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## Olfactory identification ability is associated to emotional states and expression in individuals with schizotypy

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## ABSTRACT

Previous studies have provided compelling support for the olfactory dysfunction and emotion deficits in schizophrenia spectrum disorders. The present research aimed to study whether olfactory function is associated with emotional states and emotional expression in individuals with schizotypy. Thirty individuals with schizotypy and 30 controls were recruited for this study. The Sniffin' sticks test was used to evaluate olfactory function. The Emotional Expressivity Scale (EES) was used to assess the expression of emotion. The Beck Depression Inventory (BDI) and the State-Trait Anxiety Inventory (STAI) were used to assess depression and anxiety symptoms, respectively. Compared with the controls, individuals in schizotypal group had weaker emotional expression and more severe emotional states (including depression and anxiety). The results showed that odor identification scores were positively correlated with emotional expression scores and negatively correlated with depression, state anxiety, and trait anxiety in the schizotypal group. Emotional expression was inversely related to the olfactory threshold in the controls, but not in the schizotypal group. Odor identification showed a positive correlation with emotional expression and negative correlations with emotional states in individuals with schizotypy, which may provide new insight for the exploration of the sensory perception impairments and emotional deficits in schizophrenia spectrum disorders.

### 1. Introduction

Previous studies established that olfactory deficits exist in schizophrenia spectrum patients, which can be seen in a variety of olfactory tasks, such as odor identification, odor discrimination, and odor threshold (Moberg et al., 2014). Olfactory dysfunction has also been regarded as a useful marker of schizophrenia risk status (Moberg et al., 2014). Moreover, emotional deficits—including reduced ability of emotional experience, expression (Berenbaum & Oltmanns, 1992; Phillips & Seidman, 2008), and regulation (Giakoumaki, 2016)—are considered to be core features of schizophrenia (Gaebel & Wölwer, 2004). Given the demonstrated genetic basis of schizophrenia (Roussos et al., 2013), the observable behavioral, neurocognitive, and psychopathological symptoms of schizotypal individuals represent a high risk for schizophrenia disorders (Lenzenweger, 2006, 2015; Meehl, 1962; Meehl, 1989). Similar to individuals with schizophrenia, schizotypal individuals also show critical impairments in emotional experience (Phillips & Seidman, 2008; Shi et al., 2012), expression (Shi et al., 2012), and regulation (Giakoumaki, 2016). Emotional expression is the most observable stage of emotion processing (Chan et al., 2010; Coan &

Allen, 2007), which makes it a good measurement of the developmental state of schizotypy.

The neural bases of olfactory function and emotional processing have been reported to be similar in terms of brain anatomy (Soudry, Lemogne, Malinvaud, Consoli, & Bonfils, 2011), which is also related to schizophrenia (Moberg et al., 1999). Previous studies indicated that emotion perception may depend on several significant brain regions, such as amygdala, insula, hippocampus, anterior cingulate gyrus, and prefrontal cortex (Phillips, Drevets, Rauch, & Lane, 2003). These brain regions also play an important role in olfactory processing through attributing positive (appetitive) or negative (aversive) valence to the environment (Soudry et al., 2011). Olfactory function is also associated with emotional states such as depression (Croy et al., 2014; Croy & Hummel, 2017; Taalman, Wallace, & Milev, 2017; Yuan & Slotnick, 2014) and anxiety (Krusemark, Novak, Gitelman, & Li, 2013). Moreover, studies have found a significant overlap between the brain regions that regulate olfaction and pleasure experience (Zou, van Hartevelt, Kringelbach, Cheung, & Chan, 2016). A relationship between odor identification and pleasure experience was found in individuals with schizotypy (Zou et al., 2015; Zou et al., 2018), which may be mediated

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by parahippocampal gyrus volume (Zou et al., 2015). However, it remains unknown whether olfactory function is associated with emotional states and emotional expression in individuals with schizotypy.

The present study aimed to investigate whether olfactory function is associated with emotional states and emotional expression in individuals with schizotypy, which may provide new insights for exploring the emotional impairments related to olfactory sensation in schizophrenia spectrum disorders and determining their pathological mechanisms. We hypothesized that odor identification was positively associated with emotional expression and negatively associated with emotional states (depression and anxiety) in individuals with schizotypy.

## 2. Methods

### 2.1. Participants

Based on scores on the Chapman Social Anhedonia Scale (CSAS) and Chapman Physical Anhedonia Scale (CPAS) (Meehl, 1962; Meehl, 1989), participants were recruited from a sample of 2811 freshmen at a university. Thirty participants who scored  $\geq 18$  on the CSAS were classified into the schizotypal group, and 30 participants who scored  $\leq 10$  on the CSAS and  $\leq 15$  on the CPAS, respectively, were classified into the control group (Li et al., 2016; Zou et al., 2018). All the participants were free from ear/nose/throat diseases, psychiatric diseases, organic lesions, and drug/alcohol misuse based on self-reports. The study was approved by the Ethics Committee of our university, and all participants gave informed consent to participate in the study.

### 2.2. Measures

#### 2.2.1. Sniffin' sticks olfactory test

Sniffin' sticks is a test for assessing olfactory chemosensory performance based on pen-like odor-dispensing devices (Hummel, Sekinger, Wolf, Pauli, & Kobal, 1997; Kobal et al., 2000). It includes three tests of olfactory function: olfactory threshold, odor discrimination, and odor identification (Hummel et al., 1997; Kobal et al., 2000). The Sniffin' sticks test was standardized in the European population, but it has been widely used in the Chinese population as well (Chen et al., 2012; Yang, Wei, Yu, Zhang, & Liu, 2010; Zou et al., 2015; Zou et al., 2016). The olfactory test methods in this study were based on Hummel et al. (1997) and Kobal et al. (2000).

In the olfactory threshold test, odors were presented in 16 triplets of pens, two of the pens containing nearly odorless solvents and one containing the specific odor (2-phenylethanol) at a certain dilution (a total of 16 dilutions). The participants were asked to indicate the pen with odorant, and triplets were presented 20 s apart. The threshold was determined by a single-staircase, triple-forced choice procedure. Two successive correct identifications or an incorrect identification triggered a reversal of the staircase, i.e., the next-higher or the next-lower concentration step was presented, respectively. Seven reversals had to be obtained (including the starting point), and the olfactory threshold was defined as the mean of the last four staircase reversals.

In the odor discrimination test, 16 triplets of pens, two containing the same odor and the third containing a different odor, were again presented at intervals of 20 s. Participants were asked to identify which one of the three pens smelled differently. The test result was the sum score of correctly identified pens, which represented the level of odor discrimination.

In the odor identification test, subjects were presented with and asked to identify 16 common odors from a list of four descriptors (multiple forced-choice procedure). The interval between odor presentations was approximately 20 s to prevent olfactory desensitization. The test result was the sum score of correctly identified pens, which represented the degree of odor identification.

#### 2.2.2. Emotional expressivity scale (EES)

The EES, which consists of 17 items, is commonly used to assess emotional expressiveness (Kring, Smith, & Neale, 1994). The participants rated each item on a 6-point Likert scale (1 = *never true* and 6 = *always true*) indicating how they express their emotions and feelings most of the time. The Chinese version of EES showed high overall internal consistency in the general population ( $\alpha = 0.82$ ) (Chan et al., 2010).

#### 2.2.3. State-trait anxiety inventory (STAI)

The STAI is a self-report questionnaire used to measure participants' state anxiety and trait anxiety (Spielberger, 1970; Spielberger & Gorsuch, 1983). It consists of 40 items, with 20 items allocated to each of the two subscales: the State Anxiety Scale (STAI-st) and the Trait Anxiety Scale (STAI-tr). The STAI-st evaluates how the participants feel "right now," including participants' subjective feelings of apprehension, tension, nervousness, worry, and arousal of the autonomic nervous system. The STAI-tr evaluates how the participants feel "generally" and assesses relatively stable aspects of anxiety proneness, involving general states of calmness, confidence, and security. The items are rated on a 4-point Likert scale (1 = *not at all* and 4 = *very much so* on the STAI-st questions; 1 = *almost never* and 4 = *almost always* on the STAI-tr questions), with higher scores on the scales representing more severe symptoms and higher proneness to be anxiety, respectively (Julian, 2011). The internal consistency of the STAI is good (Cronbach's  $\alpha$  for STAI-st = 0.81, for STAI-tr = 0.86).

#### 2.2.4. Beck depression inventory (BDI)

The BDI, which includes 21 reliable and well-validated items, is a brief self-report measure for assessing depressive symptoms (Beck, Ward, Mendelson, Mock, & Erbaugh, 1961). Participants indicate how much they have been bothered by each symptom over the past week by selecting one of four statements, which are scored from 0 (none) to 3 (severe). Higher scores reflect more symptoms and/or higher levels of depressive symptoms (Beck et al., 1961). The internal consistency of the BDI is good ( $\alpha = 0.85$ ).

### 2.3. Data analysis

A multivariate analysis of variance (MANOVA) was used to compare the mean values of olfactory function (olfactory threshold, odor discrimination, and odor identification), emotional states (BDI and STAI), EES, and hedonic traits (CSAS and CPAS) between the schizotypal group and the controls. Additionally, Spearman correlations were calculated to assess the relationships between olfactory function and emotion performance scores in both groups.

## 3. Results

There was no significant difference in gender between the schizotypal group and controls ( $\chi^2 = 0.67, p = 0.79$ ; Table 1). The MANOVA results showed that the mean values of the emotional states (BDI and STAI), EES, and hedonic traits tests (CSAS and CPAS), but not the olfactory tests, differed significantly between the two groups (see Table 1).

The results showed that odor identification scores were positively correlated with emotional expression scores ( $r = 0.512, p < 0.05$ ) and negatively correlated with depression ( $r = -0.465, p < 0.01$ ), state anxiety ( $r = -0.422, p < 0.05$ ), and trait anxiety scores ( $r = -0.482, p < 0.01$ ) in the schizotypal group (Table 2). Emotional expression was negatively correlated with olfactory threshold ( $r = -0.372, p < 0.05$ ) in the controls (Table 2), but not in the schizotypal group. No other correlations were found in either group.

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