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Subjective awareness of everyday dysexecutive behavior precedes 'objective' executive problems in schizotypy: A replication and extension study

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ABSTRACT

This study aimed to examine the subjective awareness of everyday dysexecutive function and the 'objective' executive function in individuals with schizotypal personality features. Forty-nine individuals with schizotypal personality disorder (SPD) proneness (25 negative schizotypy and 24 non-negative schizotypy were identified using cluster analysis) and 44 non-SPD individuals completed a battery of 'objective' executive function tests and a self-reported Dysexecutive Questionnaire (DEX) on everyday executive problems. The findings showed that individuals with SPD proneness including negative schizotypy and non-negative schizotypy did not have significant worse performance than non-SPD in most of 'objective' executive function tests, but self-reported significantly disproportionate more dysexecutive problems than non-SPD. Furthermore, SPD proneness, especially negative schizotypy was found to give undependable estimation on their everyday dysexecutive function while non-negative schizotypy was not. The current findings suggest that the subjective awareness of dysexecutive function may precede actual 'objective' executive function impairments in a subtype of SPD (non-negative schizotypy) and the subjective complaint of the daily dysexecutive behavior in SPD proneness, especially negative schizotypy might result from their unreliable estimation of executive function.

1. Introduction

Executive function is a comprehensive term (see review in Chan et al., 2008a) and is fractionalized into several components by Chan and Toulopoulou (2006): initiation, sustained attention, online updating, switching and flexibility, inhibitions, attention allocation and planning. Usually, we consider the capacity captured by some operational assessments as "objective executive function". These assessments could be Wisconsin Card Sorting Test (WCST, Nelson, 1976), Trials Making Test (TMT, Reitan and Wolfson, 1995), Verbal Fluency Test (VFT, Spreen and Strauss, 1991), Sustained Attention to Response Task (SART, Robertson et al., 1997), Visual Pattern Test (VPT, Della Sala et al., 1999), Hayling Sentence Completion Test (Burgess and Shallice, 1996) and so on. On the other hand, subjective complaint of executive function is widely assessed by a self-rating scale, namely the Dysexecutive Questionnaire (DEX) (Chan et al., 2008b; Evans et al., 1997; Laws et al., 2008; Wilson et al., 1996)

Previous substantial studies in schizophrenia have demonstrated that the illness is associated with impairment on 'objective' executive functions in both chronic patients (Chan et al., 2006a; Elliott et al., 1995; Heinrichs and Zakzanis, 1998; Mahurin et al., 2006; Remillard et al., 2005; Silver and Goodman, 2007) and first-episode medication naïve patients (Chan et al., 2006b; Hutton et al., 1998), but with a relatively normal level of subjective complaints of dysexecutive function (Chan et al., 2008b; Evans et al., 1997). As part of schizophrenia spectrum disorder, schizotypal personality disorder displays many similar but minor problems (Raine, 2006; Siever and Davis, 2004). Finding out the mechanism of executive function in SPD may aid to comprehending the feature of executive function in schizophrenia spectrum disorder. As to 'objective' executive functions in participants with schizotypal personality features, results are inconsistent, some studies found 'objective' executive impairments in executive function (Avons et al., 2003; Gooding et al., 2001; Suhr and Spitznagel, 2001), while some studies did not find 'objective'

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executive impairments in this population (Chan et al., 2008b; Jahshan and Sergi, 2007; Laws et al., 2008; Spitznagel and Suhr, 2002). And it is also not clear on the subjective complaint of executive function in individuals with schizotypal personality feature (Chan et al., 2008b; Laws et al., 2008). Therefore, it is worth elucidating the executive function in schizotypal personality disorder in terms of both objective and subjective assessments.

Chan et al. (2008b) found that the SPD proneness group demonstrated more subjective complaints of everyday dysexecutive behavior and prospective memory deficits than the healthy control despite their normal performance on objective executive function. Furthermore, Laws et al. (2008) found that, while there were no significant differences between high and low SPD feature scorers in 'objective' executive functions, high SPD scorers reported significantly more everyday dysexecutive functions than low SPQ scorers. They also found that these subjective complaints of dysexecutive functions were significantly associated with the disorganization and cognitive-perceptual features of the Schizotypal Personality Questionnaire-Brief version (SPQ) (Raine and Benishay, 1995). These authors thus suggested that awareness of everyday executive difficulties precedes overt executive dysfunction in schizotypal subjects.

However, it should be noted whether the subjective complaint is associated with 'objective' executive function tests in individuals with schizotypal feature, because it may be on account of the reliability of their subjective complaint of dysexecutive behavior. In other words, if subjective complaint is linked to 'objective' tests in individuals with SPD proneness, it could be inferred that they have been experiencing what they complained about; otherwise, then it could be inferred that what they self-reported is not reliable. In the current study, we further investigated the relationship between subjective complaint and objective tests.

Moreover, it is widely acknowledged that schizotypy can be decomposed into some dissociable subtypes (Claridge et al., 1996; Raine, 2006; Raine et al., 1994) including the dimension of positive and negative schizotypy. Positive schizotypy refers to schizotypal dimension closely associated with ideational experience, perceptual experience or magical thinking, while negative schizotypy refers to the one dimension link to anhedonia, social anxiety or lack of close friend (Suhr and Spitznagel, 2001; Williams, 1994). Some studies suggested that negative schizotypy and positive schizotypy are two discrepant subtypes which link to the different patterns of cognition problems (Dinn et al., 2002; Sarkin et al., 1998; Shrira and Tsakanikos, 2009), and negative schizotypy was specifically found to be associated with 'objective' executive function deficit such as sustained attention (Barrantes-Vidal and Obiols, 2000) and executive function (Dinn et al., 2002; Suhr and Spitznagel, 2001). However, little is known about the subjective complaint, 'objective' executive function and their relationship in schizotypal subtypes. Several studies obtained distinct schizotypal sub-groups including positive and negative schizotypy by using cluster analysis (Suhr and Spitznagel, 2001; Williams, 1994). Therefore, in the current study we adopted cluster analysis to acquire schizotypal subtypes.

In the current study, we aimed to: 1) test whether individuals with SPD proneness including schizotypy subtypes complained more about their everyday dysexecutive function but displayed a normal level of 'objective' executive function; 2) verify the relationship between subjective and objective executive functions in SPD proneness including schizotypy subtypes.

2. Method

2.1. Participants

2.1.1. Participants with schizotypal personality disorder proneness

Forty-nine participants with schizotypal personality disorder (SPD) proneness were recruited from 600 community people and college students. The participants were screened using Schizotypal Personality Questionnaire (SPQ, Chen et al., 1997; Raine, 1991). According to the scoring criteria suggested by Raine (1991), the participants whose score were in the top 10th percentile of the score distribution were considered as SPD proneness. The other inclusion criteria of this group: no history of psychiatric illness, no first-degree relatives with psychiatric illness, no history of neurological illness, and no history of drug/alcohol dependence. Fifty-six approached, and 7 declined. Thus 49 participants with schizotypal personality feature were included into further analysis. In order to obtain schizotypal subtypes, we conducted a hierarchical and then a K-means cluster analysis in 49 individuals with schizotypal feature on the factor scores of SPQ, including cognitive-perceptual, interpersonal and disorganization factors. There were two reasons we elect to use a two-cluster model in the cluster analysis. Firstly, positive and negative schizotypy was consistently obtained in the prior researches by using cluster analysis (Suhr and Spitznagel, 2001; Williams, 1994); secondly, the results of hierarchical cluster analysis (Ward Method) in the current research also suggested two clusters in individuals with schizotypal personality feature. In this sample, cluster 1 consisting of 24 subjects, scored lower on interpersonal factor than cluster 2, but scored similar as cluster 2 did on cognitive-perceptual and disorganization factors. Cluster 2 consisted of 25 subjects who scored higher on interpersonal factor score than cluster 1, but scored similar as cluster 1 did on cognitive-perceptual and disorganization factors (ANOVA between two clusters: interpersonal factor: $F(1, 47) = 120.11$, $P < 0.001$; cognitive-perceptual and disorganization factors: both $Ps > 0.05$). Since interpersonal factor was related to negative schizotypy (Suhr and Spitznagel, 2001), clusters 1 and 2 were named as non-negative schizotypy and negative schizotypy based on their interpersonal factor scores, respectively. Partially not as we expected, we did not obtain a positive schizotypy cluster in this sample. So in the current study, we just investigate non-negative and negative schizotypy.

2.1.2. Non-SPD participants

Forty-four healthy participants were recruited from community people and college students, their SPQ score were in the low 10th percentile of distribution. These participants fulfilled the following criteria: no history of psychiatric illness, no first-degree relatives with psychiatric illness, no history of neurological illness, and no history of drug/alcohol dependence. Fifty approached, and 6 declined.

Intellectual function was estimated for all participants by conducting the short form (information, arithmetic, similarity, and digit span) of the Chinese version of the Wechsler Adult Intelligence Scale-Revised (WAIS-R, Gong, 1992). This study was approved by the ethical committee of the Institute of Psychology, Chinese Academy of Sciences. See the demographic details in Table 1.

2.2. Assessment

2.2.1. Schizotypal personality screening scale

Schizotypal Personality Questionnaire (SPQ, Raine, 1991) was used to screen the participants with SPD features. SPQ was a 74 item dichotomous (yes–no) questionnaire. This questionnaire was shown to have good psychometric properties and taps three main factors of schizotypal personality: cognitive-perceptual, interpersonal, and disorganization. Several researches found significant correlation of SPQ with subjectively and objectively executive functions (Chen et al., 1997; Laws et al., 2008). The Chinese version was used in the current study (Chan et al., submitted for publication; Chen et al., 1997).

2.2.2. Subjective assessment of executive function

The self-rated Dysexecutive Questionnaire (DEX, Wilson et al., 1996) was adopted to assess subjective complaints of everyday life executive function. The DEX asked the participants to rate the frequency of certain dysexecutive behaviors. It consisted of 20 items (i.e. I can't understand what others are talking about unless they express their opinion simply and directly; I have difficulties in planning for the future; I talk in one way but act in another; I sometimes act without thinking, doing the first thing that comes to mind; I am unconcerned about how I should behave in certain situations…); each was scored on a 5-points scale, ranging from 'never' to 'very often' (0–4), with a higher score indicating a higher frequency of dysexecutive behavior in everyday life. In Burgess's study, the factor analysis indicated that informant rated DEX consists of five factors: inhibition, intentionality, executive memory, positive affect, and negative affect (Burgess et al., 1998). Chan (2001) conducted an exploratory factor analysis of a DEX informant report in Chinese participants and also suggested a 5-factor solution very similar to the factors derived from the Burgess' study: inhibition, intentionality, knowing–doing dissociation, in-resistance, and social regulation. Given that we adopted the Chinese version of the DEX (Chan, 2001), we used Chan's 5-factor structure in the current study.

2.2.3. Objective assessment of executive function

The Verbal Fluency Test (Spreen and Strauss, 1991) was used to assess one's initiation ability and verbal response component of executive function. In this test, participants were asked to say as many animal names as possible in 1 min. The number of correct items was recorded.

The Hayling Sentence Completion Test (Parts A and B) (Burgess and Shallice, 1996) was used to assess one's initiation and semantic response suppression ability. This test consists of two sections (A and B) of 15 sentences each, in which the last word is missing. In section A, participants were asked to complete the sentences with one word; and in section B, participants were asked to complete the sentences with a word semantically irrelevant to the sentence. There were two types of errors in part B, error A means to

Table 1
Demographic and clinical data of non-SPD and SPD proneness group.

	Non-SPD proneness ($N=44$)		SPD proneness ($N=49$)						t/χ^2	P	F/χ^2	P
	Mean	S.D.	Overall ($N=49$)		Non-negative ($N=24$)		Negative ($N=25$)					
			Mean	S.D.	Mean	S.D.	Mean	S.D.				
Age	28.77	10.92	21.06	4.88	21.08	4.92	21.04	4.93	4.313	<0.001	9.891	<0.005
Education (years)	13.05	2.27	13.59	1.32	13.54	1.56	13.64	1.08	−1.397	0.167	1.036	0.359
IQ	103.34	17.60	98.57	18.90	103.54	19.44	93.80	17.44	1.255	0.213	2.595	0.080
Gender (male:female)	18:26		30:19		12:12		18:7		3.831	0.05	6.204	0.045
SPQ cognitive-perceptual factor	9.50	4.32	18.67	4.00	18.17	3.16	19.16	4.68	−10.635	<0.001	56.708	<0.005
SPQ interpersonal factor	7.91	4.32	17.59	5.22	13.13	3.05	21.88	2.52	−9.688	<0.001	119.808	<0.005
SPQ disorganization factor	4.02	2.22	10.41	3.01	10.42	2.65	10.40	3.37	−11.550	<0.001	65.967	<0.005
SPQ total score	19.70	7.23	42.63	7.40	38.29	5.34	46.80	6.73	−15.084	<0.001	147.516	<0.005

Note: The dichotic data was tested by χ^2 test. t/χ^2 refers to the value of T test or the chi-square between non-SPD proneness and SPD proneness; F/χ^2 refers to the results of ANOVA analysis among non-SPD, non-negative schizotypy, and negative schizotypy.
SPD = schizotypal personality disorder; SPQ = Schizotypal Personality Questionnaire. SPQ factor includes cognitive-perceptual, interpersonal, and disorganization factors.

complete the sentence with a semantically correct word; error B means to complete the sentence with a word not semantically correct but somewhat relevant. The numbers of correct items completed and reaction time in Hayling test part A were recorded to assess the initiation of executive function while the total numbers of errors A and error B committed and reaction time in Hayling test part B were recorded to measure inhibition components of executive function.

The Sustained Attention Response to Task (SART, Robertson et al., 1997) was function. In the test, the participants were asked to respond to numbers 1–9 except "3" presented at the centre of the screen by pressing the left key of the mouse. Number of correct responses and commission errors (press to the digit "3") were recorded which reflect the level of sustained attention and inhibition, respectively.

The modified Wisconsin Card Sorting Test (WCST, Nelson, 1976) was adopted to assess the executive function, and the number of perseverative errors and categories were recorded to measure switching and flexibility component and attention allocation and planning of executive function.

2.3. Procedure

SPQ was used for screening participants, so it was completed first, after selecting and approaching the participants, the procedure are as follows. The participants were given a general introduction of the study and they had a chance to ask questions, written informed consent was signed before the tests began. IQ subscales were administered to each participant first, and the executive function tests including verbal fluency test, Hayling Sentence Completion Test (Part A and B), SART, and WCST were administered to the participants in a random order. Finally all the participants completed DEX.

2.4. Data analysis

Firstly, we tested whether the performances of objective and subjective measures were significantly different between SPD proneness and non-SPD proneness. Considering the significant difference of age between these two groups (t (91) = 9.891, $P<0.005$), MANCOVA was used to compare the performance of 'objective' executive function tests and DEX scores between groups with age as a covariate. Secondly, we tested the same performances among negative schizotypy, non-negative schizotypy, and non-SPD proneness. Viewing that age (F (2, 90) = 9.819, $P<0.001$) was significantly different among the three groups, this variable was also controlled in the subsequent analysis. Although gender ratio was different among three groups ($\chi^2 = 6.204$, $P = 0.045$), the results of MANCOVA with gender ratio as a control variable did not display an effect on all the performances (all Ps > 0.05). So only the age was controlled in the MANCOVA. Mean comparison of LSD test was used in further group pair wise comparison. We also calculated the effect size by using Cohen's d to illustrate the strength of differences among groups.

To further investigate the relationship between subjective awareness of dysexecutive behavior and 'objective' executive functions as well as between subjective awareness of dysexecutive function and schizotypal traits, we did partial correlation analysis between DEX factor scores (inhibition, intentionality, knowing–doing dissociation, in-resistance and social regulation), DEX total score, SPQ total score and 'objective' executive function performances with age controlled in the non-SPD group, SPD proneness group, non-negative SPD group and negative SPD group separately.

3. Results

3.1. Comparison of subjective and 'objective' executive functions

For non-SPD vs. SPD proneness group comparison, MANCOVA analysis to 'objective' executive function tests revealed no significant difference of most 'objective' executive function tests between SPD proneness and non-SPD proneness groups (all but Hayling A reaction time, Ps > 0.05; for Hayling A reaction time, $P = 0.049$, Cohen's $d = 0.31$). MANCOVA (five DEX factor scores and total DEX scores as dependent variables) revealed a significant group effect, with the SPD proneness group self-reporting more serious dysexecutive problems than non-SPD proneness groups (all Ps < 0.05) (see Table 2).

MANCOVA was also used to compare the performance of 'objective' executive function tests and DEX scores among negative schizotypy, non-negative schizotypy and non-SPD proneness. It also revealed no significant difference of 'objective' executive function tests but significant difference of DEX factors and total scores among three groups. For negative subtype of SPD proneness, post-hoc analysis demonstrated that individuals with negative schizotypy complained more dysexecutive function (all but social regulation factor, Ps < 0.05) than non-SPD proneness despite most of their normal 'objective' executive function (all but Hayling A reaction time, Ps > 0.05; for Hayling A reaction time, $P = 0.048$, Cohen's $d = 0.38$). For non-negative subtype of SPD proneness, post-hoc analysis revealed no significant difference of all 'objective' executive function (all Ps > 0.05) but significant difference of DEX factors and total scores (all Ps < 0.05) between individuals with non-negative SPD proneness and non-SPD proneness.

We also used the explore method to test the normality of all executive functions including subjective and 'objective' executive functioning test performances, and found many of them to be non-normal distributed (such as WCST perseverative error and category; SART correct response; Hayling test A correct, reaction time, Hayling test B error A + B, reaction time; DEX factor inhibition, in-resistance, and social regulation; Ps < 0.05 across non-SPD, SPD proneness, negative SPD and non-negative SPD). Viewing this, 2-independent-sample and k-independent-sample non-parameter-test were used to further test the effect of schizotypal feature on executive function between overall SPD proneness and non-SPD and among negative SPD, non-negative SPD and non-SPD, respectively, and they revealed similar results as the MANCOVA analysis above. Since the non-parametric method can not control for covariates, we just present the results of the MANCOVA analysis here.

3.2. Correlation between subjective and objective executive functions

Partial correlation analysis with age controlled was conducted to examine the relationship between DEX scores and 'objective' executive function performance as well as between DEX scores and SPD total score in the non-SPD group and SPD proneness group.

For the non-SPD proneness group, intentionality, in-resistance factor scores and total score of DEX were related to the correct

Table 2
Comparison of 'subjective' and 'objective' executive functions between non-SPD and SPD proneness groups with age controlled.

	Non-SPD proneness ($N=44$)		SPD proneness ($N=49$)						F^*	P	$F^\#$	P	Cohen's d			
	Mean	S.D.	Overall ($N=49$)		NonNeg ($N=24$)		Neg ($N=25$)						Non_SPD vs.SPD	Non_SPD vs.NonNeg	Non_SPD vs.Neg	NonNeg vs.Neg
			Mean	S.D.	Mean	S.D.	Mean	S.D.								
Verbal fluency correct	18.66	4.6	19.41	5.68	20.17	5.68	18.68	5.7	0.111	0.74	0.554	0.58	0.14	0.3	0.004	0.26
WCST perseverative error	2.7	4.08	2.78	3.55	2.17	2.66	3.36	4.21	2.329	0.13	1.849	0.16	0.02	0.15	0.16	0.34
WCST category	4.98	1.47	4.92	1.68	5.17	1.01	4.68	2.14	1.389	0.24	1.31	0.28	0.04	0.14	0.17	0.29
SART correct response	0.97	0.05	0.98	0.04	0.99	0.02	0.97	0.05	0.001	0.98	1.504	0.23	0.2	0.5	0.03	0.52
SART commission error	0.39	0.25	0.33	0.2	0.38	0.2	0.29	0.2	2.28	0.13	2.287	0.11	0.24	0.03	0.44	0.49
Hayling A RT (s)	28.92	12.2	33.59	17.6	32.27	15.16	34.85	19.9	3.981	0.049	2.155	0.12	0.31	0.25	0.38	0.15
Hayling A correct	14.61	0.75	14.36	1.62	14.5	0.66	14.24	2.2	0.114	0.74	0.303	0.74	0.19	0.16	0.26	0.16
Hayling B RT (s)	48.49	34.69	51.55	41.16	50.61	48.72	52.45	33.35	2.51	0.12	1.26	0.29	0.08	0.05	0.12	0.04
Hayling B error A + B	4.48	4.18	4.14	4.1	4.42	4.37	3.88	3.89	0.719	0.4	0.464	0.63	0.08	0.01	0.15	0.13
DEX_inhibition	5.3	2.95	8.43	2.94	8.54	3.26	8.32	2.66	16.974	<0.001	8.434	<0.001	1.07	1.06	1.06	0.07
DEX _intentionality	5.8	2.95	8.47	2.69	8.25	2.64	8.68	2.78	11.789	0.001	5.991	0.004	0.95	0.86	1	0.16
DEX _knowing–doing dissociation	4.36	2.66	6.8	2.81	6.54	2.3	7.04	3.25	10.338	0.002	5.338	0.01	0.89	0.86	0.93	0.18
DEX _in-resistance	3.77	1.95	4.98	1.61	5.25	1.51	4.72	1.7	6.802	0.01	3.946	0.02	0.68	0.82	0.51	0.33
DEX _social regulation	2.41	1.39	3.04	1.19	3.25	1.15	2.84	1.21	4.308	0.04	2.777	0.07	0.49	0.64	0.32	0.35
DEX self report total score	23.55	10.69	34.84	9.83	34.92	9.07	34.76	10.71	17.245	<0.001	8.529	<0.001	1.1	1.12	1.05	0.02

Note: *: the difference between non-SPD and SPD proneness groups; #: the difference among non-SPD, non-negative schizotypy, and negative schizotypy.
VFT_Correct = verbal fluency test correct number of response; WCST = Wisconsin Card Sorting Test; SART = Sustained Attention Response Test; Hayling A = Hayling Sentence Completion Test part A; Hayling B = Hayling Sentence Completion Test part B; DEX = Dysexecutive Questionnaire, DEX factors include: inhibition, intentionality, knowing–doing dissociation, in-resistance and social regulation; SPD = Schizotypal Personality Disorder. Non-neg = non-negative schizotypy; Neg = Negative schizotypy; SPD = Schizotypal personality disorder proneness.

response in SART. And inhibition factor score of DEX was linked to reaction time and the total number of error A and error B in Hayling test B. No significant correlations between SPQ total score and DEX factor and total score were found. For the SPD proneness group, however, no significant correlations were found between DEX scores and 'objective' executive function. Self-reported features of schizotypal personality were significantly linked to intentionality and the knowing–doing disassociation factor of DEX in the SPD proneness group (see Table 3).

Partial correlation with age controlled was also conducted across negative schizotypy and non-negative schizotypy groups. No significant correlations were found between DEX scores and some 'objective' executive functions in the negative schizotypy group, but in the non-negative schizotypy group, there were some significant correlations between DEX scores and 'objective' executive functions. Further analysis in the subtype of SPD proneness group only revealed significant relationships between SPQ total scores and inhibition factor of DEX in the negative schizotypy group (see Table 4).

4. Discussion

One of the main findings of the current study was that individuals with SPD proneness, including negative schizotypy and non-negative schizotypy did not perform significantly worse than the non-SPD controls on most of 'objective' executive function tests. However, individuals with SPD proneness and its two subtypes reported

Table 3
Partial correlations among neurocognitive functional performance, DEX scores, and SPQ scores in non-SPD and SPD proneness groups.

	Non-SPD						SPD proneness					
	DEX						DEX					
	Inhibition	Intentionality	Knowing–doing dissociation	In-resistance	Social regulation	Total	Inhibition	Intentionality	Knowing–doing dissociation	In-resistance	Social regulation	Total
VFT_Correct	−0.241	−0.339	−0.227	−0.182	**−0.341***	**−0.344***	0.085	−0.247	0.028	0.145	0.071	0.008
WCST_PE	0.074	0.103	0.155	0.164	−0.028	0.13	−0.068	0.212	0.102	0.181	0.018	0.081
WCST category	−0.027	−0.175	−0.089	−0.043	0.099	−0.084	0.038	−0.162	−0.035	−0.091	0.036	−0.036
SART_CR	−0.208	**−0.332***	−0.179	**−0.394****	−0.25	**−0.346***	0.04	−0.131	−0.083	0.135	0.088	−0.027
SART_CE	0.047	0.163	0.143	0.141	0.164	0.151	−0.054	−0.17	−0.034	−0.104	−0.031	−0.093
Hayling A RT (s)	0.004	−0.036	−0.019	−0.001	0.048	−0.006	−0.215	−0.030	−0.174	−0.091	−0.092	−0.175
Hayling A correct	−0.231	−0.046	−0.009	−0.148	−0.14	−0.166	−0.19	−0.217	−0.184	−0.115	−0.093	−0.231
Hayling B RT (s)	**0.308***	0.204	0.257	0.058	0.172	0.222	−0.012	0.013	−0.057	−0.135	−0.050	−0.045
Hayling B error A + B	**0.312***	0.182	0.24	0.06	0.14	0.235	0.09	0.131	0.005	−0.035	0.067	0.075
SPQ total	−0.056	0.024	0.03	0.067	0.033	0.007	0.177	0.319*	0.323*	0.065	−0.005	0.259

Note: VFT_Correct = verbal fluency test correct number of response; WCST_PE = perseverative error of Wisconsin Card Sorting Test; SART CR = Correct response of Sustained Attention Response Task; SART_CE = Commission error of Sustained Attention Response Task; DEX = Self-Rated Dysexecutive Questionnaire; SPQ = Schizotypal Personality Questionnaire. Those correlation coefficients with p-value less than 0.05 were set in bold.
* $P<0.05$.
** $P<0.01$.

Table 4
Partial correlations among objective executive functional performance, DEX scores, and SPQ scores in negative and non-negative schizotypy groups.

	Non-Negative schizotypy						Negative schizotypy					
	DEX						DEX					
	Inhibition	Intentionality	Knowing–doing dissociation	In-resistance	Social regulation	Total	Inhibition	Intentionality	Knowing–doing dissociation	In-resistance	Social regulation	Total
VF_Correct	−0.11	**−0.418***	−0.078	0.195	0.159	−0.154	0.174	−0.146	0.009	−0.075	−0.16	0.012
WCST_PE	−0.09	0.094	0.08	**0.479***	−0.117	0.038	−0.016	0.28	0.124	0.126	0.18	0.142
WCST category	−0.042	−0.141	−0.269	**−0.517***	−0.011	−0.181	−0.008	−0.201	−0.015	−0.076	−0.059	−0.066
SART_CR	0.052	0.051	0.168	0.204	0.179	0.145	−0.133	−0.247	−0.283	−0.113	−0.136	−0.242
SART_CE	−0.176	−0.289	−0.078	−0.158	−0.105	−0.221	0.074	−0.032	0.045	−0.141	−0.043	0.01
Hayling A RT (s)	−0.170	−0.048	−0.296	−0.396	−0.155	−0.265	−0.201	−0.008	−0.061	0.225	0.035	−0.059
Hayling A correct	0.047	−0.322	−0.107	−0.26	0.212	−0.078	−0.352	−0.218	−0.224	−0.138	−0.228	−0.315
Hayling B RT (s)	0.038	0.003	−0.063	−0.209	0.039	−0.035	−0.036	0.041	−0.011	0.019	−0.119	−0.007
Hayling B error A + B	0.312	0.272	0.258	0.045	0.359	0.329	−0.112	0.032	−0.109	−0.036	−0.175	−0.073
SPQ total	0.034	0.359	0.251	0.061	0.027	0.227	0.416*	0.314	0.342	0.237	0.138	0.351

Note: VFT_Correct = verbal fluency test correct number of response; WCST_PE = Wisconsin Card Sorting Test perseverative error; SART CR = Correct response of Sustained Attention Response Task; SART_CE = Commission error of Sustained Attention Response Task; DEX = Self-Rated Dysexecutive Questionnaire; SPQ = Schizotypal Personality Questionnaire. Those correlation coefficients with *p*-value less than 0.05 were set in bold.
* $P<0.05$.

significantly more disproportionate dysexecutive problems than the controls. The effect sizes of these differences on subjective complaint range from modest to very large (SPD proneness vs. non-SPD proneness (0.49–1.07); negative schizotypy vs. non-SPD (0.32–1.06); non-negative schizotypy vs. non-SPD (0.64–1.12)), as reflected in the total score and all five factor scores of the DEX. The other main finding revealed some significant correlations between the subjective complaint of dysexecutive behavior and the objective performance of executive function in non-SPD proneness and non-negative schizotypy, but no significant correlations between these two measurements in individuals with SPD proneness, especially negative schizotypy.

In the current study, we found no differences on most of 'objective' executive tasks between the SPD proneness group and the non-SPD group. For reaction time in Hayling test A even though the *P* value was 0.049 (SPD proneness vs. non-SPD proneness), the effect size was small (Cohen's $d = 0.31$) according to Cohen's criteria (Cohen, 1988). Moreover, we also found similar results in individuals with negative schizotypy compared with non-SPD proneness, most 'objective' executive tasks were non-significant between negative schizotypy and non-SPD but for Hayling A reaction time ($P = 0.048$, Cohen's $d = 0.38$). It should be noted that individuals with negative schizotypy had a relatively lower IQ than non-SPD proneness ($P = 0.08$) in the current study. Given the evidence that executive function is related with IQ in the patients with schizophrenia, especially with regard to specific symptom-based syndromes (Dibben et al., 2009; Laws, 1999). In the analysis of MANCOVA controlling for the age and IQ, no difference of 'objective' executive function was found between non-SPD proneness and negative schizotypy. For another subtype of schizotypy, individuals with non-negative schizotypy displayed no problems on 'objective' executive tasks but subjectively complained more dysexecutive problems compared with individuals with non-SPD. Although partially inconsistent with some of the prior studies (Avons et al., 2003; Daneluzzo et al., 1998; Gooding et al., 2001; Suhr, 1997; Suhr and Spitznagel, 2001), this finding in our study was consistent with some other prior studies which found evidence of no 'objective' executive function problems in SPD proneness (Chan et al., 2008b; Jahshan and Sergi, 2007; Laws et al., 2008; Spitznagel and Suhr, 2002). As Laws and his associations mentioned, the disassociated findings may reflect the larger reliance of WCST and perseverative assessments (Laws et al., 2008). And also it should be noted that the executive function is not restricted to the perseverative measures from WCST (Chan and Toulopoulou, 2006; Laws, 1999). In this case, we adopted a wide range of 'objective' executive assessments (i.e. WCST, VFT, SART, and Hayling Sentence Completion test) to measure the components of executive function including switching and flexibility, attention allocation and planning, initiation, sustained attention, and inhibition, but almost none of which was found to be significantly different among groups. It suggested that 'objective' executive function might be intact in individuals with schizotypal feature.

Another possibility that warranted discussion is whether subjective awareness of everyday dysexecutive behavior precedes the emergence of 'objective' executive function in schizotypy. In our study, it was found that individuals with SPD proneness subjective complained of everyday dysexecutive behavior which was consistent with prior studies (Chan et al., 2008b; Laws et al., 2008). However, before the arrival at the conclusion that awareness of problems precedes the 'objective' impairment in schizotypy, it is necessary to firstly elucidate whether the estimation was reliable or not through the relationship between subjective complaint and objective executive function because it is the prerequisite for that conclusion above. If estimation in schizotypy was reliable, it could arrive at the conclusion that subjective awareness of dysexecutive function may exist before the deterioration of 'objective' executive function in SPD proneness. If it is not the case, it may be more reasonable to conclude that the subjective complaint of individuals with SPD proneness might be unreliable with underestimating their executive function and the problems of awareness itself might precede the 'objective' executive malfunction. In our study, we found some significant correlations between subjective complaint and 'objective' executive tests in non-SPD proneness (i.e. the inhibition DEX factor score was significantly associated with inhibition component measured by Hayling test B; the intentionality and in-resistance DEX factor score were linked to the sustained attention assessed by SART), but no significant correlations in the SPD proneness group. It could be inferred that individuals with non-SPD proneness gave a dependable evaluation on components of executive function such as inhibition and sustained attention and their awareness itself might be partially good. However, individuals with SPD proneness did not give a reliable estimation on all components assessed in the current study and their awareness itself might be somewhat poor. In short, the subjective complaint of everyday dysexecutive behavior in SPD proneness could not represent a reliable source for estimating their executive function. Partially

inconsistent with the findings in Laws et al. (2008), it is implied in the current study that maybe it was not self-awareness of everyday dysexecutive behavior but the problem of awareness itself precedes the 'objective' executive function impairment in SPD proneness.

Interestingly, the subtypes of schizotypy displayed discrepant relationships. For non-negative schizotypy, we found some significant correlations between DEX scores and 'objective' executive function tests, i.e. in-resistance DEX factor score was associated with the performances of WCST which is consistent with prior study indicating that this factor was correlated with mental flexibility and error commission in a non-clinical sample (Chan, 2001). Therefore, it is suggested that estimation was partially reliable in this subtype and heightened subjective awareness of dysexecutive behavior may appear in non-negative schizotypy which was parallel to prior findings in Laws and his colleagues' research. They suggested that an enhanced self-awareness of executive behavioral problems may precede the onset of clear deficits on executive tests themselves (Laws et al., 2008). For negative schizotypy, no significant correlations were found between 'objective' and 'subjective' complaints of executive function, which was not the same as the finding in individuals with non-SPD proneness. And it revealed the relatively undependable evaluation and somewhat poor awareness itself into executive function in this subtype. Although the IQ is correlated with the performances of executive function in patients with schizophrenia (Dibben et al., 2009; Laws, 1999), no significant correlations were found even controlling for the IQ in negative schizotypy (all $Ps > 0.05$). In the current study, it is suggested that the problems of awareness itself might precede their 'objective' function in negative schizotypy. Two reasons were listed below which might explain the implication in negative schizotypy above. On the one hand, as part of schizophrenia spectrum disorder, schizotypal personality disorder displays many similar but minor problems (Raine, 2006; Siever and Davis, 2004) and negative schizotypy is found to be related with the increased risk to schizophrenia (Schürhoff et al., 2005). Since insight or awareness itself into neurocognition was found to be impaired in patients with schizophrenia (Medalia and Thysen, 2008; Medalia et al., 2008), individuals with SPD, especially negative schizotypy might display, although in a reverse pattern, minor problems of self-awareness into their executive function overestimating their executive problems. On the other hand, negative schizotypy is characterized as asocial behavior and construct affect (Claridge et al., 1996), which might lead to their underestimation or hypervigilant to their executive function (Bruce et al., 2007). Meanwhile, the problems of awareness itself in SPD and negative dimension of schizotypy are found to be related to the impairment of executive function, which might give rise to a vicious circle on their executive function (Lysaker et al., 1998; Lysaker et al., 2003).

Unlike many previous studies in the patients with schizophrenia (Chan et al., 2006a; Elliott et al., 1995; Heinrichs and Zakzanis, 1998; Mahurin et al., 2006; Remillard et al., 2005; Silver and Goodman, 2007), no evidence were found that 'objective' executive function was impaired in SPD proneness and subtypes in the current study. However, individuals with SPD proneness, especially negative schizotypy displayed the problems of awareness itself which was consistent with the findings that insight was impaired in patients with schizophrenia (Medalia and Thysen, 2008; Medalia et al., 2008). And individuals with non-negative schizotypy displayed heightened self-awareness of executive behavioral problems despite their normal 'objective' function which was consistent with the previous imaging study in participants at high risk of schizophrenia (Whalley et al., 2005).

Moreover, it should be noted that we only conducted a study in the high risk group here, and could not see the development of schizotypal proneness subjects. So in further study, clinical diagnosed schizotypal personality disorder and patients with schizophrenia are needed to be recruited. Another limitation was that the 'objective' executive assessments in the study were not comprehensive. Further study needs comprehensive 'objective' executive assessments. The third limitation is that we did not invite the subjects' relatives or friends to rate the executive function for these subjects. We should also add the DEX-other rating scale to precisely infer self-awareness into their dysexecutive behavior.

In summary, these current findings suggest that the awareness of everyday dysexecutive function may precede overt 'objective' executive functions in individuals with non-negative schizotypy. Meanwhile, problems of awareness itself into executive function may exist in schizotypal personality proneness, especially negative schizotypy, despite their normal level of 'objective' executive function.

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