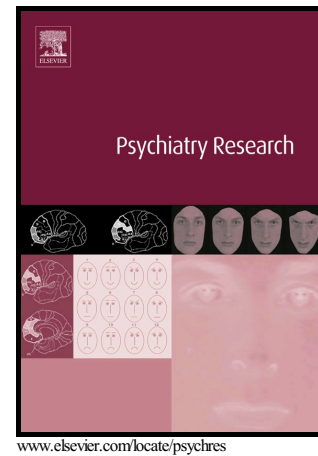


Author's Accepted Manuscript

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PII: S0165-1781(16)31145-3
DOI: <http://dx.doi.org/10.1016/j.psychres.2016.12.021>
Reference: PSY10157

To appear in: *Psychiatry Research*

Received date: 7 July 2016
Revised date: 16 December 2016
Accepted date: 18 December 2016

Cite this article as: Li-juan Shi, Wen-hua Liu, Hai-song Shi, Chao Yan, Ya Wang, Yi Wang, Eric F.C. Cheung and Raymond C.K. Chan, Co-occurrence of autistic and schizotypal traits and its association with emotional and psychosocial function in Chinese college students, *Psychiatry Research* <http://dx.doi.org/10.1016/j.psychres.2016.12.021>

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Co-occurrence of autistic and schizotypal traits and its association with emotional and psychosocial function in Chinese college students

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Abstract

Empirical findings suggest an overlap between autism spectrum disorders (ASD) and schizophrenia spectrum disorders (SSD). Co-occurring autistic and positive schizotypal traits may have a moderating effect on behaviour and cognition. This study attempted to examine the co-occurrence rate of autistic and schizotypal traits

in otherwise healthy college students and to test the moderating effect of co-occurring autistic and schizotypal traits on executive function, emotion processing and social function. Eight hundred and sixty-four participants took part in the present study. The results showed that the co-occurrence rate of autistic and schizotypal trait was 3.4% at baseline and 2.4% at one-year follow-up. The interaction between autistic traits and schizotypal traits was associated with better executive functioning and social functioning but poorer emotional expression.

Keywords: Autism spectrum disorder; Schizophrenia spectrum disorder; autistic traits; schizotypal traits; psychosocial function; emotion

1. Introduction

Although autism spectrum disorders (ASD) and schizophrenia spectrum disorders (SSD), which includes schizophrenia, other psychotic disorders, and schizotypal personality disorder, are different psychiatric disorders in DSM-5 (Association, 2013), accumulated evidence suggests some similarities between these two disorders. The main clinical manifestations of ASD include impairment in social communication and social interactions, such as lack of non-verbal communicative behaviours, impaired abilities in developing, maintaining and understanding relationships; and abnormal behaviours and interests (Association, 2013). These social deficits are similar to the negative symptoms of SSD, such as diminished emotional expression, avolition, alogia, anhedonia and asociality.

Apart from clinical manifestations, both ASD and SSD also share impairments in social cognitive (Couture et al., 2010; Pilowsky et al., 2000) and executive function (Geurts et al., 2014; Happé et al., 2006; Holmén et al., 2012). For example, it has

been reported that ASD and SSD have similar deficits in facial emotion recognition (Harms et al., 2010; Marwick and Hall, 2008), eye gaze to social cueing (Klin et al., 2002; Roux et al., 2014), performance on theory of mind tasks (Brune, 2005a, b; Korkmaz, 2011; Peterson, 2014) and attention (Eack et al., 2013). Both ASD and SSD also share similar risk factors, including advanced paternal age (McGrath et al., 2014; Weiser et al., 2008), obstetric complications (Cannon et al., 2002; Larsson et al., 2005) and maternal infections (Brown, 2006; Meyer et al., 2011). Furthermore, a family history of SSD is a risk factor for ASD (Sullivan et al., 2012).

Some studies have reported the co-occurrence rate between ASD and schizophrenia. Sporn et al. (Sporn et al., 2004) examined 75 schizophrenia probands, and found that 25% of them had a diagnosis of pervasive developmental disorder. Barneveld et al. (2011) found that among 27 ASD adolescents, 11 met DSM-IV-TR criteria for schizotypal personality disorder. Two recent large longitudinal cohort studies found that the emergence of psychotic symptoms at the age of 12 was associated with early autistic traits (Bevan Jones et al., 2012; Sullivan et al., 2013). ASD and SSD have been hypothesized to lie on the same spectrum, and the phenotypic characteristics of both disorders are thought to be distributed continuously in the general population (Nelson et al., 2013; Ronald and Hoekstra, 2014). Despite evidence for such co-occurrence in the clinical population, few studies have examined the co-occurrence rate of autistic and schizotypal traits in a non-clinical population. Furthermore, the majority of previous research has been cross-sectional. Longitudinal studies to examine the stability of the co-occurrence rate of autistic and schizotypal traits in a non-clinical population are needed.

A previous study has found that, compared with individuals with pure ASD, ASD

individuals with comorbid psychiatric disorders had significantly lower functioning levels (Mattila et al., 2010). However, a recent diametric model theory suggests that ASD and positive SSD may be diametric opposites on a cognitive continuum (Crespi and Badcock, 2008). Some studies supported this model and suggested that co-occurring autistic and positive schizotypal traits may have a moderating effect on behaviour and cognition. For example, Abu-Akel et al. (2015) found that co-occurring autistic and positive schizotypal traits exert opposing influences on mentalizing difficulties and the interaction between autistic and schizotypal traits may reduce mentalizing difficulties. The authors also found that co-occurring autistic and schizotypal traits may reduce the cost incurred in the presence of salient distractors (Abu-Akel et al., 2016). However, these studies only considered co-occurring autistic and positive schizotypal traits. The clinical manifestations of SSD not only include positive symptoms, but also negative symptoms, and a number of studies have found that the main overlap between ASD and SSD occurs between autistic social and negative schizotypal traits (Dinsdale et al., 2013b; Hurst et al., 2007b; Russell-Smith et al., 2011; Wakabayashi et al., 2006). It is unclear how co-occurring autistic and schizotypal traits (both positive and negative) would moderate cognition and behaviour. The aims of the present study were: 1) to examine the co-occurrence rate of autistic and schizotypal traits in a sample of college students, and to investigate the stability of the co-occurrence rate; 2) to test the moderating effect of co-occurring autistic and schizotypal traits on executive function, emotion processing and social function at time point 1. Given the aforementioned diametric model and the possible moderating effect of co-occurring autistic and positive schizotypal traits (Crespi and Badcock, 2008), we hypothesized that co-occurring autistic and

schizotypal traits, not only positive schizotypal traits, would moderate emotional and psychosocial functioning at time point 1. Moreover, we hypothesized that individuals with co-occurring autistic and schizotypal traits would have better self-reported cognitive, emotional, and social functioning than individuals with high autistic traits and individuals with high schizotypal traits at time point 1.

2. Methods

2.1 Sample

A total of 864 participants were recruited from the Guangzhou medical university in Guangzhou, China. All of them completed a set of self-reported questionnaires capturing autistic traits, schizotypal traits as well as executive function, emotional experiences/expressivity and social functioning at baseline and 1 year later. The survey was administered in group format. The study was approved by the Ethics Committee of the Institute of Psychology, the Chinese Academy of Sciences. Written consent was obtained from the participants before the administration of the study at baseline and 1-year follow-up time point. Participants received 10 RMB for their participation of the study at each time.

2.2 Measures

2.2.1 Autistic traits

Autistic traits were assessed using the Autism Spectrum Quotient (AQ) that was specifically designed to capture autistic traits in a non-clinical population (Baron-Cohen et al., 2001). Impressive psychometric properties in terms of test-retest reliability ($r = 0.70$) and internal consistency (Cronbach's $\alpha = 0.82$) have

been reported (Baron-Cohen et al., 2001). The Cronbach's alpha of the present sample was 0.601 for time point 1. Responses were rated on a four-point scale ranging from 'definitely agree' to 'definitely disagree'. Each item was scored as 1 or 0, with a highest possible score of 50. The AQ was shown to effectively discriminate individuals with ASD from typically-developing individuals with a cut-off of 32 in a non-clinical setting (Baron-Cohen et al., 2001), but a cut-off of 26 in the clinical settings (Woodbury-Smith et al., 2005). The present study adopted the Chinese version of the AQ I (Chan et al., 2008).

2.2.2 Schizotypal traits

Schizotypal traits were assessed using the Schizotypal Personality Questionnaire (SPQ) (Raine, 1991) was specifically design to screen for Schizotypal Personality Disorder. Each item was rated on a dichotomous response of yes or no with a maximum total score of 74. It was assumed that participants scoring in the top 10th percentile of SPQ total scores would have significant schizotypal traits (Raine, 1991). the present study adopted the Chinese version of the SPQ (Chen et al., 1997) that has been shown with good Cronbach's alpha for adults (0.90) and adolescents (0.93). The Cronbach's alpha of the SPQ in this study was 0.934 at time point 1.

2.2.3 Executive function

Executive function was assessed by the Chinese version of the Dysexecutive Questionnaire (DEX) (Chan, 2001; Wilson et al., 1997) that was specifically designed to capture the five domains of executive functions, i.e., inhibition, intentionality, knowing-doing dissociation, in-resistance and social regulation. Responses were rated on a five-point scale (ranging from 0 to 4) with a higher score reflecting more severity of dysexecutive behaviour in everyday life. The internal consistency of

the DEX in the present study was good (Cronbach's $\alpha = 0.935$) at time point 1.

2.2.4 Emotional experience

The Chinese version of the Temporal Experience of Pleasure Scale (TEPS) was used to measure individual anticipatory (contextual and abstract) and consummatory (contextual and abstract) pleasurable experience (Chan et al., 2012a). The questionnaire shows adequate test-retest reliability ($r = 0.79$ to 0.81) and internal consistency (Cronbach's $\alpha = 0.83$) (Chan et al., 2012a). The Cronbach's α of the TEPS in this study was reported to be 0.847 at time point 1.

2.2.5 Emotional expressivity

The ability of express emotions were assessed using the Emotional Expressivity Scale (EES) (Kring et al., 1994). It includes 17 items on a six-point scale capturing how participants expressed their emotions and feelings most of the time. The Chinese version of the EES included two dimensions: emotion suppression and emotion expression, and has been shown to exhibit high overall internal consistency with a Cronbach's α of 0.82 (Chan et al., 2010). In present study, the Cronbach's α of the EES was 0.83 at time point 1.

2.2.6 Social function

The Chinese version of the First Episode Social Functioning Scale (FESFS) (Wang et al., 2013) was used to assess the social functioning of all participants, including Interpersonal, Family and Friends, School, Living Skill, Intimacy and Balance. Responses were rated on a four-point Likert scale, ranging from 1 to 4. The

whole scale internal consistency of the Chinese version of the FESFS has been demonstrated in the Chinese population with a Cronbach's alpha of 0.89. The Cronbach's alpha of the present sample was 0.923 at time point 1.

2.3 Statistical analysis

Descriptive statistics (means and SD) for autistic- and schizotypal traits at time point 1 and 2 were reported. Repeated measures ANOVAs were carried out to examine the stability of AQ and SPQ total scores in the whole sample across two time points. Data analysis was performed using SPSS version 17. All statistical tests were 2-tailed using 0.05 as the level of statistical significance.

To explore the stability of the co-occurrence rate of autistic and schizotypal traits, we first conducted Pearson's correlation analyses on the test-retest reliability of the AQ and the SPQ. Then chi-square tests were conducted. Participants were first categorized as the low autistic traits group and the high autistic traits group. The cut-off for high autistic traits was 26 on the AQ, which represents the cut-off score for recommending assessment for possible ASD in clinical settings (Woodbury-Smith et al., 2005). Then the participants were categorized into the low schizotypal traits group and the high schizotypal traits group according to the cut-off of 36 on the SPQ. Approximately 10% of the participants scored ≥ 36 on the SPQ in our sample.

To examine the effect of co-occurring autistic and schizotypal traits on executive function, emotional experience, emotional expression and social function, hierarchical regression analyses were conducted. To control for gender, we first entered this covariate into the model. We then entered the AQ total scores and the SPQ total scores at time point 1 as independent variables. The AQ total scores and

the SPQ total scores were standardized before interaction terms were calculated.

Finally, we added the interaction term for the two independent variables. The dependent variables were DEX total scores, TEPS total scores, EES total scores and FESFS total scores. Before the hierarchical regression analyses, we conducted Pearson's correlation analyses.

3. Results

3.1 Descriptive statistics

The mean total AQ scores were 18.50 (SD = 5.04) at time point 1 and 18.44 (SD = 5.49) at time point 2. Repeated measures ANOVA showed that there was no significant difference in AQ total scores over time ($F(1, 863) = 0.12, p = 0.729$). The mean total SPQ scores were 19.77 (SD = 12.59) at time point 1 and 16.20 (SD = 14.00) at time point 2. Repeated measures ANOVA indicated that there was a decrement of SPQ total scores over time ($F(1, 863) = 74.48, p < 0.001$).

3.2 Co-occurrence of high autistic traits and high schizotypal traits

The test-retest reliability of the AQ and the SPQ are presented in **Table 1** and **Table 2**. Frequencies and percentages for the groups with high and low autistic and schizotypal traits over time are presented in **Table 3**. The proportion of individuals with high autistic and high schizotypal traits was not significantly different across the two time points. **Table 4** shows the percentage of co-occurring autistic and schizotypal traits at the two time points. At time point 1, 3.4% of the participants had co-occurring high autistic and high schizotypal traits. At time point 2, this was reduced to 2.4%. There was no significant difference in the prevalence of

co-occurring high autistic and high schizotypal traits across the two time points

($\chi^2=1.318$ $p=0.251$).

3.3 The effect of co-occurring autistic and schizotypal traits on executive function, emotional experience, emotional expression and social function at time point 1

Pearson's correlation analyses indicated that there were significant correlations between AQ total scores and SPQ total scores ($r = .443$ $p < 0.001$), and between AQ total scores and gender ($r = -.08$ $p = 0.019$). There were no significant correlations between age and either the AQ total scores ($r = .022$ $p = 0.522$) or the SPQ total scores ($r = -.026$ $p = 0.442$), and between SPQ total scores and gender ($r = .037$ $p = 0.280$). There were also no significant associations between age and DEX total scores, TEPS total scores, EES total scores or social functioning total scores ($-.037 \leq r \leq .028$ all $p \geq 0.284$). Therefore age was not entered into the hierarchical regression model as a covariate.

The interaction of AQ total scores and SPQ total scores accounted for significant variance in DEX total scores, EES total scores and social function total scores at time point 1. **Table 5** shows that the interaction term of AQ total scores \times SPQ total scores was significantly and negatively associated with DEX total scores and EES total scores, but was significantly and positively associated with social function total scores.

To examine the interaction further, we followed the method by Hayes & Matthes (2009) and first used the MODPROBE for SPSS to visualize by plots of simple regression lines the effect of one predictor on each dependent variable at the participants' mean score, 1 SD below the participants' mean score, and 1 SD above the participants' mean score of the other predictor. Figure 1A illustrates the association between autistic traits and DEX total scores at low SPQ (SPQ = 7.16),

average SPQ (SPQ = 19.77), and high SPQ scores (SPQ = 32.37), and Figure 1B illustrates the association between schizotypal traits and DEX total scores at low AQ (AQ= 13.45), average AQ (AQ = 18.50), and high AQ scores (AQ = 23.54). To identify the region/values of the moderator variable where the predictor had a significant effect on DEX total scores, we used the Johnson-Neyman method utilizing the MODPROBE for SPSS. According to this analysis, increasing autistic traits (Figure 1A) was significantly associated with increasing DEX total scores in individuals scoring below 37 on the SPQ, but with significantly reduced DEX total scores in individuals scoring above 73 on the SPQ. Conversely, increasing schizotypal traits were only associated with a significant increasing DEX total scores in individuals scoring below 33 on the AQ (figure 1B). Figure 2A and 3A illustrates the association between autistic traits and EES total scores, social function at low SPQ (SPQ = 7.16), average SPQ (SPQ = 19.77), and high SPQ scores (SPQ = 32.37), and Figure 2B and 3B illustrate the association between schizotypal traits and EES total scores and social function at low AQ (AQ= 13.45), average AQ (AQ = 18.50), and high AQ scores (AQ = 23.54). The analyses showed that increasing autistic traits (Figure 2A) was associated with significantly increasing EES total scores in individuals scoring below 16 on the SPQ, and was associated with significantly reduced social function scores in individuals scoring below 49 on the SPQ (Figure 3A). The analyses also showed that increasing schizotypal traits were only associated with a significant increasing EES total scores in individuals scoring below 33 on the AQ (Figure 2B), and with a significantly reduced social function scores in individuals scoring below 25 on the AQ (Figure 3B). The same analyses were conducted for the effect of co-occurring autistic and positive schizotypal traits on executive function, emotional experience, emotional expression

and social function at time point 1 (electronic supplementary material, Figure S1 and S2).

4. Discussion

Our results showed that the co-occurrence rate of high autistic and high schizotypal traits was 3.4% at baseline and 2.4% at one year follow-up in this college student sample, and the co-occurrence rate was relatively stable. Co-occurring autistic and schizotypal traits showed a moderating effect on executive function, emotional expression and social function. The interaction between autistic traits and schizotypal traits were associated with both better executive functioning and social functioning but poorer emotional expression.

4.1 The co-occurrence rate of autistic and schizotypal traits

Our results support previous reports of overlap between autistic and schizotypal traits using the AQ and SPQ in a college students sample (Dinsdale et al., 2013a; Hurst et al., 2007a; Russell-Smith et al., 2011) and extend them by determining individual co-occurrence rate of high autistic and schizotypal traits. We found that 3.4%-2.4% of our sample had overlap of high autistic and schizotypal traits. Although the cut-off values of the high autistic and high schizotypal traits were arbitrary cut-off scores, the results indicate that the co-occurrence of high autistic and high schizotypal traits not only occurs in clinical populations, but also in a non-clinical population.

4.2 The moderating effect of co-occurring autistic and schizotypal traits on executive function and social function

The results of hierarchical regression suggest that co-occurring autistic and schizotypal traits had a moderating effect on executive function and social function, but this moderating effect depended on the relative expression of the two traits. For example, either higher autistic traits or higher schizotypal traits were associated with poorer executive function. However, when autistic traits were above 33 on the AQ or schizotypal traits were above 37 on the SPQ, this effect was not significant or even reversed. This is similar to the moderating effect on social function. This finding not only provides supports to the dimensional models of ASD and positive SSD (Crespi and Badcock, 2008), but also provides evidence that co-occurrence of autistic and schizotypal traits (include positive and negative schizotypal traits) also has a moderating effect on executive function and social function.

4.3 The moderating effect of co-occurring autistic and schizotypal traits on emotional experience and emotional expression

In this study, the co-occurring autistic and schizotypal traits had no moderating effect on emotional experience. A diminished capacity to experience pleasure is a prominent symptom in schizophrenia (Loas et al., 2000), but no previous studies have directly examined this deficit in individuals with ASD. Although a recent review integrating functional neuroimaging data, electrophysiological recordings and neurochemical measures data suggests that individuals with ASD may have disrupted social reward ‘wanting’ (pursue anticipatory pleasure) capacities, there is no good evidence to support the presence of disrupted ‘liking’ (consummatory pleasure) capacities in individuals with ASD (Kohls et al., 2012).

The reduced ability to express emotion have been considered a core feature of schizophrenia and ASD (Association, 2013; Trémeau et al., 2005). However, we found

that neither higher levels of autistic traits nor higher levels of schizotypal traits were associated with better emotional expression. When autistic traits were above 33 on the AQ or schizotypal traits were above 16 on the SPQ, this effect was not significant or even reversed. Co-occurring autistic and schizotypal traits were associated with poorer emotional expression. It is not known why higher levels of autistic traits and higher levels of schizotypal traits were associated with better emotional expression while co-occurring autistic and schizotypal traits were associated with poorer emotional expression in our sample. Further study is needed to determine whether population characteristics leads to such discrepant results.

4.4 Limitations

This study has several limitations. First, we only used several self-reported scales to assess schizotypal and autistic traits. There was no clinical assessment. Secondly, due to slight change in the co-occurrence rate of schizotypal and autistic traits between the two time points, we only analyzed the moderating effect based on data obtained at time point 1. Thirdly, autistic traits and schizotypal traits are distributed continuously in the general population, but in our analyses, arbitrary cut-off scores were applied to identify high and low autistic and schizotypal traits. The assessment of emotional and psychosocial functioning was also based on self-reported scales. Future studies using more objective experimental methods to assess emotional and psychosocial functioning are needed. Finally, our results should be considered preliminary in nature. Content overlap of the ASQ and SPQ might have contaminated our findings. Future study should consider a more stringent method of examining the co-occurrence of these two traits in the general population.

5. Conclusions

In conclusion, our results support that co-occurring autistic and schizotypal traits may exert moderating effects on cognition and behaviour.

Acknowledgements

This study was supported by a grant from the Beijing Training Project for the Leading Talents in S & T (Z151100000315020), the Beijing Municipal Science & Technology Commission Grant (Z161100000216138), the National Science Fund China (81571317), the key Laboratory of Mental Health, Institute of Psychology, and the CAS/SAFEA International Partnership Program for Creative Research Teams (Y2CX131003), and China Postdoctoral Science Foundation (2016M601157). These funding agents had no role in the study design; collection, analysis, and interpretation of the data; writing of the manuscript; or decision to submit the paper for publication.

References

- Abu-Akel, A., Apperly, I.A., Wood, S.J., Hansen, P.C., Mevorach, C., 2016. Autism Tendencies and Psychosis Proneness Interactively Modulate Saliency Cost. *Schizophr Bull.*
- Association, A.P., 2013. Diagnostic and statistical manual of mental disorders (DSM-5®). American Psychiatric Pub.
- Baron-Cohen, S., Wheelwright, S., Skinner, R., Martin, J., Clubley, E., 2001. The autism-spectrum quotient (AQ): evidence from Asperger syndrome/high-functioning autism, males and females, scientists and mathematicians. *J Autism Dev Disord* 31 (1), 5-17.
- Bevan Jones, R., Thapar, A., Lewis, G., Zammit, S., 2012. The association between early autistic traits and psychotic experiences in adolescence. *Schizophr Res* 135 (1-3), 164-169.
- Brown, A.S., 2006. Prenatal infection as a risk factor for schizophrenia. *Schizophrenia bulletin* 32 (2), 200-202.
- Brune, M., 2005a. Emotion recognition, 'theory of mind,' and social behavior in schizophrenia. *Psychiatry Res* 133 (2-3), 135-147.
- Brune, M., 2005b. "Theory of mind" in schizophrenia: a review of the literature. *Schizophr Bull* 31 (1),

21-42.

- Cannon, M., Jones, P.B., Murray, R.M., 2002. Obstetric complications and schizophrenia: historical and meta-analytic review. *American Journal of Psychiatry* 159 (7), 1080-1092.
- Chan, R.C., 2001. Dysexecutive symptoms among a non - clinical sample: A study with the use of the Dysexecutive Questionnaire. *British Journal of Psychology* 92 (3), 551-565.
- Chan, R.C., Shi, Y.F., Lai, M.K., Wang, Y.N., Wang, Y., Kring, A.M., 2012a. The Temporal Experience of Pleasure Scale (TEPS): exploration and confirmation of factor structure in a healthy Chinese sample. *PLoS ONE* 7 (4), e35352.
- Chan, R.C., Wang, Y., Li, H., Shi, Y., Wang, Y., Liu, W., Huang, J., 2010. A 2-stage factor analysis of the Emotional Expressivity Scale in the Chinese context. *Psychologia* 53 (1), 44-50.
- Chan, R.C., Wang, Y., Yan, C., Zhao, Q., McGrath, J., Hsi, X., Stone, W.S., 2012b. A study of trait anhedonia in non-clinical Chinese samples: evidence from the Chapman Scales for Physical and Social Anhedonia. *PLoS ONE* 7 (4), e34275.
- Chen, W.J., Hsiao, C.K., Lin, C.C., 1997. Schizotypy in community samples: the three-factor structure and correlation with sustained attention. *Journal of abnormal psychology* 106 (4), 649.
- Couture, S.M., Penn, D.L., Losh, M., Adolphs, R., Hurley, R., Piven, J., 2010. Comparison of social cognitive functioning in schizophrenia and high functioning autism: more convergence than divergence. *Psychol Med* 40 (4), 569-579.
- Crespi, B., Badcock, C., 2008. Psychosis and autism as diametrical disorders of the social brain. *Behavioral and Brain Sciences* 31 (03), 241-261.
- Dinsdale, N.L., Hurd, P.L., Wakabayashi, A., Elliot, M., Crespi, B.J., 2013a. How Are Autism and Schizotypy Related? Evidence from a Non-Clinical Population. *PLoS One* 8 (5).
- Dinsdale, N.L., Hurd, P.L., Wakabayashi, A., Elliot, M., Crespi, B.J., 2013b. How are autism and schizotypy related? Evidence from a non-clinical population. *PLoS ONE* 8 (5), e63316.
- Eack, S.M., Bahorik, A.L., McKnight, S.A., Hogarty, S.S., Greenwald, D.P., Newhill, C.E., Phillips, M.L., Keshavan, M.S., Minshew, N.J., 2013. Commonalities in social and non-social cognitive impairments in adults with autism spectrum disorder and schizophrenia. *Schizophr Res* 148 (1-3), 24-28.
- Geng, F.-l., Xu, T., Wang, Y., Shi, H.-s., Yan, C., Neumann, D.L., Shum, D.H., Lui, S.S., Cheung, E.F., Chan, R.C., 2013. Developmental trajectories of schizotypal personality disorder-like behavioural manifestations: a two-year longitudinal prospective study of college students. *BMC psychiatry* 13 (1), 1.
- Geurts, H.M., de Vries, M., van den Bergh, S.F., 2014. Executive functioning theory and autism, *Handbook of executive functioning*. Springer, pp. 121-141.
- Happé, F., Booth, R., Charlton, R., Hughes, C., 2006. Executive function deficits in autism spectrum disorders and attention-deficit/hyperactivity disorder: examining profiles across domains and ages. *Brain and cognition* 61 (1), 25-39.
- Harms, M.B., Martin, A., Wallace, G.L., 2010. Facial emotion recognition in autism spectrum disorders: a review of behavioral and neuroimaging studies. *Neuropsychology review* 20 (3), 290-322.
- Hayes, A.F., Matthes, J., 2009. Computational procedures for probing interactions in OLS and logistic regression: SPSS and SAS implementations. *Behav Res Methods* 41 (3), 924-936.
- Holmén, A., Juuhl-Langseth, M., Thormodsen, R., Ueland, T., Agartz, I., Sundet, K., Andreassen, O.A., Rund, B.R., Melle, I., 2012. Executive function in early-and adult onset schizophrenia. *Schizophrenia research* 142 (1), 177-182.
- Hurst, R.M., Nelson-Gray, R.O., Mitchell, J.T., Kwapil, T.R., 2007a. The relationship of asperger's characteristics and schizotypal personality traits in a non-clinical adult sample. *J Autism Dev Disord* 37 (9), 1711-1720.
- Hurst, R.M., Nelson-Gray, R.O., Mitchell, J.T., Kwapil, T.R., 2007b. The relationship of Asperger's characteristics and schizotypal personality traits in a non-clinical adult sample. *Journal of Autism and Developmental Disorders* 37 (9), 1711-1720.
- Klin, A., Jones, W., Schultz, R., Volkmar, F., Cohen, D., 2002. Visual fixation patterns during viewing of naturalistic social situations as predictors of social competence in individuals with autism. *Archives of general psychiatry* 59 (9), 809-816.
- Kohls, G., Chevallier, C., Troiani, V., Schultz, R.T., 2012. Social 'wanting' dysfunction in autism: neurobiological underpinnings and treatment implications. *Journal of Neurodevelopmental Disorders* 4 (1), 1.
- Korkmaz, B., 2011. Theory of mind and neurodevelopmental disorders of childhood. *Pediatric Research* 69, 101R-108R.
- Kring, A.M., Smith, D.A., Neale, J.M., 1994. Individual differences in dispositional expressiveness: development and validation of the Emotional Expressivity Scale. *Journal of personality and*

- social psychology 66 (5), 934.
- Larsson, H.J., Eaton, W.W., Madsen, K.M., Vestergaard, M., Olesen, A.V., Agerbo, E., Schendel, D., Thorsen, P., Mortensen, P.B., 2005. Risk factors for autism: perinatal factors, parental psychiatric history, and socioeconomic status. *American journal of epidemiology* 161 (10), 916-925.
- Loas, G., Noisette, C., Legrand, A., Boyer, P., 2000. Is anhedonia a specific dimension in chronic schizophrenia? *Schizophrenia bulletin* 26 (2), 495.
- Marwick, K., Hall, J., 2008. Social cognition in schizophrenia: a review of face processing. *British Medical Bulletin* 88 (1), 43-58.
- Mattila, M.-L., Hurtig, T., Haapsamo, H., Jussila, K., Kuusikko-Gauffin, S., Kielinen, M., Linna, S.-L., Ebeling, H., Bloigu, R., Joskitt, L., 2010. Comorbid psychiatric disorders associated with Asperger syndrome/high-functioning autism: A community-and clinic-based study. *Journal of autism and developmental disorders* 40 (9), 1080-1093.
- McGrath, J.J., Petersen, L., Agerbo, E., Mors, O., Mortensen, P.B., Pedersen, C.B., 2014. A comprehensive assessment of parental age and psychiatric disorders. *JAMA psychiatry* 71 (3), 301-309.
- Meyer, U., Feldon, J., Dammann, O., 2011. Schizophrenia and autism: both shared and disorder-specific pathogenesis via perinatal inflammation? *Pediatric research* 69, 26R-33R.
- Nelson, M.T., Seal, M.L., Pantelis, C., Phillips, L.J., 2013. Evidence of a dimensional relationship between schizotypy and schizophrenia: A systematic review. *Neurosci Biobehav Rev* 37 (3), 317-327.
- Peterson, C., 2014. Theory of mind understanding and empathic behavior in children with autism spectrum disorders. *Int J Dev Neurosci* 39, 16-21.
- Pilowsky, T., Yirmiya, N., Arbelle, S., Mozes, T., 2000. Theory of mind abilities of children with schizophrenia, children with autism, and normally developing children. *Schizophr Res* 42 (2), 145-155.
- Raine, A., 1991. The SPQ: a scale for the assessment of schizotypal personality based on DSM-III-R criteria. *Schizophrenia bulletin* 17 (4), 555.
- Ronald, A., Hoekstra, R., 2014. Progress in understanding the causes of autism spectrum disorders and autistic traits: twin studies from 1977 to the present day, *Behavior genetics of psychopathology*. Springer, pp. 33-65.
- Roux, P., d'Arc, B.F., Passerieux, C., Ramus, F., 2014. Is the Theory of Mind deficit observed in visual paradigms in schizophrenia explained by an impaired attention toward gaze orientation? *Schizophrenia research* 157 (1), 78-83.
- Russell-Smith, S.N., Maybery, M.T., Bayliss, D.M., 2011. Relationships between autistic-like and schizotypy traits: An analysis using the Autism Spectrum Quotient and Oxford-Liverpool Inventory of Feelings and Experiences. *Personality and Individual Differences* 51 (2), 128-132.
- Shi, Y.-f., Wang, Y., Cao, X.-y., Wang, Y., Wang, Y.-n., Zong, J.-g., Xu, T., Vincent, W., Hsi, X.-l., Stone, W.S., 2012. Experience of pleasure and emotional expression in individuals with schizotypal personality features. *PLoS ONE* 7 (5), e34147.
- Sporn, A.L., Addington, A.M., Gogtay, N., Odonez, A.E., Gornick, M., Clasen, L., Greenstein, D., Tossell, J.W., Gochman, P., Lenane, M., Sharp, W.S., Straub, R.E., Rapoport, J.L., 2004. Pervasive developmental disorder and childhood-onset schizophrenia: comorbid disorder or a phenotypic variant of a very early onset illness? *Biol Psychiatry* 55 (10), 989-994.
- Sullivan, P.F., Magnusson, C., Reichenberg, A., Boman, M., Dalman, C., Davidson, M., Fruchter, E., Hultman, C.M., Lundberg, M., Långström, N., 2012. Family history of schizophrenia and bipolar disorder as risk factors for autism. *Archives of General Psychiatry* 69 (11), 1099-1103.
- Sullivan, S., Rai, D., Golding, J., Zammit, S., Steer, C., 2013. The association between autism spectrum disorder and psychotic experiences in the Avon longitudinal study of parents and children (ALSPAC) birth cohort. *J Am Acad Child Adolesc Psychiatry* 52 (8), 806-814 e802.
- Trémeau, F., Malaspina, D., Duval, F., Corrêa, H., Hager-Budny, M., Coin-Bariou, L., Macher, J.-P., Gorman, J.M., 2005. Facial expressiveness in patients with schizophrenia compared to depressed patients and nonpatient comparison subjects. *American Journal of Psychiatry*.
- Wakabayashi, A., Baron-Cohen, S., Wheelwright, S., 2006. Are autistic traits an independent personality dimension? A study of the Autism-Spectrum Quotient (AQ) and the NEO-PI-R. *Personality and individual differences* 41 (5), 873-883.
- Wang, Y., Yeh, Y.H., Tsang, S.M., Liu, W.H., Shi, H.S., Li, Z., Shi, Y.F., Wang, Y., Wang, Y.N., Lui, S.S., Neumann, D.L., Shum, D.H., Chan, R.C., 2013. Social functioning in Chinese college students with and without schizotypal personality traits: an exploratory study of the Chinese

- version of the First Episode Social Functioning Scale. PLoS ONE 8 (5), e61115.
- Weiser, M., Reichenberg, A., Werbeloff, N., Kleinhaus, K., Lubin, G., Shmushkevitch, M., Caspi, A., Malaspina, D., Davidson, M., 2008. Advanced parental age at birth is associated with poorer social functioning in adolescent males: shedding light on a core symptom of schizophrenia and autism. *Schizophrenia bulletin* 34 (6), 1042-1046.
- Wilson, B.A., Evans, J.J., Alderman, N., Burgess, P.W., Emslie, H., 1997. Behavioural assessment of the dysexecutive syndrome. *Methodology of frontal and executive function*, 239-250.
- Woodbury-Smith, M.R., Robinson, J., Wheelwright, S., Baron-Cohen, S., 2005. Screening adults for Asperger syndrome using the AQ: A preliminary study of its diagnostic validity in clinical practice. *Journal of autism and developmental disorders* 35 (3), 331-335.

Fig. 1. (A) Visualizes the association between autistic traits and DEX total scores by plots of simple regression lines with low (−1 SD), average, and high (+1 SD) SPQ scores as moderators. (B) Visualizes the association between schizotypal traits and DEX total scores by plots of simple regression lines with low (−1 SD), average, and high AQ scores (+1 SD) as moderators. Overall, DEX total scores is increased with increasing autistic traits when SPQ scores are below 37 (figure 1A) and increased with increasing schizotypal traits when AQ score are below 33 (figure 1B). AQ: Autism Spectrum Quotient; SPQ: Schizotypal Personality Questionnaire; DEX: Dysexecutive Questionnaire.

Fig. 2. (A) Visualizes the association between autistic traits and EES total scores by plots of simple regression lines with low (−1 SD), average, and high (+1 SD) SPQ scores as moderators. (B) Visualizes the association between schizotypal traits and EES total scores by plots of simple regression lines with low (−1 SD), average, and high AQ scores (+1 SD) as moderators. Overall, EES total scores is increased with increasing autistic traits when SPQ scores are below 16 (figure 2A) and increased with increasing schizotypal traits when AQ score are below 33 (figure 2B). AQ: Autism Spectrum Quotient; SPQ: Schizotypal Personality Questionnaire; EES: Emotional Expressivity Scale.

Fig. 3. (A) Visualizes the association between autistic traits and social function scores by plots of simple regression lines with low (−1 SD), average, and high (+1 SD) SPQ scores as moderators. (B) Visualizes the association between schizotypal traits and social function scores by plots of simple regression lines with low (−1 SD), average, and high AQ scores (+1 SD) as moderators. Overall, social function scores is reduced with increasing autistic traits when SPQ scores are below 49 (figure 3A) and reduced with increasing schizotypal traits when AQ score are below 25 (figure 3B). AQ: Autism Spectrum Quotient; SPQ: Schizotypal Personality Questionnaire.

Table 1 The test-retest reliability of the AQ

	1	2	3	4	5	6	7	8	9	10	11	12
AQ total T1	1											

Table 2The test-retest reliability of the SPQ

	1	2	3	4	5	6	7	8
SPQ total T1	1							
SPQ cognitive perceptual T1	0.871**	1						
SPQ interpersonal T1	0.899**	0.642**	1					
SPQ disorganization T1	0.878**	0.676**	0.713**	1				
SPQ total T2	0.587**	0.504**	0.542**	0.497**	1			

SPQ cognitive perceptual T2	0.507**	0.538**	0.40**	0.405**	0.915**	1	
SPQ interpersonal T2	0.555**	0.404**	0.598**	0.444**	0.939**	0.771**	1
SPQ disorganization T2	0.566**	0.446**	0.503**	0.56**	0.901**	0.743**	0.807**

SPQ: the Schizotypal Personality Questionnaire; T1: time point 1; T2: time point 2; ** p<0.01; * p<0.05

Table 3 The percentages of high autistic trait and high schizotypal trait across two time points

	Time point 1		Time point 2		χ^2	p
	Low trait	High trait	Low trait	High trait		
Autistic trait n (%)	787 (91.9%)	77 (8.9%)	788 (91.2%)	76 (8.8%)	0.007	0.933
Male:Female		41:36		31:45	2.382	0.123
Schizotypal trait n (%)	768 (88.9%)	96 (11.1%)	773 (89.5%)	91 (10.5%)	0.15	0.699
Male:Female		48:48		50:41	0.458	0.499

Table 4 The percentages of co-occurring autistic trait and schizotypal trait across two time points

	Time point 1	Time point 2	χ^2	p
Low autistic and low schizotypal trait n (%)	720 (83.3%)	718 (83.1%)	1.824	0.61
High autistic and high schizotypal trait n (%)	29 (3.4%)	21 (2.4%)		
High autistic trait and low schizotypal trait n (%)	48 (5.6%)	55 (6.4%)		
Low autistic trait and high schizotypal trait n (%)	67 (7.8%)	70 (8.1%)		

Table 5 The hierarchical regression analyses on the associations between autistic and schizotypal traits and executive function, emotion and social function at time point 1.

		R ²	R ² _{change}	F _{change}	Beta	P
DEX total scores						
Model1	Gender	0.001	0.001	0.579	0.026	0.447
Model2	Gender	0.382	0.381	264.747**	0.030	0.265
	AQ total scores				0.264	0.000
	SPQ total scores				0.453	0.000
Model3	Gender	0.395	0.013	18.863***	0.028	0.301
	AQ total scores				0.261	0.000

	SPQ total scores				0.499	0.000
	AQ total scores×SPQ total scores				-0.124	0.000
	TEPS total scores					
Model1	Gender	0.064	0.064	58.668***	0.253	0.000
Model2	Gender	0.106	0.043	20.463***	0.230	0.000
	AQ total scores				-0.232	0.000
	SPQ total scores				0.108	0.003
Model3	Gender	0.107	0.000	0.320	0.230	0.000
	AQ total scores				-0.232	0.000
	SPQ total scores				0.115	0.003
	AQ total scores×SPQ total scores				-0.019	0.572
	EES total scores					
Model1	Gender	0.016	0.016	14.301***	0.128	0.000
Model2	Gender	0.157	0.141	71.299***	0.119	0.000
	AQ total scores				0.056	0.113
	SPQ total scores				.347	.000
Model3	Gender	0.162	0.005	4.720*	0.118	0.000
	AQ total scores				0.054	0.123
	SPQ total scores				0.374	0.000
	AQ total scores×SPQ total scores				-0.073	0.030
	Social function total scores					
Model1	Gender	0.011	0.011	8.850**	-0.103	0.003
Model2	Gender	0.220	0.209	109.529**	-0.127	0.000
	AQ total scores				-0.350	0.000
	SPQ total scores				-0.177	0.000
Model3	Gender	0.227	0.007	7.477**	-0.125	0.000
	AQ total scores				-0.349	0.000
	SPQ total scores				-0.210	0.000
	AQ total scores×SPQ total scores				0.090	0.006

Note: DEX: Dysexecutive Questionnaire; TEPS: Temporal Experience of Pleasure Scale;

EES: Emotional Expressivity Scale. *: <0.05; **<0.01; ***<0.001

Highlights

- The co-occurrence rate of autistic and schizotypal trait was 3.4% at baseline and 2.4% at one year follow-up.
- There were opposing moderating effects of co-occurring autistic and schizotypal traits between groups with low and high autistic and low and high schizotypal traits.
- Individuals with both high autistic and high schizotypal traits showed significantly more impairments in executive function and social functioning, but better emotion expression.

