentation. As such, it is possible that reduced anticipatory pleasure observed in people with more depressive symptoms may not only be related to their mood per se, but rather explained by other co-existing stable trait-like features. Another potential reason might be the “threshold” effect. According to the *Diagnostic and Statistical Manual of Mental Disorders* (5th ed.; American Psychiatric Association, 2013), individuals should meet at least one of the first two criteria (depressed mood and loss of interests) to be diagnosed with clinical depression. Therefore, it is possible that some participants may not have had depression at all (low scores on Item 1/Item 2) even though their PHQ-9 scores were high. These findings may not be generalizable to clinical populations.

Interestingly, obsessive–compulsive traits were positively correlated with anticipatory pleasure, suggesting that the observed anhedonia in OCD may not be anticipatory (Abramovitch et al., 2014). Moreover, obsessive–compulsive traits were associated with more contextual anticipatory pleasure, indicating an overexperience of anticipatory pleasure with contextual information. One possible reason may be the holding in mind of obsessions and the subsequent cognitive and psychological discomfort could interfere with the factors that need to be drawn to the fore of the mind in contextual anticipatory pleasure. Alternatively, the amount of detailed contextual factors that need to be drawn to mind may induce obsessive thoughts or distress in individuals with obsessive–compulsive traits. Moreover, given that some items in the OCI-R do not describe induced negative or uncomfortable feelings, it is also possible that individuals with higher scores on the OCIR may have obsessive–compulsive personality disorder (OCPD), which is characterized by perfectionism and preoccupation with details (American Psychiatric Association, 2013). OCPD differs from OCD by its egosyntonic obsessions (de Reus & Emmelkamp, 2012) and thus individuals with OCPD may not be distressed by their perfectionism or preoccupation with details. This may lead to the positive correlation between OCIR scores and contextual anticipatory pleasure. However, since the observed correlation was relatively weak, replication in future research is needed.

Anticipatory pleasure was found to be uncorrelated with the severity of anxiety symptoms in this study. It is possible that the reported correlation between anhedonia and anxiety symptoms severity may mainly lie in consummatory pleasure (Winer et al., 2017). Our finding is also in line with previous studies reporting that individuals with anxiety symptoms would anticipate more negative emotions but a similar level of positive emotion compared with healthy controls (Hoerger, Quirk, Chapman, & Duberstein, 2012; Wenze, Gunthert, Ahrens, & Taylor Bos, 2013).

Our results showed that social anticipatory pleasure had the highest centrality among the three anticipatory pleasure components, suggesting the crucial role of the social component in the relationship between anticipatory pleasure and risk features. Moreover, interpersonal features of SP traits showed the highest strength centrality in the network, which means that interpersonal features had the greatest impact in the network. This is consistent with results from a recent study using the SPQ to explore the structure of SP traits, which found that constricted affect, a subdimension of interpersonal features, showed high centrality in the network (Fonseca-Pedrero et al., 2018). Given their importance as the center of our network, interpersonal features could be an intervention target to improve risk features and anticipatory pleasure, perhaps preventing the deterioration of mental well-being.

This study has several limitations. First, although the sample size was large, given issues with stability and replicability of psychopathology network analysis (Forbes, Wright, Markon, & Krueger, 2017), our findings require replication across different time-points and samples. Second, the measurements we used did not capture the subdimensions of depressive and anxiety symptoms severity, which may contribute to nonsignificant correlations with anticipatory pleasure. Moreover, it would be helpful if future studies could include objective measurements to validate our findings. Finally, we did not control for the presence of past and/or family history of mental disorders in the participants. It is possible that people with clinical mental disorders were included in this sample.

Despite these limitations, the present study contributes to the field by improving our understanding of anhedonia and its importance in the expression of risk features. It should be noted that although the results of this study provide suggestive information for clinical symptoms, the interpretation should be cautious given

that the study is based on a college student sample. Our results indicate that anhedonia in individuals with more SP traits, autistic traits, and depressive symptoms may lie in anticipatory pleasure deficits. Second, our findings suggest that deficits in anticipatory pleasure in individuals with high SP and autistic traits mainly lie in social situations. As a result, interventions that aim to improve anticipatory pleasure in individuals with SP traits or autistic traits may target social components. Furthermore, interpersonal features could be treatment targets to reduce risk features or improve anticipatory pleasure.

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## Disclosure of conflict of interest

The authors declare that they have no conflicts of interest.

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