Mind wandering in schizophrenia: A thought-sampling study

**ABSTRACT**

Mind wandering has consistently been associated with impairments in cognition, emotion and daily performance. However, few experimental studies on mind wandering have been conducted in individuals with schizophrenia. The present study aimed to examine mind wandering in schizophrenia patients with a thought-sampling experiment embedded in a rapid go/no-go task and the relationship between the frequency of mind wandering and psychotic symptoms. Fifty-eight schizophrenia patients and 56 matched healthy controls were recruited and engaged in a task that assessed mind wandering. The results showed that schizophrenia patients (1.4%) reported less frequent mind wandering than healthy controls (5.8%). Moreover, there was no significant correlation between the frequency of mind wandering and psychotic symptoms in schizophrenia patients. Further studies in different stages of schizophrenia and in patients with more severe psychotic symptoms are needed to demonstrate a more comprehensive picture of mind wandering in schizophrenia.

***Keywords:*** Mind wandering, Thought-sampling, Schizophrenia

## 1. Introduction

Mind wandering refers to thoughts decoupled from the immediate stimulus (stimulus-independent) (Teasdale et al., 1995) and unrelated to the task being performed (task-unrelated) (Giambra, 1995). Thus, mind wandering can be regarded as “stimulus-independent and task-unrelated thoughts” (Stawarczyk, Majerus, Maj, Van der Linden, & D'Argembeau, 2011).

Studies have consistently demonstrated that frequent mind wandering was associated with impairments in cognition (Hu, He, & Xu, 2012), mood (Killingsworth & Gilbert, 2010) and daily performance (Mcvay, Kane, & Kwapil, 2009), such as increased driving risk (Albert et al., 2018). Specifically, when their mind wanders, individuals decouple from the current environment and live with experiences beyond the here and now (Smallwood, O'Connor, Sudbery, & Obonsawin, 2007). The sense of decoupling from the external world (Stanghellini & Ballerini, 2007) underlying



The following publication Chen, T., Qin, X. J., Cui, J. F., Li, Y., Liu, L. L., Wang, P., ... & Chan, R. C. K. (2019). Mind wandering in schizophrenia: A thought-sampling study. Consciousness and Cognition, 74, 102774 is available at https://doi.org/10.1016/j.concog.2019.102774

psychotic symptoms (mainly positive symptoms such as hallucinations and delusions) (Kean, 2009) has been considered a core feature of schizophrenia (Parnas, 2011).

Schizophrenia is a severe mental disease characterized by positive symptoms, negative symptoms and cognitive deficits (Insel, 2010). Positive symptoms refer to abnormal experiences, such as delusions and hallucinations. Negative symptoms are characterized by decreased or loss of mental functions such as anhedonia and social withdrawal. Cognitive deficits include attention and memory problems and executive dysfunction.

Empirical evidence has shown that the frequency of mind wandering was positively correlated with positive symptom severity in patients with schizophrenia (Shin et al., 2015). Thus, it is important to study mind wandering in this clinical group.

To date, few empirical studies have directly explored the frequency of mind wandering in patients with schizophrenia. However, studies using the Sustained Attention to Response Task (SART, a variant of the Go/No-Go task) (Robertson, Manly, Andrade, Baddeley, & Yiend, 1997) have shown that patients with schizophrenia committed more performance errors or achieved lower accuracy than healthy controls (Chan, Chen, Cheung, Chen, & Cheung, 2004; O'Gráda et al., 2009). In addition, it was proposed that the performance errors or accuracy in the SART can be regarded as an indirect behavioral index of mind wandering (Christoff, Gordon, Smallwood, Smith, & Schooler, 2009; Smallwood, Beach, Schooler, & Handy, 2007); that is, more performance errors indicate more mind wandering. These findings imply that patients with schizophrenia may experience more mind wandering. In addition, patients with schizophrenia were also found to show difficulties in mindfulness (Tabak, Horan, & Green, 2015). Empirical findings demonstrated that people with low levels of mindfulness experienced more mind wandering (Mrazek, Smallwood, & Schooler, 2012). Recently, Shin et al. (2015) have directly examined mind wandering in schizophrenia patients with the Mind Wandering Questionnaire and found that patients exhibited more frequent mind wandering than healthy

controls. They also found that mind-wandering frequency was correlated with the severity of positive symptoms but not negative symptoms.

It is noteworthy that there are several limitations in previous studies that prevent us from better understanding the frequency of mind wandering and its association with psychotic symptoms in schizophrenia. First, most studies did not directly assess mind-wandering frequency in schizophrenia. Second, the study that directly measured mind wandering (Shin et al., 2015) only adopted a self-report questionnaire.

In the current study, we aimed to examine mind wandering with an experimental paradigm (thought-sampling task) in patients with schizophrenia. Thought-sampling tasks, generally viewed as an effective method for studying mind wandering (Smallwood & Schooler, 2015), in which participants are asked to intermittently report their experience, can provide access to online momentary changes in the mental state of individuals (Christoff et al., 2009). Currently, studies adopting the thought-sampling method usually probe the participants' current experience at random intervals when performing an ongoing task, such as the SART (Seli, Risko, & Smilek, 2016; Smallwood & Schooler, 2006). Participants were required to report whether they had been fully focused on the task or distracted by stimulusindependent thoughts (or task-unrelated thoughts) immediately prior to the thought probe. Based on the "task-relatedness" and "stimulus-dependency" dimensions described by Stawarczyk, Majerus, Maj, et al. (2011), each thought can be categorized as 1) on-task thoughts (task-related and stimulus-dependent): fully focusing on the current task; 2) external distractions (EDs; task-unrelated and stimulus-dependent): exteroceptive and interoceptive perceptions irrelevant to the task, such as noises or thirst; 3) task-related interferences (TRIs; task-related and stimulus-independent): interfering thoughts related to the appraisal of the task, such as thoughts about their personal overall performance; and 4) mind wandering (taskunrelated and stimulus-independent): the attention decoupled from external stimuli and the thoughts were unrelated to the current task, such as thoughts about

dinner preparation. Thus, distractions from tasks requiring sustained attention may not only result from mind wandering but also from EDs and TRIs (Stawarczyk, Majerus, Maj, et al., 2011). In view of the inherent differences among mind wandering, EDs and TRIs (Stawarczyk, Majerus, Maj, et al., 2011; Stawarczyk, Majerus, Maquet, &
D'Argembeau, 2011), it is necessary to separate and isolate mind wandering from EDs and TRIs. Questionnaire studies cannot distinguish such types of thoughts. In the current study, with the thought-probing method (Stawarczyk, Majerus, Maj, et al., 2011), we tried to capture mind wandering more precisely by distinguishing mind wandering from EDs and TRIs.

Taken together, we aimed to explore mind wandering with a thought-sampling method in a reasonably sized sample of schizophrenia patients. We hypothesized that schizophrenia patients would experience more mind wandering than healthy controls and that mind wandering would be positively correlated with psychotic symptoms in these patients. In this study, because we mainly focused on mind wandering by excluding on-task thoughts, TRIs and EDs, we did not derive specific hypotheses about on-task thoughts, TRIs or EDs.

## 2. Method

### *2.1. Participants*

Fifty-eight chronic schizophrenia patients from Haidian District Mental Health Prevention and Treatment Hospital, Beijing, were recruited. All of them fulfilled the DSM-IV diagnostic criteria (American Psychiatric Association, 1994) for schizophrenia, had an estimated IQ ≥ 70, were aged between 18 to 60 years and were clinically stable. Participants were excluded if they had a history of alcohol or drug dependence/abuse or neurological illness or had received electroconvulsive therapy within the past three months.

Fifty-six demographically matched healthy controls were recruited. Those with a history of alcohol or drug dependence/abuse, neurological illness, or mental illness, an estimated IQ<70, and a positive family history of mental disorders were excluded.

All the participants were administered the four-subscale (information, arithmetic, similarity, and digit span) short form of the Chinese version of the Wechsler Adult Intelligence Scale-Revised (WAIS-R) (Gong, Jiang, Deng, Dai, & Zhou, 1989) and the Annett Handedness Scale (Spreen & Strauss, 1991).

This study was approved by the Ethics Committee of the Institute of Psychology, Chinese Academy of Sciences. Written informed consent was obtained from all participants before the formal experiment began.

### *2.2. Measures*

#### *2.2.1. Mind wandering*

Mind wandering was measured with a thought-sampling task. The thoughtsampling task embedded thought probes in a task adapted from the Sustained
Attention to Response Task (SART) (Chan, Chen, & Law, 2006; Chan et al., 2004; Robertson et al., 1997). The task was programmed with E-Prime version 2.0. The whole task included 16 virtual blocks, and each block consisted of 45 trials and one thought probe.

The 45 trials in each block involved the presentation of digits ranging from 1 to 9, with 5 different font sizes at the center of a computer screen. The participants were required to press the left button of the mouse to respond to the stimulus (nontargets: 1-2,4-9) as accurately and as fast as possible, but withhold responding when the digit “3” (target) appeared. The order of the stimulus presentations (targets and nontargets) was randomized. The probability of the target was 11% in each block. Each trial began with a 900-ms mask, followed by a 250-ms stimulus presentation.

The thought probe appeared in each block at a randomized place. For each probe, participants were required to report whether they were off-task immediately prior to the thought probe and write down their thoughts briefly on a piece of paper (Stawarczyk, Majerus, Maj, et al., 2011). Participants were also instructed that offtask thoughts were thoughts not on task, including EDs (e.g., “someone are talking outside now”), TRIs (e.g., “the task is really too difficult”) and mind wandering (e.g., “planning for the coming holiday”) (Xu, Purdon, Seli, & Smilek, 2017).

Specifically, participants were required to press the “1” key on a keyboard if they were off task and press the “2” key if they were fully on task. Then, they were reminded by a text displayed on the screen to write down their thoughts on a piece of paper with several key words. The participants were suggested to do so to facilitate remembering the details of the thoughts that they were required to further describe after the whole task.

The response time for the thought probe and description was unlimited. After the probe, the SART resumed when participants press “ENTER” on the keyboard. See Figure 1 for the task flow. To ensure correct understanding of the instructions, all participants finished a short practice session of the thought-sampling task (40 nontargets, 5 targets, and one thought probe) before the formal task.

INSERT FIGURE 1 HERE

After finishing the SART task, participants were required to describe the details of their thoughts at each probe with the help of the keywords they had previously written down. If the participants’ thoughts were off task, two raters further categorized them into EDs, TRIs or mind wandering according to the descriptions of participants. The proportion of each type of thought was calculated as the dependent variables. In addition, the skill-index (mean target accuracy/mean nontarget response time) score (Jonker, Seli, Cheyne, & Smilek, 2013), which represented task efficiency, was calculated as a measure of performance on the SART.

For this task, we undertook the following manipulations to ensure that the participants reported mind wandering as honestly as possible. First, we explicitly described the purpose of the study and explained that it aimed to survey the frequency of thoughts that were not on task (e.g., mind wandering) and emphasized that these thoughts were common in daily life, everyone experiences these thoughts, and the thoughts were not problematic. This instruction facilitated participants to honestly report their thoughts by reducing social desirability. Second, we asked participants to write down key words that could help them remember the details of thoughts. This method could help to avoid discomfort when reporting personal thoughts (Klinger, Murphy, Ostrem, & Stark-Wroblewski, 2004) as well as decrease memory load. Third, we also asked participants to write down key words on probes even when they reported on-task. This manipulation could help to avoid dishonest reports for those who viewed writing down thoughts on paper as a burden. When classifying participants' thoughts into different categories (mind wandering, on-task, EDs, TRIs), we had two raters rate all the responses. The interrater reliabilities were excellent (on-task thoughts: kappa = 0.98; EDs: kappa = 0.92; TRIs: kappa = 0.91; mind wandering: kappa = 0.93).

In the current study, target accuracy (successfully withholding a response to the digit "3") in the SART was calculated as an indirect behavioral index of mind wandering (Christoff et al., 2009).

*2.2.2. Measures of factors related to mind wandering*

Previous studies have shown that task interest (Unsworth & McMillan, 2013) and working memory (Kane et al., 2007) were associated with mind wandering. Thus, both variables were assessed in the current study.

*Interest*

The interest in the thought-probe task was assessed by the interest subscale of the Chinese version of the Intrinsic Motivation Inventory for Schizophrenia Research

(IMI-SR) (Choi, Mogami, & Medalia, 2010; Li et al., 2013). The 7-item interest subscale (e.g., 'I thought this activity was quite enjoyable') was administered immediately after the thought-probe task. Participants were required to rate on a 7point scale (1 = not at all, 7 = very right). A higher score represents a stronger interest in the task. It has been reported to have good validity and reliability in Chinese samples (Li et al., 2013). The Cronbach's alpha coefficient was 0.81 for patients and
0.73 for controls in the current study.

*Working memory*

Working memory was measured by the Chinese version of Letter–Number Span test (Chan et al., 2008). It is similar to the Letter-Number Span of the Wechsler Intelligence Test (Wechsler, 1987). The total number of correct trials as well as the longest-passed item were recorded. It has been reported to have good validity and reliability in Chinese samples (Chan et al., 2008).

*2.2.3 Clinical symptoms*

The Positive and Negative Symptom Scale (PANSS) was used to assess clinical symptoms (Kay, Fiszbein, & Opler, 1987; Si et al., 2004). The PANSS consists of 3 subscales: positive symptoms, negative symptoms and general psychopathology. The positive symptom subscale measures the severity of positive symptoms (e.g., delusions) with 7 items. The negative symptom subscale measures the severity of negative symptoms (e.g., emotional withdrawal) with 7 items. The general psychopathology subscale measures the severity of nonspecific symptoms (e.g., feeling guilty) with 16 items. All items were rated by a psychiatrist through an interview with the patients on a 7-point scale (1= none, 7= extremely serious). The alpha coefficients were 0.78, 0.85, 0.71 and 0.84 for the positive subscale, negative subscale, general psychopathology and total scale, respectively, in this study. The Barnes Akathisia Rating Scale (BARS) (Barnes, 1989) and Abnormal Involuntary Movement Scale (AIMS) (Smith, Kucharski, Oswald, & Waterman, 1979) were

adopted to assess medication side effects. These measures were also assessed by psychiatrists.

### *2.3. Procedure*

All participants were introduced to the purpose of the study and asked to sign an informed consent form before the test began. Then, participants performed the thought-sampling task after a short practice session. The IMI-SR was administered following the thought-sampling task. IQ and working memory tests were subsequently administered in a counterbalanced order. Finally, clinical symptoms were assessed by psychiatrists.

### *2.4. Data analysis*

Independent *t*-tests or chi-square tests were conducted to examine differences in demographic information and the related factors of mind wandering (viz., task interest and working memory) between the schizophrenia and healthy control groups. On-task thoughts, EDs, TRIs, mind wandering and target accuracy were compared between groups with the permutation test (with 5000 resamples), a nonparametric test with good statistical power since the assumptions for parametric testing were not met in the present study (distribution information of mind wandering and clinical symptoms are presented in Table S1 in supplementary material). Cohen's *d* was calculated, and medium (> 0.5) and large (> 0.8) effects were viewed as meaningful (Cohen, 1988). Spearman's correlation analyses were conducted to examine the relationship between on-task thoughts, EDs, TRIs, mind wandering and clinical symptoms in schizophrenia.

## 3. Results

### *3.1. Demographic information, clinical characteristics, and mind wandering related factors*

As shown in Table 1, the two groups did not show any significant differences in demographic variables and factors related to mind wandering. The factors related to mind wandering were thus not considered in the subsequent analyses.

INSERT TABLE 1 HERE

### *3.2. SART performance and proportion of on-task thoughts, EDs, TRIs and mind wandering*

As shown in Table 2, the results indicated that schizophrenia patients reported a significantly lower proportion of mind wandering than healthy controls ($p < 0.001$), but the two groups did not show a significant difference in SART target accuracy ($p = 0.341$). No significant difference was found in the proportion of on-task thoughts, EDs and TRIs between the two groups. There was no significant difference in the skill-index score between the two groups. In addition, commission error rates were negatively correlated with response times ($r = -0.49$, $p < 0.001$) for the go trials.

INSERT TABLE 2 HERE

### *3.3. Relationship between target accuracy, proportion of on-task thoughts, EDs, TRIs, mind wandering and clinical symptoms in schizophrenia*

As presented in Table 3, target accuracy, proportion of on-task thoughts, EDs, TRIs and mind wandering did not significantly correlate with clinical symptoms in schizophrenia. There were no significant correlations between target accuracy and the proportion of EDs ($r = -0.25$, $p = 0.063$), TRIs ($r = -0.01$, $p = 0.93$) or mind

wandering ($r$ = -0.15, $p$ = 0.27), but there was a positive significant correlation with on-task thoughts ($r$ = 0.27, $p$ = 0.037).

INSERT TABLE 3 HERE

**4. Discussion**

The current study found that schizophrenia patients experienced less frequent mind wandering than healthy controls in a laboratory task, and the frequency of mind wandering did not correlate with psychotic symptoms in these patients.

We assessed mind wandering through a laboratory design, namely, the thought-sampling method, in a sample of 58 schizophrenia patients. In addition, we reduced the potential confounding effects of key factors, such as task interest (Unsworth & McMillan, 2013) and working memory (Kane et al., 2007), in the present study. However, our study showed that schizophrenia patients reported less mind wandering than healthy controls, which was not consistent with the findings of a previous study (Shin et al., 2015). One possible reason is that the self-report questionnaire used by Shin et al. (2015) did not distinguish among the various types of thoughts underlying the distractions. For example, the Mind Wandering Questionnaire (MWQ) (Singer & Antrobus, 1963) mainly asked participants the frequency of experiencing distraction from tasks requiring attention (e.g., “During a lecture or speech, my mind often wanders”). However, the distraction from daily tasks that required sustained attention may result not only from mind wandering but also from other types of thoughts (e.g., EDs) (Stawarczyk, Majerus, Maj, et al., 2011), which meant that the assessment of mind wandering with a questionnaire might not be accurate or precise. Further studies are needed to clarify this issue. In fact, our results were supported by some previous findings. For example, Phillips, Salo, and Carter (2015) found that in the A-X Continuous Performance Task, attention lapses were associated with more activations in the default mode network and frontalparietal control network in healthy controls than in schizophrenia patients.

Because these networks showed increased connectivity during mind wandering (Christoff, 2012), Phillips et al.'s results suggested that schizophrenia patients might experience less mind wandering during attention tasks than controls. In addition, a transcranial direct current stimulation (tDCS) study showed that the inhibitory stimulation of the medial prefrontal cortex (mPFC) reduced the frequency as well as the self-related contents of mind wandering among male participants (Bertossi, Peccenini, Solmi, Avenanti, & Ciaramelli, 2017). A lesion study also demonstrated that patients with lesions in the ventromedial prefrontal cortex (vmPFC), a key region for selfreferential processing, reported less mind wandering (Bertossi & Ciaramelli, 2016). Thus, it is reasonable to speculate that schizophrenia patients who showed impairments in the vmPFC (Kühn & Gallinat, 2013; Pankow et al., 2015) reported less mind wandering. Moreover, mind wandering is generally related to the function of anticipation and planning for the future (Baird, Smallwood, & Schooler, 2011; Stawarczyk, Majerus, Maj, et al., 2011). Schizophrenia patients usually have difficulties in prospection (Painter & Kring, 2016) and anticipatory pleasure (Kring & Elis, 2013). Thus, it is possible that schizophrenia patients experience less mind wandering than healthy controls.

We did not find a significant difference in target accuracy, an indirect behavioral index of mind wandering (Christoff et al., 2009), between schizophrenia patients and healthy controls. Further analysis also showed that target accuracy did not correlate with mind wandering in the thought-sampling task among the schizophrenia patients and healthy controls. This result is consistent with the finding that there is no association between performance errors in the SART and mind wandering in the thought-sampling task among undergraduate students (Mrazek et al., 2012). In fact, a transcranial direct current stimulation (tDCS) study found that active stimulation of the left dorsolateral prefrontal cortex (DLPFC) facilitated participants' reporting of a higher frequency of mind wandering in a thought-sampling task without reducing the target accuracy in SART relative to those who received stimulation in the occipital cortex or sham stimulation at the DLPFC (Axelrod, Rees, Lavidor, & Bar, 2015). In

addition, commission errors negatively correlated with response time for go trials in this study. Such a result may suggest that commission errors reflect impulsive responding or response time/accuracy tradeoffs (Helton, Kern, & Walker, 2009), which may help to explain the discrepancy between commission errors and mind wandering. More studies are needed to ascertain the association between SART task performance and mind wandering in a thought-sampling task.

We did not find significant relationships between mind wandering and psychotic symptoms in this study. This finding is inconsistent with that of a previous study (Shin et al., 2015). However, another study also showed no relationship between mindfulness and psychotic symptoms in schizophrenia patients (Tabak et al., 2015). The close association between mindfulness and mind wandering (Mrazek et al., 2012) may imply that mind wandering does not correlate with psychotic symptoms in schizophrenia patients. It was noteworthy that the patients in the present study were in a stable state and had relatively intact functioning. Thus, we speculated that our results might be due to the low level and narrow range of symptoms in our sample.

In the current study, schizophrenia participants reported mind wandering in 1.4% of the probes, and healthy controls reported mind wandering in 5.8% of the probes in this thought-sampling task. The results were similar to the findings that the proportion of mind wandering during probes reported by older adults was 4% (Jackson & Balota, 2012), but different from studies in young adults that reported 20% (Stawarczyk, Majerus, Maj, et al., 2011; Stawarczyk, Majerus, Maquet, et al., 2011). There might be several reasons for the comparatively less mind wandering in the current study. First, it may be partly due to the rapid stimulus presentation of the modified SART task. In this study, the SART task in which the thought sampling was embedded was fast-paced (duration of stimulus = 250 ms, interstimulus interval = 900 ms). One study based on the SART found that participants reported mind wandering with a rate of 12% in the fast-paced SART (duration of stimulus = 200 ms, intertribal interval = 900 ms) but with a rate of 53% in the slow-paced SART (duration of stimulus = 1250 ms, intertribal interval = 1250 ms) (Jackson & Balota, 2012). In

fact, participants generally reported a lower frequency of mind wandering when performing difficult tasks (Smallwood & Schooler, 2006). Second, the age of participants may also account for less mind wandering reported in the study since older adults reported a lower frequency of mind wandering than younger adults (Jackson & Balota, 2012). Participants in our study (healthy controls: M = 44.48, range from 20-60 years) were much older than those in previous studies (average age = 22 years old, range from 18-30 years) (Stawarczyk, Majerus, Maj, et al., 2011; Stawarczyk, Majerus, Maquet, et al., 2011).

Some limitations of this study need to be addressed. First, the reported frequency of mind wandering was relatively low. Future studies may use different versions of the SART task and a wider age range of participants to clarify this issue. Second, the variance of psychotic symptoms in our schizophrenia sample was very small, which may be the reason for the lack of relationship between mind wandering and psychotic symptoms. Future studies need to recruit schizophrenia patients with a larger variance in psychotic symptoms. Third, the conclusion of this study may be limited to patients whose cognitive functions were relatively intact. Therefore, future studies need to recruit patients with a wider range of cognitive abilities to examine the generalizability of the findings. Last, the schizophrenia patients reported less mind wandering but not fewer other off-task thoughts, such as EDs and TRIs, which also require some degree of metacognitive ability; thus, the present results are unlikely to be confounded by the metacognitive ability of patients. Nevertheless, future studies still need to further clarify the relationship between metacognition and mind wandering. Despite these limitations, this study provided the first piece of experimental evidence on mind wandering in individuals with schizophrenia.

In conclusion, this study showed that schizophrenia patients manifested less frequent mind wandering than healthy controls, and the mind-wandering frequency did not correlate with psychotic symptoms. Further studies in different stages of schizophrenia and recruiting patients with more severe psychotic symptoms are

needed to demonstrate a more comprehensive picture of mind wandering in schizophrenia.

**Role of funding source**

This work was supported by the National Science Foundation of China (31571130 and 81571317), Beijing Municipal Science & Technology Commission (Z1610000021638), and China Scholarship Council.

**Conflict of interest**

None.

## References

Albert, D. A., Ouimet, M. C., Jarret, J., Cloutier, M.-S., Paquette, M., Badeau, N., & Brown, T. G. (2018). Linking mind wandering tendency to risky driving in young male drivers. Accident Analysis & Prevention, 111, 125-132. doi:10.1016/j.aap.2017.11.019

American Psychiatric Association. (1994). Diagnostic and Statistical Manual of Mental Disorders (4th ed.). Washington, DC: American Psychiatric Association.

Axelrod, V., Rees, G., Lavidor, M., & Bar, M. (2015). Increasing propensity to mind-wander with transcranial direct current stimulation. Proceedings of the National Academy of Sciences, 112(11), 3314-3319. doi:10.1073/pnas.1421435112

Baird, B., Smallwood, J., & Schooler, J. W. (2011). Back to the future: Autobiographical planning and the functionality of mind-wandering. Consciousness and Cognition, 20(4), 1604-1611. doi:10.1016/j.concog.2011.08.007

Barnes, T. R. (1989). A rating scale for drug-induced akathisia. The British Journal of Psychiatry, 154(5), 672-676. doi:10.1192/bjp.154.5.672

Bertossi, E., & Ciaramelli, E. (2016). Ventromedial prefrontal damage reduces mind-wandering and biases its temporal focus. Social Cognitive and Affective Neuroscience, 11(11), 1783-1791. doi:10.1093/scan/nsw099

Bertossi, E., Peccenini, L., Solmi, A., Avenanti, A., & Ciaramelli, E. (2017). Transcranial direct current stimulation of the medial prefrontal cortex dampens mind-wandering in men. Scientific Reports, 7(1), 16962. doi:10.1038/s41598-017-17267-4

Chan, R. C. K., Chen, E. Y., & Law, C. W. (2006). Specific executive dysfunction in patients with firstepisode medication-naive schizophrenia. Schizophrenia Research, 82(1), 51-64. doi:10.1016/j.schres.2005.09.020

Chan, R. C. K., Chen, E. Y. H., Cheung, E. F. C., Chen, R. Y. L., & Cheung, H. K. (2004). A Study of Sensitivity of the Sustained Attention to Response Task in Patients With Schizophrenia. The Clinical Neuropsychologist, 18(1), 114-121. doi:10.1080/13854040490507208

Chan, R. C. K., Wang, Y., Deng, Y., Zhang, Y., Yiao, X., & Zhang, C. (2008). The Development of a Chinese Equivalence Version of Letter–Number Span Test. Clinical Neuropsychologist, 22(1), 112-121.

Choi, J., Mogami, T., & Medalia, A. (2010). Intrinsic Motivation Inventory: An Adapted Measure for Schizophrenia Research. Schizophrenia Bulletin, 36(5), 966-976. doi:10.1093/schbul/sbp030

Christoff, K. (2012). Undirected thought: Neural determinants and correlates. Brain Research, 1428, 51-59. doi:10.1016/j.brainres.2011.09.060

Christoff, K., Gordon, A. M., Smallwood, J., Smith, R., & Schooler, J. W. (2009). Experience sampling during fMRI reveals default network and executive system contributions to mind wandering. Proceedings of the National Academy of Sciences, 106(21), 8719-8724. doi:10.1073/pnas.0900234106

Cohen, J. (1988). Statistical power analysis for the behavioral sciences (2nd Ed.). Hillsdale, NJ: Lawrence Earlbaum Associates.

Giambra, L. M. (1995). A Laboratory Method for Investigating Influences on Switching Attention to Task-Unrelated Imagery and Thought. Consciousness and Cognition, 4(1), 1-21. doi:10.1006/ccog.1995.1001

Gong, Y.-X., Jiang, D.-W., Deng, J.-L., Dai, Z.-S., & Zhou, Q.-Z. (1989). Manual of Wechsler Memory Scale-Chinese version. Changsha: Hunan Medical College Press.

Helton, W. S., Kern, R. P., & Walker, D. R. (2009). Conscious thought and the sustained attention to response task. Consciousness and Cognition, 18(3), 600-607. doi:10.1016/j.concog.2009.06.002

Hu, N., He, S., & Xu, B. (2012). Different efficiencies of attentional orienting in different wandering minds. Consciousness and Cognition, 21(1), 139-148. doi:10.1016/j.concog.2011.12.007 Insel, T. R. (2010). Rethinking schizophrenia. Nature, 468(7321), 187-193.

Jackson, J. D., & Balota, D. A. (2012). Mind-wandering in younger and older adults: Converging evidence from the sustained attention to response task and reading for comprehension. Psychology and Aging, 27(1), 106-119. doi:10.1037/a0023933

Jonker, T. R., Seli, P., Cheyne, J. A., & Smilek, D. (2013). Performance reactivity in a continuousperformance task: Implications for understanding post-error behavior. Consciousness and Cognition, 22(4), 1468-1476. doi:10.1016/j.concog.2013.10.005

Kühn, S., & Gallinat, J. (2013). Resting-State Brain Activity in Schizophrenia and Major Depression: A Quantitative Meta-Analysis. Schizophrenia Bulletin, 39(2), 358-365. doi:10.1093/schbul/sbr151

Kane, M. J., Brown, L. H., McVay, J. C., Silvia, P. J., Myin-Germeys, I., & Kwapil, T. R. (2007). For Whom the Mind Wanders, and When: An Experience-Sampling Study of Working Memory and Executive Control in Daily Life. Psychological Science, 18(7), 614-621. doi:10.1111/j.1467-9280.2007.01948.x

Kay, S. R., Fiszbein, A., & Opler, L. A. (1987). The Positive and Negative Syndrome Scale (PANSS) for Schizophrenia. Schizophrenia Bulletin, 13(2), 261-276. doi:10.1093/schbul/13.2.261

Kean, C. (2009). Silencing the Self: Schizophrenia as a Self-disturbance. Schizophrenia Bulletin, 35(6), 1034-1036. doi:10.1093/schbul/sbp043

Killingsworth, M. A., & Gilbert, D. T. (2010). A wandering mind is an unhappy mind. Science, 330(6006), 932-932.

Klinger, E., Murphy, M. D., Ostrem, J. L., & Stark-Wroblewski, K. (2004). Disclosing Daydreams versus Real Experiences: Attitudes, Emotional Reactions, and Personality Correlates. Imagination, Cognition and Personality, 24(2), 101-138. doi:10.2190/FTRA-31CH-6A2WHV3N

Kring, A. M., & Elis, O. (2013). Emotion Deficits in People with Schizophrenia. Annual Review of Clinical Psychology, 9(1), 409-433. doi:10.1146/annurev-clinpsy-050212-185538

Li, Q.-Q., Dong, Y., Wang, K., Choi, J., Yang, L.-D., Zhu, C.-Y., . . . Zhao, Z.-C. (2013). The relation between the intrinsic motivation, eye expressionrecognition and symtoms in schizophrenia. Acta Universitatis Medicinalis Anhui, 48(1), 77-81.

Mcvay, J. C., Kane, M. J., & Kwapil, T. R. (2009). Tracking the train of thought from the laboratory into everyday life: An experience-sampling study of mind wandering across controlled and ecological contexts. Psychonomic Bulletin & Review, 16(5), 857-863.

Mrazek, M. D., Smallwood, J., & Schooler, J. W. (2012). Mindfulness and mind-wandering: Finding convergence through opposing constructs. Emotion, 12(3), 442-448. doi:10.1037/a0026678

O'Gráda, C., Barry, S., McGlade, N., Behan, C., Haq, F., Hayden, J., . . . Donohoe, G. (2009). Does the ability to sustain attention underlie symptom severity in schizophrenia? Schizophrenia Research, 107(2), 319-323. doi:10.1016/j.schres.2008.07.013

Painter, J. M., & Kring, A. M. (2016). Toward an understanding of anticipatory pleasure deficits in schizophrenia: Memory, prospection, and emotion experience. Journal of Abnormal Psychology, 125(3), 442-452. doi:10.1037/abn0000151

Pankow, A., Deserno, L., Walter, M., Fydrich, T., Bermpohl, F., Schlagenhauf, F., & Heinz, A. (2015). Reduced default mode network connectivity in schizophrenia patients. Schizophrenia Research, 165(1), 90-93. doi:10.1016/j.schres.2015.03.027

Parnas, J. (2011). A Disappearing Heritage: The Clinical Core of Schizophrenia. Schizophrenia Bulletin, 37(6), 1121-1130. doi:10.1093/schbul/sbr081

Phillips, R. C., Salo, T., & Carter, C. S. (2015). Distinct neural correlates for attention lapses in patients with schizophrenia and healthy participants. Frontiers in Human Neuroscience, 9(502). doi:10.3389/fnhum.2015.00502

Robertson, I. H., Manly, T., Andrade, J., Baddeley, B. T., & Yiend, J. (1997). `Oops!': Performance correlates of everyday attentional failures in traumatic brain injured and normal subjects. Neuropsychologia, 35(6), 747-758. doi:10.1016/S0028-3932(97)00015-8

Seli, P., Risko, E. F., & Smilek, D. (2016). On the Necessity of Distinguishing Between Unintentional and Intentional Mind Wandering. Psychological Science, 27(5), 685-691. doi:10.1177/0956797616634068

Shin, D.-J., Lee, T. Y., Jung, W. H., Kim, S. N., Jang, J. H., & Kwon, J. S. (2015). Away from home: the brain of the wandering mind as a model for schizophrenia. Schizophrenia Research, 165(1), 83-89. doi:10.1016/j.schres.2015.03.021

Si, T.-M., Yang, J.-Z., Shu, L., Wang, X.-L., Kong, Q.-M., Zhou, M., . . . Liu-Cui. (2004). The Reliability, Validity of PANSS and its Implication. Chinese Mental Health Journal, 18(1), 45-47.

Singer, J. L., & Antrobus, J. S. (1963). A Factor-Analytic Study of Daydreaming and ConceptuallyRelated Cognitive and Personality Variables. Perceptual and Motor Skills, 17(1), 187-209. doi:10.2466/pms.1963.17.1.187

Smallwood, J., Beach, E., Schooler, J. W., & Handy, T. C. (2007). Going AWOL in the Brain: Mind Wandering Reduces Cortical Analysis of External Events. Journal of Cognitive Neuroscience, 20(3), 458-469. doi:10.1162/jocn.2008.20037

Smallwood, J., O'Connor, R. C., Sudbery, M. V., & Obonsawin, M. (2007). Mind-wandering and dysphoria. Cognition and Emotion, 21(4), 816-842. doi:10.1080/02699930600911531

Smallwood, J., & Schooler, J. W. (2006). The restless mind. Psychological Bulletin, 132(6), 946-958. doi:10.1037/0033-2909.132.6.946

Smallwood, J., & Schooler, J. W. (2015). The Science of Mind Wandering: Empirically Navigating the Stream of Consciousness. Annual Review of Psychology, 66(1), 487-518. doi:doi:10.1146/annurev-psych-010814-015331

Smith, J. M., Kucharski, L. T., Oswald, W. T., & Waterman, L. J. (1979). A systematic investigation of tardive dyskinesia in inpatients. American Journal of Psychiatry, 136(7), 918-922.

Spreen, O., & Strauss, E. (1991). A Compendium of Neuropsychological Tests: Administration, Norms, and Commentary. NY: Oxford University Press.

Stanghellini, G., & Ballerini, M. (2007). Values in Persons With Schizophrenia. Schizophrenia Bulletin, 33(1), 131-141. doi:10.1093/schbul/sbl036

Stawarczyk, D., Majerus, S., Maj, M., Van der Linden, M., & D'Argembeau, A. (2011). Mindwandering: Phenomenology and function as assessed with a novel experience sampling method. Acta Psychologica, 136(3), 370-381. doi:10.1016/j.actpsy.2011.01.002

Stawarczyk, D., Majerus, S., Maquet, P., & D'Argembeau, A. (2011). Neural Correlates of Ongoing Conscious Experience: Both Task-Unrelatedness and Stimulus-Independence Are Related to Default Network Activity. Plos One, 6(2), e16997.

Tabak, N. T., Horan, W. P., & Green, M. F. (2015). Mindfulness in schizophrenia: Associations with self-reported motivation, emotion regulation, dysfunctional attitudes, and negative symptoms. Schizophrenia Research, 168(1), 537-542. doi:10.1016/j.schres.2015.07.030

Teasdale, J. D., Dritschel, B. H., Taylor, M. J., Proctor, L., Lloyd, C. A., Nimmo-Smith, I., & Baddeley, A. D. (1995). Stimulus-independent thought depends on central executive resources. Memory & Cognition, 23(5), 551-559. doi:10.3758/bf03197257

Unsworth, N., & McMillan, B. D. (2013). Mind wandering and reading comprehension: Examining the roles of working memory capacity, interest, motivation, and topic experience. Journal of Experimental Psychology: Learning, Memory, and Cognition, 39(3), 832-842. doi:10.1037/a0029669

Wechsler, D. (1987). WAIS-R administration and scoring manual. San Antonio, TX: The Psychological Corporation.

Xu, M., Purdon, C., Seli, P., & Smilek, D. (2017). Mindfulness and mind wandering: The protective effects of brief meditation in anxious individuals. Consciousness and Cognition, 51, 157165. doi:10.1016/j.concog.2017.03.009

**Figure captions**

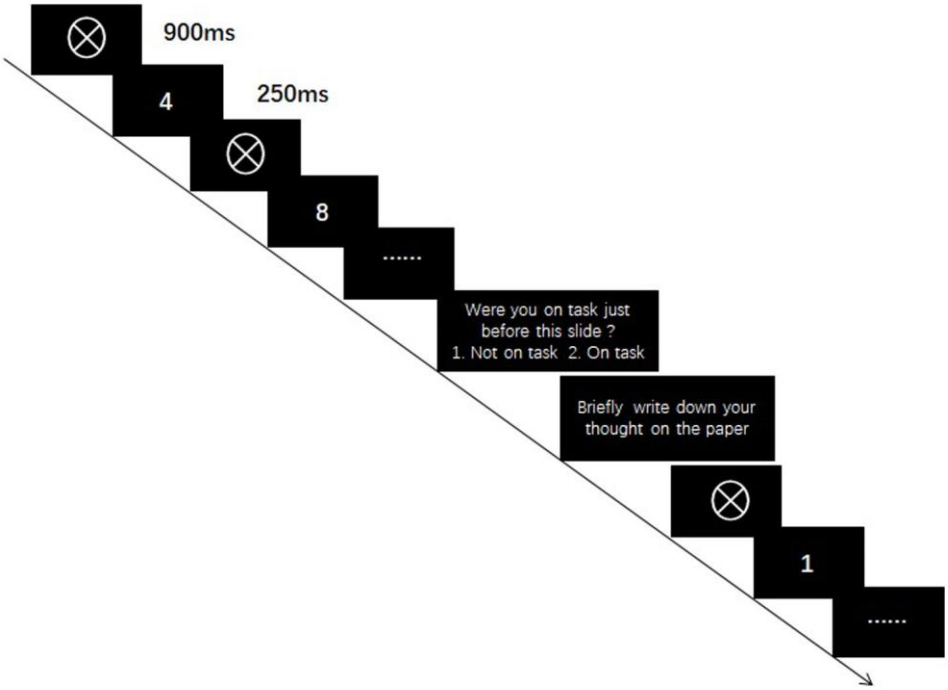


Figure 1. The procedure of the thought-sampling task. For the Chinese origin of the first question slide: “你刚才有与任务无关的想法吗？如果有，请按键”1”；如果没有，请按键”2”. For the Chinese origin of the second question slide: “请在纸上简要记录你刚才的任务无关想法的内容”.

Table 1

Demographic information, clinical characteristics, and mind wandering related variables of participants

| | Schizophrenia (N = 58) | Healthy Control (N = 56) | | |
|---|---|---|---|---|
| | Mean (SD) | Mean (SD) | $t/x_2$ | *p* |
| Male: female | 27:31 | 21:35 | 0.96 | 0.328 |
| Age (years) | 43.38 (8.79) | 44.48 (10.18) | 0.62 | 0.537 |
| Education (years) | 12.47 (2.83) | 12.16 (2.34) | -0.63 | 0.533 |
| IQ | 108.36 (15.73) | 108.25 (14.89) | -0.04 | 0.969 |
| Handedness (right vs left) | 54: 4 | 55:1 | 1.78 | 0.183 |
| Illness duration (years) | 18.34 (7.87) | - | | |
| PANSS_T | 44.67 (9.13) | - | | |
| PANSS_P | 9.29 (2.81) | - | | |
| PANSS_N | 12.34 (3.82) | - | | |
| PANSS_G | 23.03 (4.91) | - | | |
| AIMS | 0.64 (1.41) | - | | |
| BARS | 1.00 (1.78) | - | | |
| Medication (Chlorpromazine equivalence mg/day) | 313.93 (219.46) | - | | |
| IMI-SR | 32.79 (8.11) | 35.27 (6.89) | 1.75 | 0.082 |
| CLN_corr | 13.79 (4.20) | 14.46 (3.99) | -0.43 | 0.669 |
| CLN_lg | 5.14 (1.08) | 5.14 (1.18) | 0.02 | 0.982 |

PANSS_T = Positive and Negative Symptom Scale, total score; PANSS_P = Positive and Negative Symptom Scale, positive symptom score; PANSS_N = Positive and Negative Symptom, negative symptom score; PANSS_G = Positive and Negative Symptom, general symptom Score; AIMS = Abnormal Involuntary Movement Scale; BARS = Barnes Akathisia Rating Scale.

IMI-SR = the Interest subscale of Intrinsic Motivation Inventory for Schizophrenia Research; CLN_corr = Chinese Letter–Number span total correct; CLN_lg= Chinese Letter–Number span longest passed.

Table 2

SART performance and proportion of on-task thoughts, EDs, TRIs and mind wandering in the two groups

| | Schizophrenia (N = 58) | Healthy Control (N = 56) | | | |
|---|---|---|---|---|---|
| | Mean (SD) | Mean (SD) | *Z* | *p* | Cohen's *d* |
| Target accuracy | 0.56 (0.24) | 0.52 (0.24) | 0.95 | 0.341 | 0.17 |
| Skill-index | 1.33 (0.52) | 1.37 (0.56) | 0.35 | 0.730 | -0.07 |
| % on-task | 77.59 (25.49) | 71.32 (27.56) | 1.25 | 0.215 | 0.24 |
| % EDs | 15.09 (20.61) | 12.28 (17.27) | 0.81 | 0.416 | 0.15 |
| % TRIs | 5.93 (10.69) | 10.60 (16.25) | -1.81 | 0.075 | -0.34 |
| % MW | 1.40 (3.52) | 5.80 (9.52) | -3.17 | **<0.001** | **-0.61** |

In the *p* column, those values less than 0.05 were bolded; in the Cohen's *d* column, those values larger than 0.5 (absolute value) were bolded; Skill-index = mean target accuracy/mean non- target response time; on-task: on-task thoughts; EDs: external distractions; TRIs: task-related interferences; MW: mind wandering. Permutation test was used for the group comparisons.

Table 3

Correlations between target accuracy, on-task thoughts, EDs, TRIs and mind wandering and symptoms in schizophrenia (N = 58)

| | PANSS_T | PANSS_P | PANSS_N | PANSS_G |
|---|---|---|---|---|
| Target accuracy | -0.23 | -0.12 | -0.12 | -0.19 |
| % on-task | -0.09 | 0.18 | 0.06 | 0.09 |
| % EDs | 0.12 | -0.18 | -0.05 | -0.10 |
| % TRIs | -0.01 | -0.16 | -0.03 | -0.07 |
| % MW | -0.01 | 0.17 | 0.06 | 0.09 |

PANSS_T = Positive and Negative Symptom Scale, total score; PANSS_P = Positive and Negative Symptom Scale, positive symptom score; PANSS_N = Positive and Negative Symptom, negative symptom score; PANSS_G = Positive and Negative Symptom, general symptom Score; on-task: on-task thoughts; EDs: external distractions; TRIs: task-related interferences; MW: mind wandering. Spearman's correlation was used for this analysis.