



# Relationships between schizotypal features, trait anticipatory and consummatory pleasure, and naturalistic hedonic States

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## Abstract

Deficient anticipatory and preserved consummatory pleasure are hypothesized in schizophrenia-spectrum conditions. However, corresponding findings regarding schizotypy are inconsistent presumably due to heterogeneity of schizotypal traits. We explored the relationships of trait anticipatory and consummatory pleasure with schizotypal features in 740 individuals using network modelling and cluster analysis and then, in a subsample of 191 subjects, examined whether clusters with distinct constellations of hedonic and schizotypal traits would differ in pleasurable states occurring during cognitive testing. Trait anticipatory pleasure correlated with positive and negative but not disorganized schizotypal signs and predicted in-the-moment pleasure, while there was no significant difference between clusters on emotional states. The results agree with the idea that trait anticipatory pleasure is of primary interest in schizotypy research and show that the heterogeneity of schizotypal traits and the proportion of anhedonic individuals in non-schizotypal control samples account for inconsistent findings regarding the reduction of trait anticipatory pleasure in schizotypy.

**Keywords** Anhedonia · Schizotypy · Personality · Knowledge emotions

## Introduction

Schizotypy is a constellation of personality traits spreading throughout the general population and resembling positive (delusions, hallucinations), negative (flat affect, avolition, anhedonia, and asociality) and disorganized (bizarre thinking and behavior) symptoms of schizophrenia. Schizotypy research has long been aimed to answer a variety of questions regarding the etiology and presentation of schizophrenia (Barrantes-Vidal et al., 2015; Grant et al., 2018; Lenzenweger, 2006; Meehl, 1990). Now, schizotypy is also considered as an organizing framework for investigating affective and social processes outside psychiatry (Cohen et al., 2015).

Anhedonia, a diminished ability to experience pleasure, is a core feature of schizophrenia-spectrum conditions, including schizotypy (Horan et al., 2007; Meehl, 1962). Among several conceptualizations of psychological processes behind the hedonic deficit in schizophrenia-related pathology (see

Cohen et al., 2011a, 2011b, for review), the hypothesis suggesting difficulties in the experience of pleasure in anticipation of future events (anticipatory pleasure, Ant) and relatively preserved hedonic experiences in the moment, when directly engaged in an enjoyable activity (consummatory pleasure, Con), has received much attention. The hypothesis is drawn on the neurobiological distinction between wanting (corresponds to Ant) and liking (corresponds to Con), and is intended to explain the “liking-wanting paradox”, i.e., the observations that schizophrenia patients are rated as anhedonic with clinical instruments and questionnaires that use trait self-report formats but demonstrate relatively normal physiological and subjective emotional reactions to the presentation of potentially pleasant stimuli (Gard et al., 2006; Kring & Barch, 2014).

Studies designed to confirm the Ant deficit hypothesis yielded inconsistent results (Kring & Barch, 2014; Painter & Kring, 2016; Visser et al., 2020). Moreover, the second emotion paradox has emerged, that is, a discrepancy between relatively preserved Con in schizophrenia and its reduction in schizotypy (Strauss & Cohen, 2018). While several specific factors could explain each paradox (Kring & Barch, 2014; Painter & Kring, 2016; Strauss & Cohen, 2018), an inspection of the literature suggests two possible common

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causes for the overall mixed and unexpected findings, which warrant further investigation. The first one is a trait-state status of hedonic variables under study. The liking-wanting paradox is also labeled as the state-trait disjunction of anhedonia in schizophrenia-related conditions (Cohen et al., 2011a, 2011b). However, the Ant-Con and trait-state dichotomies capture different temporal aspects of emotional experiences, the former being reward- and the latter being personality-centered. Both the Ant and Con components of hedonic capacity can, therefore, be measured as traits/pre-dispositions (tAnt and tCon) and as current short-term states. To date, investigations of the relations between trait and state pleasure in schizotypy distinguishing between Ant and Con are scarce, and their results are not in line with the predictions, showing that tAnt is more in agreement with pleasure responses to laboratory stimuli than is tCon (Da Silva et al., 2018; Hooker et al., 2014; Wilson, 2012).

The second factor is the heterogeneity of schizotypal traits, with positive, negative, and disorganized schizotypy might be associated with different patterns of hedonic characteristics. Specifically, evidence suggests the decreased trait and state pleasure in negative schizotypy (Cohen et al., 2011a, 2011b; Cohen et al., 2012; Da Silva et al., 2018; Hooker et al., 2014; Kemp et al., 2018; Kwapil et al., 2012; Li et al., 2015; Lui et al., 2016; Martin et al., 2011; Shi et al., 2012; Xie et al., 2014; see also Wilson, 2012, for review). A less conclusive picture has arisen regarding positive schizotypy, which associated with intact (Martin et al., 2011; McCarthy, 2013) or elevated tAnt and tCon (Fonseca-Pedrero et al., 2017; Lui et al., 2018; Shi et al., 2012) and decreased (Cohen et al., 2011a, 2011b) or relatively preserved in-the-moment pleasure (Kwapil et al., 2012; Martin et al., 2011). And there are few data on the disorganized cluster of traits (Loas et al., 2014).

Here, we aimed to explore the complex relations between schizotypal traits and hedonic capacity focusing on the following questions: (1) whether tAnt and tCon would be associated differently and independently with different schizotypal features, and (2) whether different constellations of schizotypal and hedonic traits would predict different in-the-moment experiences during an ecologically valid activity.

We applied the Schizotypal Personality Questionnaire (SPQ; Raine, 1991) and the Temporal Experience of Pleasure Scale (TEPS; Gard et al., 2006) to measure schizotypal and hedonic traits, respectively, in healthy individuals from the general population. The SPQ evaluates all nine criteria of schizotypal personality disorder introduced by the Diagnostic and Statistical Manual of Mental Disorders (DSM)-III-R, thus enabling a comprehensive quantitative assessment of positive, negative, and disorganized manifestations of schizotypy. TEPS has been the first instrument developed to measure individual differences in tAnt and tCon separately and is widely used to assess hedonic capacity in cohorts

at different stages of liability to schizophrenia, including psychometrically defined schizotypal individuals (Fonseca-Pedrero et al., 2017; Li et al., 2015; Loas et al., 2014; Martin et al., 2011; Shi et al., 2012; Yan et al., 2011).

To answer the first question, namely, the specificity of the relationships of tAnt and tCon with schizotypal traits, we ran a network analysis. While the network approach allows for several inferences about a complex psychological phenomenon under study (Marsman et al., 2018), we used it to model and visualize unique interactions between variables. TEPS Ant and Con scores are interrelated, as are the SPQ scales, and pairwise correlations between the TEPS and SPQ variables may capture common factors underlying the subject's responses rather than the individual link between two specific traits. Network modelling eliminates this problem by evaluating an association within each pair from a set of analyzed variables taking into account all the other associations in the set. In other words, for two variables to be connected in the network, their relationship cannot be explained by any other variable in the set. In addition, the network analysis enables the development of a graphical model in which edges reflect these conditional associations between the variables (nodes). One recent study used network modelling to explore the relations between tAnt and different symptoms, including the positive, negative, and disorganized SPQ dimensions (Zhang et al., 2020). While it confirmed the negative correlation between tAnt and negative schizotypy, tCon was not considered.

To answer the second question, namely, whether constellations of schizotypal and hedonic traits would predict in-the-moment pleasure, we first conducted data mining to find groups with different combinations of schizotypal and hedonic features and then compared these groups on the frequency of positive hedonic states, which were self-reported at the end of cognitive testing. Our state measure differed from those usually used in two ways. Prior research mostly explored state consummatory pleasure assessing reactions to external stimuli—pleasurable words/pictures/videos presented for passive viewing or expected monetary rewards (Da Silva et al., 2018; Hooker et al., 2014; Martin et al., 2011; Wilson, 2012; Xie et al., 2014). In addition, a few researchers examined the cognitive component of state anticipatory pleasure asking subjects how much pleasure they anticipated/predicted from the foregoing activity/reward (Wilson, 2012; Xie et al., 2014; Yan et al., 2019). We evaluated feelings of interest, surprise and joy/happiness, which are positively valenced, high arousal states arising in response to novelty and complexity. In this way, we intended to extend knowledge on the relations between hedonic traits and states in schizotypy to the state pleasure that presumably underlies intrinsic motivation (Ryan & Deci, 2000; Silvia, 2006). The rationale for this was that the Ant deficit model proposes a link between anticipatory pleasure and

motivation which drives goal-directed behavior (Kring & Barch, 2014). This suggests that tAnt is the most closely related to emotional states accompanying intentional, effortful activity, with solving cognitive tasks being an example of such activity. In addition, we attempted to combine the strengths of laboratory-based and naturalistic approaches to evaluating in-the-moment pleasure (see Wilson, 2012, for discussion) by assessing naturalistic emotions in the standardized situation.

Our overall hypothesis put forward by the Ant deficit model was that the diminished anticipatory pleasure is an intrinsic part of the negative syndrome of schizophrenia spectrum conditions rather than an independent potentiator of decompensation in schizotypy (Meehl, 1990), and manifests itself both as a trait and as a state. Therefore, we expected that at the dimensional level tAnt would correlate with negative schizotypal signs, and all the other associations between tAnt and tCon on one hand and schizotypal signs on the other would be indirect or negligible having been modelled simultaneously as a network. Second, at the taxonomic level of analysis, (i) we would observe negative and/or mixed schizotypy clusters, where high negative schizotypy conjoins with diminished tAnt, while groups without negative schizotypal signs would demonstrate an average level of tAnt; (ii) the clusters characterized by high negative schizotypy and low tAnt would also demonstrate a low frequency of positive states associated with cognitive activity. Of note, given that the TEPS Ant and TEPS Con scales positively correlate at 0.40–0.60 in different populations (Alfimova et al., 2018; Gard et al., 2006), the pattern of tCon levels in the clusters might to some extent replicate that of tAnt.

## Methods

### Participants

Data used in this study were extracted from a database of larger research on the genetics of psychiatric disorders and are available as the dataset file in the online Supplementary Materials. The study sample ( $n = 740$ ; mean age 23.57, SD 7.47; 66% women) was a mixture of several convenience samples. It included staff members of research institutes and hospitals and their friends ( $n = 163$ ; mean age 32.79, SD 11.41; 64% women), students of psychological, medical and biological faculties of different universities ( $n = 242$ ; mean age 22.10, SD 2.01; 78% women), and male conscripts ( $n = 335$ ; mean age 20.14, SD 1.61). All participants were of European ancestry, mainly Russians (85%). Everyone was interviewed personally either at the institute or at one's service place about demographic characteristics, psychiatric conditions, personal histories of substance use

or heard injury, and a family history of psychoses. Candidates, who did not have at least lower secondary general education (9 years of schooling) or a good command of the Russian language, reported a history of psychiatric or neurologic conditions or had first-degree relatives with any psychotic illness, were not included into the sample. The entire research design required each subject to sign an informed consent for participation in the research, to donate a blood or salivary sample for DNA extraction, and to complete a set of inventories, including the SPQ and TEPS, and a cognitive battery. The cognitive battery was administered to only a subset of the entire sample ( $n = 191$ , mean age 26.26, SD 9.23; 69% women) for administrative reasons. The study was approved by the local Ethics Committee.

### Measures

The SPQ-74 developed by Raine (1991) is a 74-item true–false questionnaire assessing nine DSM symptoms of schizotypal personality disorder, which can be grouped into three higher-order factors (Raine et al., 1994). The cognitive-perceptual (positive) factor includes four scales: Ideas of Reference, Odd Beliefs or Magical Thinking, Unusual Perceptual Experiences, and Suspiciousness; the interpersonal (negative) factor is composed of Excessive Social Anxiety, No Close Friends, Constricted Affect, and Suspiciousness; and the disorganized factor consists of Odd or Eccentric Behavior and Odd Speech. In our sample, internal consistency as estimated by Cronbach's alpha coefficients was good (Cronbach's  $\alpha > 0.7$ ) for Excessive Social Anxiety, Odd or Eccentric Behavior, Odd Speech, and Suspiciousness; satisfactory (Cronbach's  $\alpha > 0.6$ ) for Ideas of Reference, Odd Beliefs or Magical Thinking, Unusual Perceptual Experiences, and No Close Friends; and somewhat low (Cronbach's  $\alpha = 0.52$ ) for the Constricted Affect scale, with mean Cronbach's  $\alpha = 0.69$ .

TEPS is an 18-item self-report scale assessing tAnt, ten items, and tCon, eight items (Gard et al., 2006). The items are rated on a Likert-type scale ranging from 1 (*very false for me*) to 6 (*very true for me*). Lower scores indicate greater levels of anhedonia. The two-factor structure of TEPS has been confirmed in the Russian population along with the other psychometric properties of the inventory, with Cronbach's alphas for tAnt and tCon being 0.78 and 0.74 (Alfimova et al., 2018).

To evaluate hedonic states, a facial affect recognition task was presented at the end of the cognitive session that included standard tests of verbal fluency, episodic memory and executive functions and took about half an hour to complete. The facial affect recognition task is a labeling, non-speeded task (Alfimova et al., 2009). Stimuli are nine black-and-white photographs of actors depicting basic emotions: anger, contempt, disgust, fear, happiness, interest, sadness,

shame, and surprise (Izard, 1977). The subject is asked to choose one or two, which to the greatest degree corresponds to the subject's current state, and to give a name to this emotion. The subject then must name all the other emotions.

## Data analysis

It should be noted that the factor structure of the SPQ-74 is problematic (e.g., Barron et al., 2015; Fonseca-Pedrero et al., 2014). In the Russian population, the Raine's three-factor model was partly supported by an exploratory factor analysis, whereas a confirmatory factor analysis showed the best fit for the four-factor "paranoid" model (Alfimova et al., 2020). In the latter, the cognitive-perceptual domain encompasses only the Odd Beliefs or Magical Thinking and Unusual Perceptual Experiences scales, while the Ideas of Reference and Suspiciousness scales form the fourth factor of paranoia, which also includes Excessive Social Anxiety (Stefanis et al., 2004). The both factor models contain cross-loading scales and show imperfect measurement invariance across age, which makes the interpretation of the correlations of factors with each other and with external variables difficult. Given this, the network analysis was based on the nine SPQ-74 scales instead of factors, and the most investigated Raine's three-factor model was used for descriptive statistics and comparison with prior research. A network based on the three SPQ factors was calculated for illustrative purposes.

For the network modelling we employed the JASP 012.2.0 software (JASP Team, 2020). Variables were transformed using the nonparanormal transformation, and a Gaussian graphical model, also known as a partial correlation network, was estimated. For regularization and model selection we applied the Extended Bayesian Information Criterion Graphical Least Absolute Shrinkage and Selection Operator, EBICglasso, the hyperparameter  $\gamma$  being set to the default of 0.5. This technique removes edges that are likely spurious thereby ensuring a high specificity (a low rate of false edges) of the model (Epskamp & Fried, 2018).

To detect clusters of individuals with different combinations of schizotypal and hedonic traits and to assign individuals to the clusters, we used the k-means method based on the expectation maximization clustering algorithm, a data mining procedure implemented in Statistica 12. Models with up to 25 clusters were tested, and the tenfold cross-validation was applied to determine the best number of clusters. The association between the constellations of traits (clusters) and hedonic states was assessed with binomial logistic regression adjusted for age, gender and education. The education level of each participant was coded based on the International Standard Classification of Education, ISCED 2011 (The UNESCO Institute for Statistics, 2011), and the codes were then dichotomized into two broader categories: 1—any

level of secondary education (ISCED levels 2–4; 40% of the entire sample) and 2—any level of tertiary education (ISCED levels 5–8; 60% of the entire sample), with university students being included in the latter category.

We conducted multivariate analyses of covariance/variance (MANCOVA/MANOVA) to assess effects of different factors on schizotypal and hedonic traits. The  $p$ -value used for significance was set at 0.05, two-tailed. Bonferroni correction ( $p_{\text{corr}}$ ) was applied for follow up analyses of MANCOVA/MANOVA results.

As we had no theoretical expectations about the network structure and the number of clusters, post hoc accuracy/power analyses were conducted instead of a priori ones. Specifically, to estimate the accuracy of edge weights in the network, bootstrapped 95% confidence intervals (CIs) were calculated using non-parametric bootstrap with 1000 bootstrap samples. Regarding the cluster analysis and logistic regression, we applied, respectively, the rule of thumb  $n \geq 70 \times d$  ( $d$ —number of variables) based on the simulation study of Dolnicar et al. (2014) and the rule of thumb  $EPV \geq 10$  ( $EPV$ —number of events per each independent variable) based on the simulation study of Peduzzi et al. (1996). In addition, to estimate the precision of logistic regression coefficients, we calculated their bias-corrected and accelerated bootstrap 95% confidence intervals (bca CIs) using 1000 bootstrap samples.

## Results

### Descriptive data

Mean SPQ-74 and TEPS scores are given in Table 1. We ran a MANCOVA to evaluate effects of age, gender and education on schizotypal factors and hedonic traits. The omnibus effect of each demographic variable was significant (all  $p < 0.001$ ). Follow-up ANCOVAs showed that women had higher SPQ-74 negative factor scores [ $F(1,723) = 7.08$ ;  $p_{\text{corr}} = 0.040$ ;  $\eta_p^2 = 0.01$ ],  $t_{\text{Ant}}$  [ $F(1,723) = 15.11$ ;  $p_{\text{corr}} < 0.001$ ;  $\eta_p^2 = 0.02$ ] and  $t_{\text{Con}}$  [ $F(1,723) = 7.35$ ;  $p_{\text{corr}} = 0.035$ ;  $\eta_p^2 = 0.01$ ] than men. Lower education predicted higher SPQ positive factor scores [ $F(1,723) = 8.95$ ;  $p_{\text{corr}} = 0.015$ ;  $\eta_p^2 = 0.01$ ] and higher  $t_{\text{Ant}}$  [ $F(1,723) = 12.50$ ;  $p_{\text{corr}} = 0.002$ ;  $\eta_p^2 = 0.02$ ], while age correlated negatively with  $t_{\text{Ant}}$  [ $F(1,723) = 28.32$ ;  $p_{\text{corr}} < 0.001$ ;  $\eta_p^2 = 0.04$ ].

### Relations between hedonic and schizotypal traits

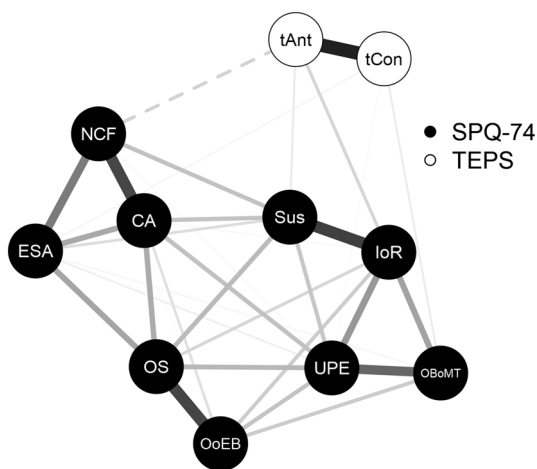
To enable comparisons with prior research (Fonseca-Pedrero et al., 2017) and the network analysis, Pearson correlations between trait pleasure and SPQ-74 scores are given in Table 1. The network based on the SPQ-74 scales is shown in Fig. 1. The bootstrap 95% CIs for edge

**Table 1** Descriptive statistics and Pearson correlations for schizotypal and hedonic traits

Variable	Mean	SD	Correlation			
			With anticipatory pleasure		With consummatory Pleasure	
			r	p	r	p
<b>TEPS</b>						
Anticipatory pleasure	41.59	7.34			0.51	<0.001
Consummatory pleasure	37.15	5.70	0.51	<0.001		
<b>SPQ-74</b>						
Ideas of Reference	1.72	1.79	0.18	<0.001	0.09	0.012
Excessive Social Anxiety	2.07	2.23	0.06	0.123	0.07	0.065
Odd Beliefs or Magical Thinking	0.84	1.35	0.03	0.494	0.10	0.008
Unusual Perceptual Experiences	1.11	1.56	0.04	0.309	0.09	0.014
Odd or Eccentric Behavior	0.99	1.57	−0.002	0.949	0.07	0.049
No Close Friends	1.62	1.70	−0.10	0.005	0.01	0.722
Odd Speech	2.14	2.00	0.04	0.262	0.06	0.109
Constricted Affect	1.59	1.41	−0.03	0.372	0.01	0.694
Suspiciousness	1.74	1.76	0.15	<0.001	0.07	0.052
Cognitive-Perceptual Factor	5.41	5.16	0.15	<0.001	0.11	0.003
Interpersonal Factor	7.02	5.53	0.03	0.423	0.06	0.116
Disorganized Factor	3.13	3.21	0.02	0.504	0.07	0.050
Total SPQ-74 score	13.74	9.79	0.06	0.096	0.09	0.012

For 26 correlations between TEPS and SPQ indicators, the Bonferroni corrected significance threshold is  $\alpha = 0.05/26 = 0.002$

TEPS the Temporal Experience of Pleasure Scale; SPQ-74 the Schizotypal Personality Questionnaire



**Fig. 1** The network of schizotypal and hedonic traits. The network presents conditional associations between schizotypal and hedonic traits, with solid lines designate positive correlations, dashed lines designate negative correlations, and the line thickness corresponds to the strength of the connections. The SPQ-74 scales: *IoR* Ideas of Reference, *ESA* Excessive Social Anxiety, *OBoMT* Odd Beliefs or Magical Thinking, *UPE* Unusual Perceptual Experiences, *OoEB* Odd or Eccentric Behavior, *NCF* No Close Friends, *OS* Odd Speech, *CA* Constricted Affect, *Sus* Suspiciousness. The scales of the Temporal Experience of Pleasure Scale: *tAnt* Anticipatory Pleasure, *tCon* Consummatory Pleasure

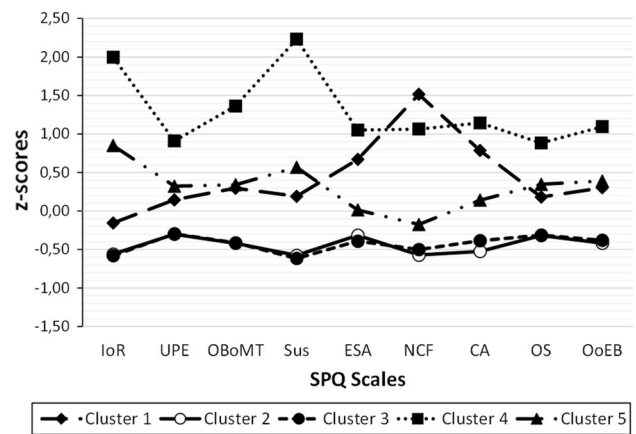
weights, along with characteristics of the network (centrality and clustering indices), which are not relevant to the study’s aims, and the network based on factors are presented in Figures S1 and S2 and Tables S1–S3 in the Supplementary Materials. As can be seen in Fig. 1, *tAnt* positively correlated with the Ideas of Reference scale from the cognitive-perceptual factor, and negatively with the No Close Friends scale from the interpersonal factor; a subtle association was also found with Suspiciousness, the scale belonging to both factors. In addition, there were very weak, albeit non-zero, connections of *tCon* with Odd Beliefs, Excessive Social Anxiety, and Unusual Perceptual Experiences. The interrelations of the SPQ scales were in line with the theoretical model and empirical data (Fonseca-Pedrero et al., 2018).

To check if age, gender and education might influence the observed relationships, we conducted a subsidiary MANCOVA adjusted for these demographic characteristics, where *tAnt* and *tCon* were predictors of the SPQ-74 scales. Only *tAnt* significantly predicted schizotypal traits,  $F(9,713) = 6.43; p < 0.001; \eta_p^2 = 0.08$ . In accordance with the network structure, follow-up ANCOVAs showed that *tAnt* significantly correlated with Ideas of Reference [ $F(1,721) = 15.25; p_{corr} < 0.001; \eta_p^2 = 0.02$ ], No Close Friends [ $F(1,721) = 8.19; p_{corr} = 0.039; \eta_p^2 = 0.01$ ] and Suspiciousness [ $F(1,721) = 10.87; p_{corr} = 0.009; \eta_p^2 = 0.01$ ].

Overall, the results indicated that tAnt was related to schizotypal traits, while correlations of tCon with the SPQ parameters were exceedingly small and became nonsignificant after adjustment for the demographic variables. To avoid including irrelevant and redundant attributes, which may cause problems in segmentation, we, therefore, focused the cluster analysis on tAnt and three schizotypal traits that directly correlated with it. The pairwise correlations of the four variables ranged between |0.10| and |0.63|, suggesting no collinearity and making it highly likely to obtain informative mixed-value clusters. With these four variables as the basis for clustering, our sample size of 740 individuals was well above that specified by the rule of thumb ( $n = 70 \times 4 = 280$ ).

**Clusters with different combinations of schizotypal and hedonic traits**

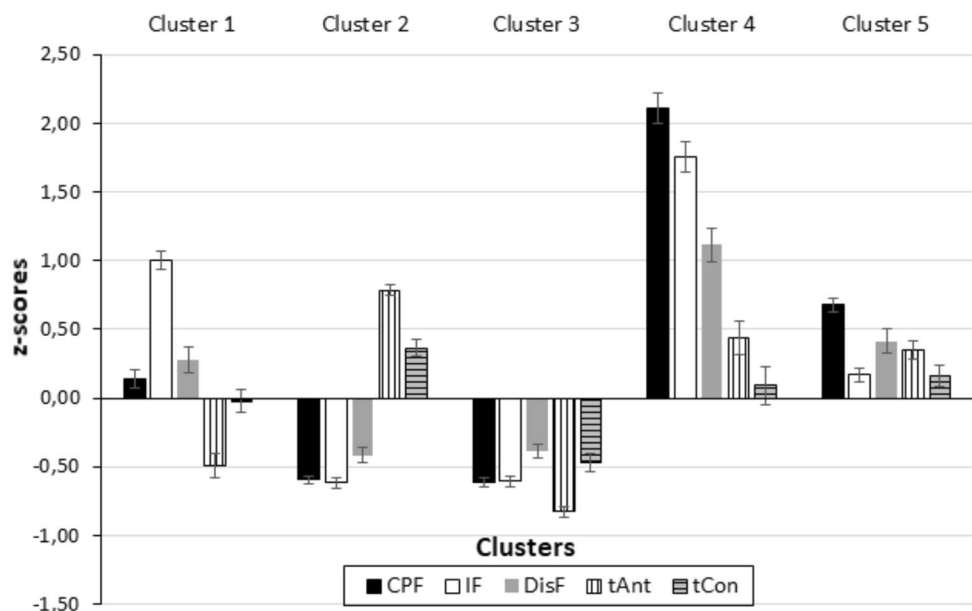
The data mining based on standardized scores of Ideas of Reference, No Close Friends, Suspiciousness and tAnt yielded a five-cluster model (related data are presented in Tables S4 and S5 and in Figures S3 and S4). To interpret the clusters, we compared them on the SPQ-74 scales and factors, tAnt and tCon (Figs. 2 and 3, see also Table S6 for clusters' means). Based on these results we interpreted cluster 1 (16% of the sample) as an anhedonic negative schizotypy group; clusters 2 (26%) and 3 (28%) as hedonic and anhedonic low-schizotypy groups, respectively; clusters 4 (8%) and 5 (21%) as high/mixed schizotypy and average/positive schizotypy groups with preserved tAnt. The differences between the clusters were significant for each of the schizotypal scales and factors, tAnt and tCon (MANOVA, the omnibus effect of



**Fig. 3** Clusters' Means of Schizotypal Traits. Figure 3 shows means of the standardized SPQ scale scores by cluster. The SPQ-74 scales: *IoR* Ideas of Reference, *ESA* Excessive Social Anxiety, *OBOMT* Odd Beliefs or Magical Thinking, *UPE* Unusual Perceptual Experiences, *OoEB* Odd or Eccentric Behavior, *NCF* No Close Friends, *OS* Odd Speech, *CA* Constricted Affect, *Sus* Suspiciousness

cluster,  $F(4,735) = 74.46; p < 0.001; \eta_p^2 = 0.54$ ; all fourteen follow-up ANOVAs were significant,  $p_{corr} < 0.001$ . Post hoc comparisons showed that pairwise differences in SPQ scores and tAnt between the clusters were significant (all  $p_{corr} < 0.001$ ), with few exceptions. Specifically, the two low-schizotypy clusters were similar in all schizotypal traits, the negative and positive schizotypy groups did not differ in disorganized factor scores, and the high and positive schizotypy groups did not differ in tAnt. At the same time, there were few between-cluster differences in tCon: the anhedonic low-schizotypy group had reduced tCon compared to each of the other groups

**Fig. 2** Clusters' means of schizotypal factors and hedonic traits. Figure 2 shows means of the standardized SPQ factor scores and hedonic traits by cluster (error bars represent standard errors). The higher-order factors of the Schizotypal Personality Questionnaire (SPQ-74): *CPF* Cognitive-Perceptual, *IF* Interpersonal, *Dis* Disorganized. The scales of the Temporal Experience of Pleasure Scale: *tAnt* Anticipatory Pleasure, *tCon* Consummatory Pleasure



(all  $p_{\text{corr}} < 0.001$ ) and the negative schizotypy group had reduced tCon compared to the hedonic low-schizotypy cluster ( $p_{\text{corr}} = 0.005$ ). Of note, the clusters were similar in gender composition, but differed in education (Pearson  $\chi^2(4) = 13.37$ ;  $p = 0.010$ ) and mean age [ANOVA,  $F(4,735) = 4.77$ ;  $p < 0.001$ ;  $\eta_p^2 = 0.03$ ], the negative schizotypy group (cluster 1) being significantly older than clusters 2 and 5 (both  $p_{\text{corr}} = 0.001$ ).

**Current emotions**

Based on the emotion literature (Ryan & Deci, 2000; Silvia, 2006) and previous data (Alfimova et al., 2009), we expected that up to 70% of subjects would describe their emotional states as a positively valenced arousal presumably reflecting high intrinsic motivation associated with curiosity and new experience and would thus choose pictures with epistemological emotions (surprise, interest) or joy/happiness. Given this, for the further analysis the selection of pictures with these emotions was encoded as 1, and the selection of any other emotion as 0. The results were consistent with the expectations. In the entire sample, 74% of subjects chose the images of interest, happiness, or surprise to designate their current states, with the high concordance being seen between chosen pictures and verbal descriptions of the states [Pearson  $\chi^2(1) = 138$ ,  $p < 0.001$ ]. Subjects, who did not choose these positive emotions, described their actual states either as the absence of arousal or as emotionally negative experience. Specifically, the image of fear was used for the negatively valenced surprise. These subjects were slightly older [ $t(189) = 2.28$ ,  $p = 0.024$ ] and labeled all emotions less accurately [ $t(187) = 2.03$ ,  $p = 0.043$ ] than the rest of the sample (see Table S7 for means). Given this, we included the facial emotion recognition score along with three demographic variables as covariates into subsequent

logistic regression. With five predictors, we had EPV = 9.8, which approached the threshold (EPV  $\geq 10$ ).

**Trait–state relations**

Before assessing the associations between the constellations of schizotypal and hedonic traits and in-the-moment pleasure, we evaluated the individual impact of each trait on the current state. To do this, we used forward stepwise logistic regression where the current state was the dependent variable, and nine schizotypal and two hedonic scales were predictors. We also included likely confounders into the model: age, gender, education, and the facial emotion recognition score. The analysis demonstrated that, among hedonic and schizotypal traits, tAnt was the only significant predictor of the emotional states (adjusted for the facial emotion recognition score  $Wald = 6.69$ ;  $df = 1$ ;  $p = 0.010$ ; OR = 1.07, 95% bca CI 1.01–1.13), higher tAnt being related to positive emotions.

The proportions of individuals with pleasurable states are given in Table 2. In the logistic regression, adding cluster did not significantly improve the prediction of emotional states compared to the null model, which included age, gender, education, and the facial emotion recognition score [Pearson  $\chi^2(180) = 6.21$ ;  $p = 0.184$ ; Nagelkerke  $R^2 = 0.05$ ]. Of note, all clusters demonstrated lower rates of positive emotional states compared to the hedonic low-schizotypal individuals (the reference category), with the adjusted regression coefficient for the high schizotypy cluster being nominally significant ( $Wald = 4.53$ ;  $df = 1$ ;  $p = 0.033$ ; OR = 0.19, 95% CI 0.04–0.88; see Table 2 for bca ORs and CIs).

**Discussion**

The present study was designed to assess the complexity of the relations between schizotypal and hedonic traits and to explore how different combinations of these traits

**Table 2** Frequency (proportion) of subjects with positively valenced actual states in different clusters

Cluster	In-the-moment emotion, n (proportion of cluster)		Effect size*	
	Interest/Joy/Surprise	Others	OR	95% bca CI
Cluster 1. Negative schizotypy	26 (0.67)	13 (0.33)	0.29	0.08–1.29
Cluster 2. Hedonic low schizotypy	38 (0.89)	6 (0.11)	–	–
Cluster 3. Anhedonic low schizotypy	42 (0.72)	16 (0.28)	0.41	0.13–1.56
Cluster 4. High schizotypy	8 (0.62)	5 (0.38)	0.17	0.38–5.55
Cluster 5. Positive schizotypy	27 (0.73)	10 (0.27)	0.36	0.10–1.62

\*Effect size is the odds ratio (OR) for chances to experience interest/joy/surprise for a member of the given cluster compared to the hedonic low schizotypy cluster (the reference category) adjusted for age, education, gender, and facial emotion recognition accuracy. The ORs are derived from the binomial regression model that predicts emotional states; bias-corrected and accelerated bootstrap 95% confidence intervals (bca CIs) for ORs are calculated using 1000 bootstrap samples

impact naturalistic emotional states arising during cognitive activity and presumably underlying intrinsic motivation. We expected that trait anticipatory pleasure would correlate with signs of negative schizotypy and no other links between hedonic and schizotypal traits would be substantial after controlling for these correlations. We further hypothesized that we would observe negative and mixed schizotypy groups with reduced tAnt and lower frequencies of positive hedonic states associated with motivational processes and groups without negative schizotypal features and preserved hedonic capacity. None of our hypotheses has been entirely confirmed. The main findings are as follows. First, the simultaneous analysis of wanting and liking components of hedonic capacity by means of the network analysis demonstrated that tAnt was associated with positive and negative schizotypy facets mainly through Ideas of Reference and No Close Friends; the associations between trait consummatory pleasure and positive and negative schizotypal traits were weak; and there were no direct connections between any hedonic trait and disorganized features. Second, while tAnt individually predicted in-the-moment pleasure (interest/surprise and joy) during cognitive testing, there was no pronounced difference in these emotional states between groups with distinct constellations of schizotypal and hedonic traits.

The results can be viewed in favor of the idea that tAnt is of primary interest in schizotypy research due to its closer relations with schizotypal traits and in-the-moment emotional experiences than tCon. They also corroborate the above-described literature regarding the negative correlation of tAnt with negative schizotypy and its positive correlation with positive schizotypy. Of note, while the former correlation is in agreement with the theory and predictions and has been widely discussed, the latter contradicts the predictions and is largely ignored. The present network analysis shows that the positive correlation of tAnt with positive schizotypy is hardly spurious and deserves in-depth research. In particular, this correlation might reflect peculiarities of dopaminergic signaling, underlying vulnerability to several psychiatric conditions. Support for this hypothesis can be found in experimental studies linking dopamine and schizotypy (Mohr & Ettinger, 2014) and in studies of psychopathological correlates of schizotypy demonstrating that positive schizotypy is associated with actual hypomanic traits and substance abuse (Barrantes-Vidal et al., 2010; Kemp et al., 2018), as well as with future mood and substance use disorders (Barrantes-Vidal et al., 2010; Kwapil et al., 2013).

The clusters we found using schizotypal and hedonic traits closely matched those identified in cluster analytic studies of schizotypy alone (Barrantes-Vidal et al., 2010; Fonseca-Pedrero et al., 2017; Suhr & Spitznagel, 2001) in that we observed a large proportion of low-schizotypal individuals, positive and negative schizotypy clusters with moderate severity of schizotypal features and a small group

(< 10%) scoring high on all dimensions of schizotypy (high/mixed schizotypy). The results also agree with the recent meta-analysis, which has shown less tAnt but not tCon in negative schizotypy than in positive schizotypy (Visser et al., 2020).

Beyond this, our data suggest that heterogeneity of non-schizotypal controls might partly explain inconsistency of previous findings regarding hedonic characteristics in schizotypy (Fonseca-Pedrero et al., 2017; Shi et al., 2012; Wilson, 2012). Namely, the cluster analysis demonstrated that low-schizotypal individuals could be “hyper”- and hypohedonic, and this could influence inferences about pleasure deficits in schizotypal individuals. Specifically, individuals scoring high on positive or all schizotypy dimensions had a reduced tAnt relative to the hedonic low-schizotypy group; at the same time, their tAnt values were above the average level of the entire sample, which could be interpreted as preserved anticipatory pleasure. The group with relatively isolated symptoms of negative schizotypy, while demonstrating a decreased tAnt relative to both the hedonic low-schizotypy cluster and the entire sample, showed a decrease in tCon scores and in frequency of positive valenced states when compared to the former but not the latter. Of note, such negative schizotypy groups have seemingly been the main basis of the recent meta-analysis of hedonic capacity in schizotypy confirming decreased tAnt and tCon in schizotypal individuals (Visser et al., 2020).

Previous studies of hedonic capacity in schizotypy were mostly based on homogenous samples of undergraduate students. Our sample comprised people aged 16–66 years from three different cohorts, allowing to examine the relations between schizotypy and hedonic traits and states across a range of ages and life circumstances. Since anhedonic low-schizotypal individuals could represent a particular cohort, for example, older people (colleagues and friends) or those under stress (conscripts), which might limit generalizability of the results, we solved to explore the relationships between cohort and cluster membership (the results are given in Table S9). The relationship was significant, Pearson  $\chi^2(8) = 37.41$ ,  $p < 0.001$ . The follow-up analysis of adjusted residuals showed that none of the three cohorts was significantly overrepresented in the anhedonic non-schizotypy cluster after Bonferroni correction. Instead, the older cohort was significantly overrepresented in the negative schizotypy cluster and underrepresented in the hedonic low-schizotypy cluster, while the conscripts were underrepresented in the negative schizotypy group. Of importance also, the enrichment of hedonic low-schizotypy cluster for students approached the significance level. Thus, anhedonic individuals can present in low-schizotypal, i.e. “control”, groups recruited from any cohort, and low-schizotypal students tend to report more pleasure than other groups, which needs to be controlled in future research.



Aside from comparisons with low schizotypal individuals, the differences in tAnt between the clusters with detectable schizotypal traits did not agree with our hypothesis that anhedonia is an integral part of negative schizotypy. Specifically, the high/mixed schizotypy group did not show a decrease in tAnt resembling that in the negative schizotypy cluster. One might speculate that this is because TEPS measures pleasure in non-social stimuli while high (“true”) schizotypy is characterized by interpersonal anhedonia (Cohen et al., 2011a, 2011b; Horan et al., 2007). In contrast to this suggestion, however, the network analysis evidenced the correlation between TEPS Ant and the SPQ No Close Friends scale. The latter scale reflects a propensity to emotionally close interpersonal relationships and has been previously associated with interpersonal pleasure, as measured by the Anticipatory and Consummatory Interpersonal Pleasure Scale (Gooding et al., 2014). Alternatively, it could be hypothesized that people scoring high on all schizotypal dimensions may have an encoding-retrieval deficit, similar to but milder than that in psychosis. This deficit presumably leads to a “negativistic bias” in retrospective or prospective/hypothetical self-reports in patients (Cohen et al., 2011a, 2011b) but, owing to high pleasure beliefs in the general population (Strauss, 2013), might yield a “positivistic bias” in psychometrically defined schizotypal individuals. Finally, it is plausible that groups with isolated negative features and high mixed schizotypy could represent qualitatively distinct cohorts, of which only the latter is at high risk of psychosis and in contrast to negative schizotypes does have preserved tAnt.

The fact that the majority of people in the entire sample and in each cluster have pleasurable at-the-moment experience is in accord with the notion that to be curious and self-motivated is normative (Ryan & Deci, 2000). Because of the motivation function of the epistemological emotions, their association with tAnt, which is held to relate to approach motivation (Kring & Barch, 2014), rather than with the TEPS Con scale mostly addressing pleasurable relaxed states (e.g., “The sound of crackling wood in the fireplace is very relaxing”) has also been expectable and might be considered as a further validation of the motivational nature of tAnt as applied to intrinsic motivation. At the same time, given the correlation between tAnt and current emotions, the lack of prominent differences in in-the-moment pleasure between the clusters is somewhat surprising. Remarkably, the distribution of individuals choosing interest/surprise/joy across the clusters agreed to some extent with the clusters’ tAnt levels, except for the high schizotypy cluster. The latter group tended to report in-the-moment pleasure with the frequency below the mean of the entire sample and nominally significantly below that of the hedonic low-schizotypy group. The discrepancy between tAnt and actual emotional states in the high schizotypy individuals was thus opposite

to that hypothesized for schizophrenia (Gard et al., 2006; Kring & Barch, 2014).

However, this and the other results of the study need to be considered in light of its limitations. First, only a subgroup of the entire sample participated in the cognitive session. As a consequence, the number of high schizotypal individuals in whom the actual emotional states were assessed turned out to be small. Meanwhile, this group is of special interest as it may represent people vulnerable to schizophrenia, regardless of whether the continuous (Claridge, 1997) or discontinuous (Meehl, 1990) hypothesis of schizotypy is adopted. Given this, the trend to the discrepancy between preserved tAnt and diminished at-the-moment pleasure found in this high schizotypy cluster deserves further investigations in larger samples.

Next, our cluster and all subsequent analyses were based on the results of network modelling. This approach might have not only advantages associated with selecting relevant variables but also shortcomings. Namely, network modelling results depend on the estimation method used to detect non-zero edges. Here, we applied glasso, the estimation method increasingly employed in psychological research. However, alternative estimation methods might have resulted in slightly different networks (Williams et al., 2019).

Finally, the study was not designed to delineate factors behind trait and state anhedonia. We cannot exclude that, in the anhedonic low-schizotypy group, low TEPS and SPQ scores have in fact resulted from the “nay-saying” response bias. At the same time, anhedonia is closely related to depression. People high in schizotypy often report elevated depressive symptoms that may be a pathway for motivation and pleasure impairment (Campellone et al., 2016). Also, in the general population, there are correlations between fluctuations in mood and curiosity occurring during daily life (Lydon-Staley et al., 2020). It would be interesting to compare the role of depression in anhedonia between groups of low-schizotypal people and of those who have signs of negative schizotypy.

## Conclusion

The present study shows that correlations of trait anticipatory pleasure with schizotypal traits are different for positive, negative, and disorganized features and more pronounced than correlations between tCon and schizotypy. In addition, trait anticipatory pleasure correlates with naturalistic pleasurable states that arise during cognitive activity and underpin intrinsic motivation. At the same time, the results do not provide evidence for the hypothesis that distinct constellations of schizotypal and hedonic traits are related to different actual hedonic experiences associated with intrinsic motivation. Overall, the findings agree with the idea that tAnt

is of primary interest in schizotypy research and that the heterogeneity of schizotypal traits accounts for inconsistent findings regarding the reduction of tAnt in schizotypy. They also suggest that the inconsistency might be partly explained by heterogeneity of control low-schizotypal groups.

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**Author contributions** MA and VG designed the study. VP and TL collected the data. MA conducted the statistical analyses and wrote the first draft of the manuscript. All authors reviewed the manuscript and approved its final version.

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## Declarations

**Conflict of interest** The authors have no conflict of interest to declare that are relevant to the content of this article.

**Ethical approval** The study was performed in accordance with the ethical standards as laid down in the 1964 Declaration of Helsinki. Approval was obtained from the Ethics Committee of the Mental Health Research Center.

**Consent to participate** Written informed consent was obtained from all individual participants included in the study.

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