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More mind wandering, fewer original ideas: Be not distracted during creative idea generation

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ABSTRACT

Several studies suggest that mind wandering (MW) benefits creativity when the MW occurs in the incubation period of creative problem solving. The aim of present study was to examine the effects of MW that occurs in the course of creative idea generation. Participants received an Alternative Uses Task (AUT) and were asked to generate ideas for 20 min. Their MW frequencies as time passed were measured by means of probe-caught MW. Comparisons of the AUT performances of high and low MW groups revealed that greater MW was associated with lower fluency and originality scores on the AUT. Furthermore, the high MW group showed greater MW as time passed, while the low MW group's MW was steady during the course of idea generation. Accordingly, the originality of idea generation decreased with time passing for the high MW group but was steady for the low MW group. The findings suggest that the MW during the course of creative idea generation is negatively related to creativity, perhaps because the control processes involved in idea generation are impaired by the mind wandering.

1. Introduction

Mind wandering (MW) refers to the occurrence of stimulus-independent and task-unrelated thoughts (Smallwood, 2013; Smallwood & Schooler, 2006; Stawarczyk, Majerus, Catale, & D'Argembeau, 2014; Stawarczyk, Majerus, Maj, Van der Linden, & D'Argembeau, 2011a; Stawarczyk, Majerus, Maquet, & D'Argembeau, 2011b). As one of the most ubiquitous mental activities (Mooneyham & Schooler, 2013), MW represents a substantial part (15%–50%) of thinking time when working on a particular task; on average 30% of people's conscious experience belongs to mind wandering (Kane et al., 2007; Killingsworth & Gilbert, 2010; Mason et al., 2007; Smallwood, Obonsawin, & Heim, 2003; Song & Wang, 2012). Numerous studies have demonstrated the negative impact of MW on various types of cognitive activity (e.g., reading, sustained attention, working memory, and intelligence testing) (for reviews see Mooneyham & Schooler, 2013). However, some research has suggested that there are benefits of MW for creative cognition. Greater MW could, for instance, be associated with enhanced creativity.

A reasonable hypothesis about the benefits of MW for creativity is suggested by a meta-analysis on incubation effects in creativity (i.e., positive effects of a break on later creative problem solving). Sio and Ormerod (2009) concluded that incubation effects tend to be larger in studies where individuals were engaged in low as compared to high demanding interpolated tasks or a rest task. This was supported by an empirical study (Baird et al., 2012), which directly compared the effects of varying cognitive demands of interpolated tasks within a single experiment. The results showed that a choice-reaction-time task (a low-demanding task) in the incubation period improved creative performance far more than did a one-back working memory task (a highly demanding task) and a rest task (Baird et al., 2012). According to the *Explicit–Implicit Interaction* (*EII*) *model* of creative thinking (Helie & Sun, 2010), incubation involves unconscious and implicit associative processes that demand little attention capacity, rather than conscious, explicit, and rule-governed processes. Empirically, low demanding tasks facilitated MW and prevented focused concentration (Mason et al., 2007; McKiernan, D'Angelo, Kaufman, & Binder, 2006; Smallwood, Nind, & O'Connor, 2009; Smallwood & Schooler, 2006). This may in turn stimulate remote activation in semantic networks during an incubation period, and could thus improve later creative performance (Baird et al., 2012; Sio & Ormerod, 2009). Note, however, that the positive effects of MW on creativity have only been observed when MW occurred in the incubation period (Baird et al., 2012). An interesting question arises: Does the MW that occurs during the course of creative idea generation enhance creativity as well?

Creative idea generation is, according to the *controlled-attention theory* of creative cognition (Beaty, Silvia, Nusbaum, Jauk, & Benedek, 2014), a top-down process that needs the involvement of executive functions (see also Runco, 1994). Previous studies revealed that some control processes affect creative performance, such as fluid intelligence (Benedek, Franz, Heene, & Neubauer, 2012a; Jauk, Benedek, Dunst, & Neubauer, 2013; Jauk, Benedek, & Neubauer, 2014) and working memory capacity

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(Chein & Weisberg, 2014; De Dreu, Nijstad, Baas, Wolsink, & Roskes, 2012; Lee & Therriault, 2013). Recent studies testified that executive function ("inhibition") plays important roles in creative thinking (Benedek, Jauk, Sommer, Arendasy, & Neubauer, 2014a; Edl, Benedek, Papousek, Weiss, & Fink, 2014; Limb & Braun, 2008). These findings are in line with the results of Electroencephalography (EEG) studies of creativity. Performance of divergent thinking (DT) tasks, for example, is associated with stronger alpha synchronization than the performance of more "convergent" or intelligence-related tasks (Bazanova & Aftanas, 2008; Fink, Benedek, Grabner, Staudt, & Neubauer, 2007; Fink et al., 2009), reflecting the absence of stimulus-driven, external bottom-up stimulation and, thus, a form of top-down control of the brain (Benedek, Bergner, Koenen, Fink, & Neubauer, 2011; Benedek, Schickel, Jauk, Fink, & Neubauer, 2014b; Fink, Schwab, & Papousek, 2011; Handel, Haarmeier, & Jensen, 2011; Jensen & Mazaheri, 2010; Klimesch, Sauseng, & Hanslmayr, 2007; von Stein & Sarnthein, 2000). In short, several lines of research support the important roles of executive functions in creative idea generation.

Notably, there are also close relationships between MW and executive function. The *perceptual decoupling theory* of mind wandering (Schooler et al., 2011; Smallwood, 2010, 2013; Smallwood & Schooler, 2006) holds that MW results from a redirection of attentional resources from the task at hand to the processing and maintenance of internal thoughts (Levinson, Smallwood, & Davidson, 2012). In this framework, MW is a resource-consuming activity that competes for control resources with the target task. As a result, MW should impair the performance of the cognitive activities that require large amount of control resources. By contrast, the *control failure theory* (Kane & McVay, 2012; McVay & Kane, 2010a,b; Stawarczyk et al., 2014) suggests that MW does not recruit attentional control resources; instead, the occurrence of MW reflects a temporary breakdown in control processes that are involved in maintaining task focused attention. In this vein, the occurrence of MW absolutely damages the performance on the target task. So, given that executive functions play important roles in creative idea generation, it is predicted that the MW during the course of creative idea generation may have negative effects on creativity, unlike the positive effects of the MW in the incubation period on creativity (Baird et al., 2012).

In the present study, we aimed to examine the effects of the MW that occurs in the course of creative idea generation. Participants were asked to work on an Alternative Uses Task (AUT) problem (Guilford, 1967) for 20 min. This comparatively long period of performance allowed assessment of the changes of MW frequency with time passing. The long period should also benefit original ideation and the discovery of remote associates (Runco & Acar, 2012). The MW frequency during the course of idea generation was measured by means of the probe-caught MW, as in the previous studies (Hu, He, & Xu, 2012; Levinson et al., 2012; Stawarczyk et al., 2014). Participants were then divided into high and low MW groups based on their MW frequencies; afterwards, the creative performances of these two groups were compared. Participants' self-reported MWs were measured by two questionnaires, which were used as an additional means for assessing MW levels (see details in the Method). To check whether inserting thought probes interfered with creative performance, participants in control group were asked to solve the same AUT problems without thought probes being inserted into the course of idea generation. The performance of the control group was then compared with that of the experimental group.

The main hypotheses were as follows. First, low MW individuals would perform better on AUT problem (e.g., generating more original answers) than high MW individuals. This follows from research showing that MW consumes the control resources involved in the target problem or indicates a failure of executive control on the target problem. Second, considering that higher MW individuals (i.e., with low control abilities) are less efficient in maintaining the attention focused on ongoing tasks (McVay & Kane, 2009, 2010a), we predicted that the MW frequency during the course of idea generation would increase with time passing for the high MW group, while remaining steady for the low MW group. Third, consistent with the change tendencies of MW frequency proposed in the second hypothesis, we predicted that originality on the AUT would decrease as time passed for the high MW group, but would remain steady for the low MW group.

2. Method

2.1. Participants

Ninety healthy college students of various academic disciplines participated individually in the study. They were all native Chinese speakers. Data from two participants were discarded due to floor performance and one was excluded for technical errors. The final sample comprised of 87 participants (12 males, 75 females) in the age range between 18 and 25 years ($M = 21.16$, $SD = 2.13$). There were 28, 29, and 30 participants in the high MW, low MW, and control groups, respectively. An ANOVA revealed that the mean age of the three groups did not differ from each other, nor did the mean years of education. Moreover, chi square analysis showed that there was no difference in the gender ratio among the three groups. Participants gave written informed consent prior to the experiment, and received approximately 5 US dollars for their participation after the experiment. The protocol of the experiment was approved by the Institutional Ethics Committee at East China Normal University.

2.2. Experimental task

The Alternative Uses Task (AUT; Guilford, 1967) was used as the target task. It requires respondents to generate as many unusual or original uses as possible for common objects, such as a paperclip ("making a ring", "cleaning fingernails"). The AUT is a well-established test of creative potential (Guilford, 1967; Runco, 1991, 1999; Runco & Mraz, 1992). Performance on this task has been demonstrated to be a reliable predictor of actual, real-world creative performance (Runco & Acar, 2012).

2.3. Experimental procedure

A between-subject design was used. Participants were asked to solve an AUT problem (i.e., "chopstick") during the 20 min experimental condition (with thought probes inserted) or the control condition (without thought probes). In the instruction about how to solve the AUT problem, participants were encouraged to try their best to produce ideas that would be thought of by no one else, as suggested by Harrington (1975); Runco (1999), and Torrance (1995).

Participants' performance on the AUT problem was recorded by a computer. Specifically, a fixation was shown on the screen, which lasted for 800 ms, signaling the start of experiment. Afterwards, the item of "chopstick" was presented on the screen. Participants were asked to press the key of "Enter" once they generated an idea, and then an input box appeared on the screen in which participants input the idea. Thus, the idea and the time point when it was generated were recorded by the software. After inputting the idea, participants pressed the key of "Enter" once more, and then the word of "chopstick" appeared on the screen again. Participants repeated such an operation until the experiment finished.

The 30 participants of the control group were instructed to work on the AUT problem and followed the aforementioned procedure. But for the 60 participants of the experimental group, a total of 12 thought probes were inserted into the period of 20 min (i.e., 3 probes per 5 min) while they worked on the AUT problem. The thought probes were inserted with a pseudorandom distribution of time points in each of four 5-min epochs to avoid expectancy effect. The probes were presented on another computer. Specifically, after a "beep" there was a thought probe: "What were you thinking just now?" Participants pressed "1" if they had been thinking task-related thoughts, that is, more original uses of "chopstick". Conversely, participants pressed "2" for task-unrelated thoughts (e.g., about watching a film tonight). Thus participants' MW frequencies during the 20-min period were easily scored, as were the MW frequencies in each of four epochs (5 min per epoch). Participants were then divided into high and low MW groups based on the median of the MW distribution.

2.4. Post-experimental measures

Immediately after participants finished the experiment, they were asked to complete the Daydreaming Frequency subscale (12 items) in the "Imaginal Process Inventory" (IPI; Singer & Antrobus, 1972), which was used to assess participants' general propensity to mind wander. This questionnaire was easily translated into Chinese. The items in the questionnaire are each expressed in a simple way (e.g., I daydream. A. infrequently. B. once a week. C. once a day. D. …) and a literal translation was therefore straightforward. Reverse translation was not necessary. Indeed, this questionnaire had a satisfactory reliability coefficient (Cronbach's alpha = .90) in this study. Participants were also required to complete the thinking part (16 items) of the "Dundee Stress State Questionnaire" (DSSQ; Matthews et al., 2002). It is a questionnaire to assess thinking states and contents during working on the target tasks, with 8 items measuring the task-unrelated thoughts (TUTs) and the others measuring the task-related interferences (TRIs). The thinking part of the DSSQ was also straightforward and allowed a direct translation into Chinese; reverse translation was not necessary, given the simple expression and wording. The TUTs subscale (Cronbach's alpha = .78) and the TRIs subscale (Cronbach's alpha = .73) had satisfactory reliability coefficients in the current study. All participants in the control and experimental groups completed these two questionnaires.

2.5. Assessment of performance on AUT problem

Participants' performance on the AUT problem was measured on the scores of fluency and originality (see Guilford, 1967; Runco, 1991, 1999). Fluency scores were based on the total number of ideas given the AUT problem. Originality scores were based on statistically infrequent responses. To this end the ideas of all participants generated for the AUT problem were collected into a comprehensive lexicon. Synonyms were identified and ideas collapsed accordingly. If a response was statistically infrequent (i.e., if 5% or less participants in the sample gave the response), then it was given a score of"1". All other responses received scores of "0", regardless of how often they appeared. Following this scoring procedure, two trained raters independently assessed the originality of the AUT performance for every participant. The inter-rater agreement (ICCs = .94) is satisfactory. Afterwards, the originality scores of the AUT performance by two raters were averaged for every participant, as were the scores in each of four epochs.

3. Results

3.1. Change of MW frequency across epochs

An ANOVA for repeated measures, with GROUP (high MW vs. Low MW) as the between-subject factor and EPOCH (1st, 2nd, 3rd, and 4th) as the within-subject factor, was performed on the MW frequency. There was a significant main effect for GROUP (F (1, 55) = 60.01, $p < .001$, $\eta_p^2 = .52$) and for EPOCH (F (3, 165) = 10.36, $p < .001$, $\eta_p^2 = .16$). Overall, the MW frequencies averaged across four epochs were significant higher for the high ($M = .85$, $SE = .06$) than the low ($M = .22$, $SE = .06$) MW group. Most importantly, there was a significant interaction effect of EPOCH × GROUP (F (3, 165) = 4.51, $p < .01$, $\eta_p^2 = .08$). Specifically, for the high MW group, EPOCH exerted a main effect on the MW frequency (F (3, 81) = 10.33, $p < .001$, $\eta_p^2 = .28$). The MW frequency was lower in the first epoch than in other three epochs (post hoc Tukey HSD test, $ps < .01$); the MW frequency in the second epoch was lower than that in the fourth epoch ($p < .05$). For the low MW group, however, there was no effect of EPOCH on the MW frequency (F (3, 84) = 1.05, $p = .37$, $\eta_p^2 = .04$) (see Fig. 1). These results indicated that the high MW group showed greater MW as time passed, but the MW frequency with time passing remained steady for the low MW group.

3.2. Creative performance of high and low MW groups

An ANOVA for repeated measures with GROUP and EPOCH as the between- and within-subject factors was performed on the fluency scores. The results revealed a significant effect of GROUP (F (1, 55) = 33.77, $p < .001$, $\eta_p^2 = .38$). Overall, the fluency scores averaged across epochs were higher for the low MW group ($M = 9.91$, $SE = .48$) than for the high MW group ($M = 5.96$, $SE = .49$). Moreover, there was a significant effect of EPOCH on the fluency scores (Greenhouse–Geisser corrected dfs; F (2.68, 147.44) = 92.15, $p < .001$, $\eta_p^2 = .63$). The fluency scores in the first epoch were higher than those in other three epochs (post hoc Tukey HSD test, $ps < .001$); the scores in the second epoch were higher than those in later two epochs ($ps < .01$). There was no interaction effect of EPOCH × GROUP (F (2.68, 147.44) = 1.66, $p = .18$, $\eta_p^2 = .03$) (see Fig. 2). These results indicated that the low MW group generated more ideas as compared to the high MW group; both of high and low MW groups generated fewer and fewer ideas as time passed.

Another ANOVA for repeated measures revealed a significant main effect of GROUP on the originality scores (F (3, 55) = 31.17, $p < .001$, $\eta_p^2 = .36$). The originality scores averaged across epochs were higher for the low MW group ($M = 2.82$, $SE = .22$) than for the high MW group ($M = 1.09$, $SE = .22$). In addition, there was a significant interaction effect of EPOCH × GROUP (F (3, 165) = 2.84, $p < .05$, $\eta_p^2 = .05$). Specifically, for the high MW group, there was a significant effect of EPOCH on the originality scores (F (3, 81) = 3.11, $p < .05$, $\eta_p^2 = .1$). The originality scores in the fourth epochs were lower than those in other three epochs (post hoc Tukey HSD test, $ps < .05$). But for the low MW group, the originality scores in four epochs showed no different from each other (F (3, 84) = 2.14, $p = .1$, $\eta_p^2 = .07$) (see Fig. 3). These findings indicated that the originality of the generated ideas remained steady with time passing for the low MW group, but it tended to be lower for the high MW group.

3.3. Thinking contents irrelevant to idea generation of high and low MW groups

An ANOVA for repeated measures with GROUP (high MW vs. low MW) and THINKING CONTENT (TUTs vs. TRIs) as the between- and

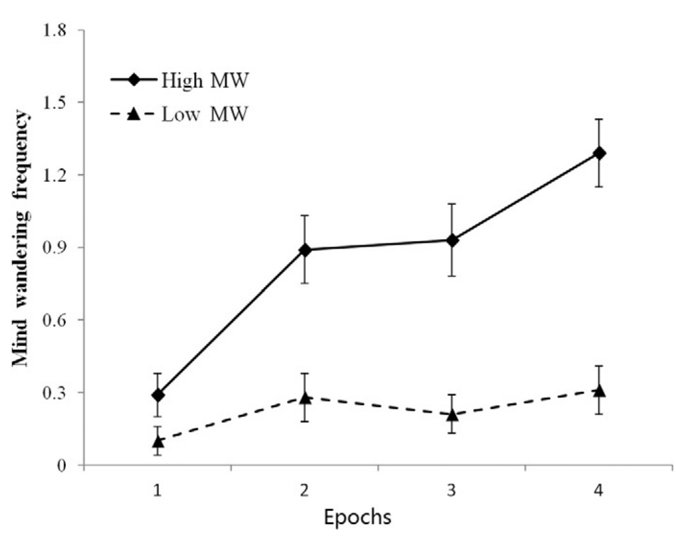

Fig. 1. Mind wandering (MW) frequencies across epochs of high and low MW groups. Error bars indicate standard errors of the mean.

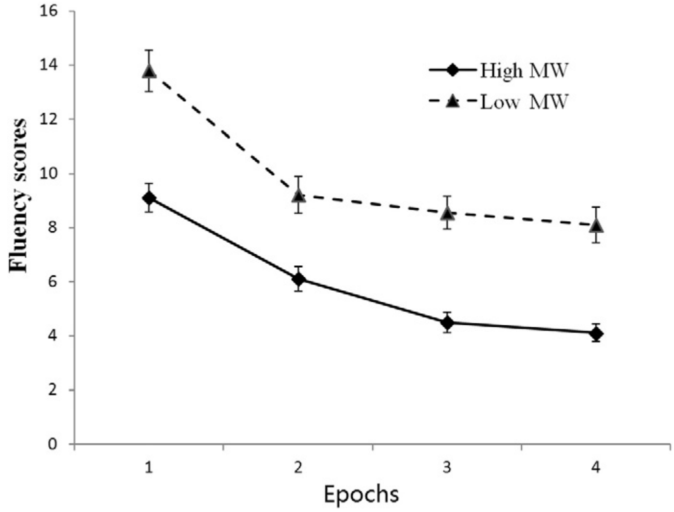

Fig. 2. Alternative uses task (AUT) fluency scores across epochs of high and low MW groups. Error bars indicate standard errors of the mean.

within-subject factors was performed on the self-rated frequency scores. The results revealed no significant main effect for GROUP (F (1, 55) = 3.09, p = .08) and for THINKING CONTENT (F (1, 55) = 2.29, p = .13). However, there was a significant interaction effect of THINKING CONTENT × GROUP (F (1, 55) = 5.07, p < .05, η_p^2 = .08). Specifically, the TUTs scores were not different between the High (M = 14.96, SE = 4.24) and Low (M = 14.93, SE = 4.54) MW groups, but the TRIs scores were higher for the high (M = 17.79, SE = 5.07) than the low (M = 14.38, SE = 4.72) MW group (F (1, 55) = 6.9, p = .01). These findings indicated that high MW individuals thought about the task-related interferences more frequently than low MW individuals during the generation of creative ideas.

3.4. Relationships between TUTs, TRIs, IPI, MW and creative performance

As shown in Table 1, the MW frequency showed no correlation with TUTs, TRIs or IPI score. The IPI score had no correlation with the fluency or originality score. The TRIs score showed negative correlations with the fluency score (p < .01, two-tailed) and the originality score (p < .05).The MW frequency was negatively correlated with the fluency and originality scores (ps < .01).

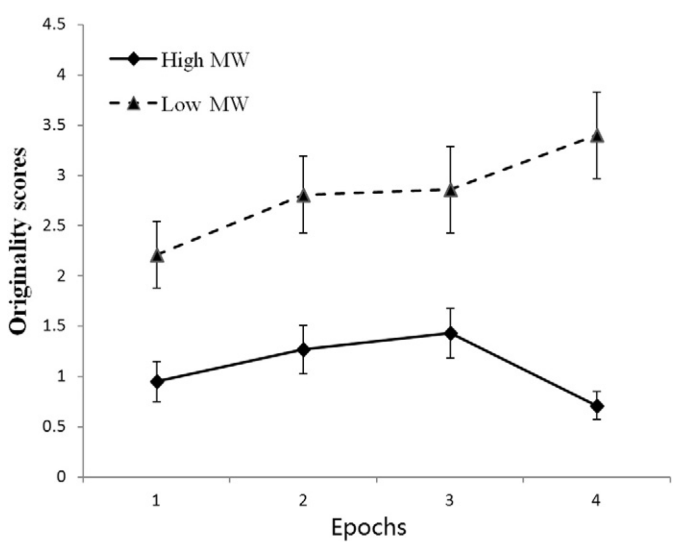

Fig. 3. Alternative uses task (AUT) originality scores across epochs of high and low MW groups. Error bars indicate standard errors of the mean.

Further, linear regressions were conducted with TUTs, TRIs, IPI score and the probe-caught MW frequency as predictors, with task performance as the independent variable. The regression with the fluency score as the independent variable (R^2_{adj} = .22, F = 4.91, p < .01) revealed that the MW frequency was a significant predictor ($\beta = -.33$, p < .01), as was the TRIs score ($\beta = -.35$, p < .01). Another regression with the originality score as the independent variable (R^2_{adj} = .18, F = 3.98, p < .01) also found that both the MW frequency ($\beta = -.31$, p < .05) and the TRIs score ($\beta = -.29$, p < .01) were significant predictors. These findings indicated that more frequently people think about task-related interferences during the idea generation, worse their creative performance would be.

3.5. Influences of inserting thought probes on AUT performance

The AUT performance of the control and experimental groups was compared. The results revealed that the fluency scores showed no significant difference between these two groups (t (85) = 1.42, p = .16), nor did the originality scores (t (85) = 1.22, p = .23). These results demonstrated that inserting thought probes did not interfere with the performance on the AUT problem.

4. Discussion

The aim of this study was to examine the effects of the MW that occurs in the course of creative idea generation. The results revealed that lower MW frequency during the course of idea generation was associated with higher fluency and originality scores on the AUT (see Figs. 2, 3 and Table 1). The low MW group generated ideas with high originality continuously as time went by, while the high MW group tended to produce ideas with lower originality as time passed (see Fig. 3). Previous studies suggested the positive effects of MW on creativity when the MW occurs in the incubation period (Baird et al., 2012), but the present study testified, for the first time, that the MW during creative idea generation is negatively related to creative thinking.

Creative idea generation has been demonstrated to be a top-down executive process (Beaty et al., 2014; Benedek et al., 2014a; Runco, 1994), in which many control processes are involved. These include inhibition of interference of external unrelated stimuli (Benedek et al., 2011; Benedek et al., 2014b; Fink et al., 2009, 2010), inhibiting dominant but not novel responses (Beaty & Silvia, 2012; Nusbaum & Silvia, 2011; Silvia & Beaty, 2012), conducting directed search and retrieval processes (Beaty & Silvia, 2013; Silvia, Beaty, & Nusbaum, 2013), judging and refining initial ideas (Finke, Ward, & Smith, 1992; Gabora, 2005; Runco & Smith, 1992; Vartanian, 2011), and choosing and applying strategies that vary in effectiveness (Gilhooly, Fioratou, Anthony, & Wynn, 2007). Whereas MW was suggested to consume the control resources (Schooler et al., 2011; Smallwood, 2010, 2013; Smallwood &

Table 1
Descriptive statistics and the results of correlations (N = 87).

	M	SD	2	3	4	5	6
1. TUTs[a]	15.05	4.19	.24*	.12	−.02	−.18	−.04
2. TRIs[b]	16.56	5.42		.04	.15	−.29**	−.22*
3. IPI[c]	34.43	8.62			−.10	.03	.11
4. MW frequency[d]	2.14	1.73				−.39**	−.37**
5. Fluency	30.51	12.47					.88**
6. Originality	7.38	5.28					

Note: MW = mind wandering.
[a] Scores of the TUTs subscale of the Dundee Stress State Questionnaire (DSSQ).
[b] Scores of the TRIs subscale of the Dundee Stress State Questionnaire (DSSQ).
[c] Scores of the Daydreaming Frequency subscale of the Imaginal Processes Inventory.
[d] Since the probe-caught MW frequencies were not collected for the control group, only data of the experimental group (N = 57) were included in the correlation analyses between the MW frequency and other factors.
* p < .05.
** p < .01.

Schooler, 2006), and in particular the "inhibition" resources (Kam & Handy, 2014); MW was proposed to indicate a temporary breakdown in control processes on the target tasks (Kane & McVay, 2012; McVay & Kane, 2010a,b; Stawarczyk et al., 2014). Accordingly, the MW that occurs during creative idea generation could negatively influence creativity, as was observed in this study.

Previous research suggested that creative idea generation starts from the retrieval of common and old ideas, and then follows the actual generation of novel and more creative ideas by overcoming typical or old responses (Gilhooly et al., 2007). This proposal is consistent with recent neurophysiological evidences (Benedek et al., 2013; Schwab, Benedek, Papousek, Weiss, & Fink, 2014). Conceivably, as time passes in the course of AUT performance, participants need a large amount of control resources to inhibit the interference of old ideas or external stimuli, as well as maintain attention on idea generation. Compared to the individuals with low MW, people with high MW (i.e., with low control abilities) are less efficient in maintaining their attention on the ongoing task (McVay & Kane, 2009, 2010a). So the high MW group tended to show greater MW as time passed, while the low MW group tended to be steady in the MW frequency (see Fig. 1). Consistent with the change tendencies of MW frequency, it was found that the originality scores of AUT performance decreased with time passing for the high MW group, but remained steady for the low MW group (see Fig. 3). These results are in line with the findings that people with greater increases in mind wandering over time demonstrated larger declines in response accuracy over time (Thomson, Seli, Besner, & Smilek, 2014), and people with higher intelligence (as an indicator of control abilities) tended to continuously generate high original ideas as time passed (Beaty & Silvia, 2012).

The present findings did not refute the proposal that the MW occurring in the incubation period may positively affect creativity (Baird et al., 2012). Recall here that the *Explicit–Implicit Interaction* (*EII*) *model* (Helie & Sun, 2010) suggests that creative thinking involves both implicit associative processes and explicit control processes. Many studies demonstrated that both associative and executive processes contribute to creative cognition (Beaty et al., 2014; Benedek et al., 2014a; Benedek, Könen, & Neubauer, 2012b). Our recent study revealed that the interpolated tasks that were assumed to elicit remote associative processes in the incubation periods also afforded benefits to creative thinking (Hao et al., 2014). The aforementioned findings provided evidence to support the proposal that remote associative processes elicited by the MW in the incubation period would be beneficial for creativity. However, things are different when the MW occurs during an idea generation stage of the creative process. The present study suggests that higher MW during idea generation is associated with worse creative performance, perhaps because MW impairs the control processes involved in creative idea generation.

Several additional issues should be discussed briefly. First, the present results indicated that inserting thought probes did not interfere with the AUT performance. This result supports the finding that "thought probe" is a secondary task with little interference effect on the target task (Giambra, 1995); thus "thought probe" is a reliable and efficient way to measure the MW in an online fashion (Giambra, 1995; Schooler, Reichle, & Olga, 2004; Smallwood & Schooler, 2006; Teasdale et al., 1995). Second, the results revealed that the high MW people thought about the TRIs more frequently than the low MW people, and only the TRIs frequency was associated with worse creative performance. This adds new knowledge to the research on MW and creativity. Accordingly, future studies should use thought-probes that can distinguish TUTs from TRIs (e.g., the thought-probes include three options: 1 = task-related thoughts; 2 = task-unrelated thoughts; 3 = task-related interferences) rather than simply asking whether the participants are experiencing on/off-task thoughts. This manipulation contributes to reveal how different irrelevant thinking contents (i.e., TUTs and TRIs) during the course of idea generation have different effects on creative performance. Third, the TUTs, TRIs and IPI scores showed no significant correlation with the probe-caught MW in this study. This may be because that the self-caught measures may confound MW with awareness of MW, resulting in inaccuracy for assessing the online MW to some extent (Smallwood & Schooler, 2006). Also, this finding may indicate that the questionnaires administered during the post-experimental session are not sensitive to catch the online MW for the "retrospective bias" (Smallwood et al., 2004).

There were three limitations to this study. First, in order to elicit MW during creative idea generation, participants were asked to solve only one AUT problem in a comparably long period (i.e., 20 min). Thus there might be a problem of reliability in using only one task. Further research should adopt more than one verbal divergent thinking (DT) tasks (e.g., Instances task; Wallach & Kogan, 1965). Second, when creating Chinese version of questionnaires (i.e., IPI and the thinking part of the DSSQ), we did carefully discuss the Chinese translation of every item of the questionnaires, and send the translated versions to potential participants to modify the items. Yet, it was still a methodological limitation that we did not use the back-translation methods. Third, the results on verbal DT performance (i.e., the AUT problem) cannot be generalized to the domain of solving insight problems (e.g., the Remote Associates Task, RAT; Mednick, 1962). Given that insight problem solving is suggested to be a spontaneous process in which executive functions are not necessarily involved (Ash & Wiley, 2006; Gilhooly & Fioratou, 2009; Jarosz, Colflesh, & Wiley, 2012; Wieth & Zacks, 2011), the effect of MW in insight performance might be different from that in verbal DT performance.

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