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The Shower Effect: Mind Wandering Facilitates Creative Incubation During Moderately Engaging Activities

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People often seem to generate creative ideas during moderately engaging activities, such as showering or walking. One explanation of this *shower effect* is that creative idea generation requires a balance between focused, linear thinking (which limits originality) and unbounded, random associations (which are rarely useful). Activities like walking may help us strike this balance by allowing mind wandering in an engaging environment that places some constraints on thought. Although past studies have found an inconsistent relationship between mind wandering and creative idea generation, they have two limitations. First, creativity researchers have not studied a key form of mind wandering, which is freely moving thought. Second, studies have used boring tasks that may encourage unconstrained and unproductive mind wandering. To overcome these limitations, we investigate the relationship between idea generation and freely moving mind wandering during boring versus engaging video tasks. Across two studies, we find that mind wandering leads to more creative ideas, but only during moderately engaging activities. Boring activities lead to either more ideas or more semantically distant ideas overall, but these effects were unrelated to mind wandering. Boring activities may therefore lead to ideas by affording time for focused problem solving, whereas engaging activities may do so by encouraging productive mind wandering.

Keywords: creativity, mind wandering, incubation, divergent thinking, boredom

> My best ideas come in the shower.
>
> —4,710 hits on Google

Nearly 5,000 websites include a version of this quote, illustrating a prominent idea in popular psychology. Creative breakthroughs often come when we are doing a moderately engaging activity, such as showering, doing the dishes, or taking a walk. Anecdotes of this phenomenon abound: Archimedes reportedly had his "Eureka!" moment while taking a bath, for example, and Virginia Woolf "made up" *To the Lighthouse* while "walking round Tavistock Square" (Schulkind, 1976, p. 81). The idea that "taking a break" facilitates creativity also has a long history in psychology. In 1926, Wallas (1926) proposed that creative solutions to a problem often comes during an "incubation period" when we engage in an unrelated activity like taking a walk.

One theoretical explanation of these reported effects is that incubation is successful during moderately engaging activities like showering and walking because they encourage a productive form of mind wandering that contributes to the generation phase of creativity. Creativity involves distinct stages and processes, some focused on the generation and others on the evaluation of creative ideas (Beaty et al., 2016; Ellamil et al., 2012; Girn et al., 2020; Simonton, 1999). Recent theories predict that creative idea generation requires that one strikes a balance between focused, linear thinking—which limits originality—and unbounded, random associations—which are often irrelevant to our creative problems (Beaty et al., 2017; Christoff et al., 2016; Irving, 2016). Activities like walking may help us strike that balance by allowing for mind wandering in an engaging environment that still places some external constraints on thought. Such activities are easy enough to allow mind wandering. But they may be engaging enough that the subject intermittently attends to her environment, which influences and perhaps constrains the contents of her mind wandering.

Despite this attractive theoretical story, the empirical evidence for an association between incubation, creative idea generation, and mind wandering is quite mixed. In many cases, the association between mind wandering and aspects of creativity seems positive. Sio and Ormerod's (2009) large meta-analysis on incubation effects—that is, the improvements in creative problem solving

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Data and analyses for both experiments reported in this article are available on the Open Science Framework (https://osf.io/73sxk/).

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after a period of unrelated activity—found that incubation was most beneficial when the subject's unrelated activity was an easy task rather than a difficult task or even rest. Baird et al.'s (2012) influential study replicated this effect and showed that it is associated with task-unrelated thought, which is the most common definition of mind wandering in the literature. They found that the easy tasks led to the highest (a) incubation effects and (b) retrospective reports of task-unrelated thought, thus establishing a condition–level association between mind wandering and creativity (as assessed through a divergent thinking task, which contributes to the idea generation phase of creativity; Lubart, 2001; Mumford & McIntosh, 2017). Subsequent researchers have also found correlations between task-unrelated thought and other tasks associated with creative idea generation, including insight problems (Tan et al., 2015) and the compound remote associates task (Leszczynski et al., 2017). Even more recently, Gable et al. (2019) found that physicists and writers report generating about 20% of their creative ideas while thinking about something else.

Although these results seem to suggest a straightforward association between creative idea generation and mind wandering, other studies suggest that this relationship is not present in all contexts. Researchers failed to find a relationship between task-unrelated thought and incubation in two conceptual replications (Smeekens & Kane, 2016; Steindorf et al., 2021) and one direct replication (Murray et al., 2021) of Baird et al. (2011). Furthermore, Hao et al. (2015) found that task-unrelated thought interferes with creative idea generation, when participants go off-task while they are trying to generate creative ideas. One interpretation of Hao et al.'s results is that unfettered thoughts, which are often unrelated to one's creative problems, do not help to generate ideas.[1] Instead, creative idea generation may require a balance between freely moving and focused thinking.

The unclear state of the literature may be due to two methodological limitations of previous laboratory studies of incubation, creative idea generation, and mind wandering. First, past studies have focused on the relationship between incubation and task-unrelated thought. But not all task-unrelated thought involves the form of mind wandering—freely moving thinking—that has been closely linked to creativity (Christoff et al., 2016; Girn et al., 2020; Irving, 2016, 2021; Irving et al., 2020; Sripada, 2018).[2] Freely moving thinking is characterized by its dynamics: how it meanders from one topic to another over time. On our operational definition, "your thoughts move around freely when there is no overarching purpose or direction to your thinking. Instead, your thoughts drift from one thing to another without focusing on anything for too long" (Study 1).

Leading theoretical models (Christoff et al., 2016; Irving, 2016) and empirical studies (Mills et al., 2018; Smith et al., 2018) suggest that not all task-unrelated thought is freely moving. Consider the range of thinking one can engage in when one's thoughts are unrelated to the sustained attention to response task (SART). One's mind might be wandering freely between loosely associated ideas. Or one might be deliberately thinking about an unrelated topic in a linear manner, and thus engaged in a type of constrained and convergent thinking.

The nonidentity of task-unrelated and freely moving thought matters because philosophical (Irving, 2016, 2021) and theoretical (Christoff et al., 2016; Sripada, 2018) models suggest that freely moving thought in particular—rather than task-unrelated thought in general—should facilitate creative-idea generation. Furthermore, researchers who found no benefits of task-unrelated thought during incubation have explicitly hypothesized that freely moving thought may be more helpful (Murray et al., 2021). There are therefore theoretical and empirical reasons to investigate the relationship between freely moving thought and creative idea generation. Consistent with this, a set of experiments by Agnoli et al. (2018) found that different types of task-unrelated thought have a distinct impact on creativity. But, while they exposed the contrasting effects of intentional and unintentional task-unrelated thought (Seli et al., 2016) on divergent thinking tasks, they did not examine the role of freely moving thought.

Past results may be inconsistent for a second reason: incubation studies have used laboratory tasks that are not ecologically valid examples of moderately engaging activities like walking (Williams et al., 2018). In particular, most studies use the SART (Baird et al., 2012; Leszczynski et al., 2017; Robertson et al., 1997; Smeekens & Kane, 2016; Tan et al., 2015), where subjects respond to boring stimuli (e.g., looking for a *3* when randomly presented with numerals between *1* and *9*) for upward of 1 hr. Boring laboratory tasks like the SART are known to induce high rates of task-unrelated thought (Baird et al., 2012; Smallwood et al., 2004; Teasdale et al., 1995; Thomson et al., 2013): If your task is boring, you will likely think about something else. Researchers who hypothesize that task-unrelated thought facilitates creativity therefore have reasons to test this hypothesis using tasks that are as boring as possible (cf. Murray et al., 2021). But as we stated in the preceding text, it is not clear that task-unrelated thought in general—rather than freely moving thought in particular—should facilitate creativity.

Furthermore, boring laboratory tasks like the SART contrast sharply with activities like "walking round Tavistock Square," which allow for mind wandering in a semantically rich, engaging environment. Engaging environments likely receive some of the subject's attention, which may constrain freely moving thought in useful ways. For one, external stimuli may prime the mind to wander in novel directions that the subject would ignore without external input. Furthermore, engaging environments likely restrict where the mind wanders, because the subject is intermittently thinking about the environment. These restrictions may inhibit freely moving thoughts that undermine creativity because their contents are either completely random or about quotidian ideas like a to-do list, which are unrelated to creative problems. Hence, there are theoretical reasons to believe that mind wandering may lead to incubation in a more engaging context, though this prediction has not been empirically tested.

Here we present two studies that address both limitations mentioned in the preceding text. First, we measured the relationship between incubation and freely moving thought rather than task-unrelated thought. Second, we used ecologically valid tasks to

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[1] Hao et al.'s (2015) results should be interpreted with caution, since they used summative originality scores to measure creative idea generation. Such originality scores can be confounded with fluency (Forthmann et al., 2020) and the originality scoring method can vary from study to study (Reiter-Palmon et al., 2019). That said, the fact that three other studies also failed to find a connection between task-unrelated thought and creative idea generation provides converging evidence that this relationship is context-dependent.

[2] By saying that freely moving thought is a form of mind-wandering, we wish to remain neutral on the debate between the dynamic and family resemblance theories of mind-wandering (Christoff et al., 2016; Irving & Glasser, 2019; Seli et al., 2018; Christoff et al., 2018; Irving et al., 2020). These views disagree over whether mind-wandering has a single defining feature (free movement). But they agree that freely moving thought is an important form of mind-wandering.

manipulate boredom and engagement through videos. In one incubation condition, participants watched a boring video of two men folding laundry (Danckert & Merrifield, 2018; Merrifield & Danckert, 2014); in the other condition, participants watched an engaging video from *When Harry Met Sally* (Gilman et al., 2017; Gross & Levenson, 1995; Schaefer et al., 2010). We therefore aim to assess whether freely moving thought helps to generate creative ideas and, if so, the contexts in which it is most effective.

Our main prediction is that mind wandering should aid creative incubation during moderately engaging, rather than completely boring tasks. The adage says that people generate creative ideas in the shower, not while idly zoning out on the couch. A secondary prediction is that boring tasks will still have a main effect of incubation simply because they afford more time for participants to focus on a problem. When you're bored on the couch, for example, you may be motivated to get up and go back to work on a project. Our secondary prediction differs from theorists who have hypothesized that boredom increases creativity by increasing mind wandering (Elpidorou, 2018b; Gomez-Ramirez & Costa, 2017; Mann & Cadman, 2014; Park et al., 2019), and instead fits with models on which boredom motivates people to switch to a new goal-directed task (Bench & Lench, 2013; Elpidorou, 2014, 2018a). In sum, boring tasks may afford more time to focus on a problem (i.e., Prediction 2). Yet we are primarily interested in conditions that should lead to productive mind wandering, under the hypothesis (i.e., Prediction 1) that creative idea generation benefits from moderate constraints (Beaty et al., 2017; Christoff et al., 2016; Irving, 2016).

Experiment 1

Method

Participants

Participants ($N = 222$; $M_{\text{age}} = 18.6$; 185 female) completed the study in the laboratory in Fall 2019. We decided to collect as many participants as possible until the semester ended, given that there were no prior effects on which to base a power analysis with our altered version of the alternate uses task (AUT). For comparison, we note that our sample included more participants than did other articles that have reported a relationship between mind wandering and creativity (e.g., Baird et al., 2012). Participants completed the study in a single testing session on a 15-in. laptop, with stimuli administered through PsychoPy.

Participants were compensated with course credit from a public university in the Northeastern US and provided written consent consistent with the procedures of this university.

Four additional participants were excluded due to their noncompliance with the AUT task preincubation; these participants typed random or inappropriate words in the response box and were thus removed from all analyses. Finally, an additional participant was excluded who did not follow instructions and listed over 50 words preincubation and over 10 random words after watching the video. This resulted in a final sample size of 217.

Preincubation AUT

Before watching the video, participants were presented with an online adapted version of the AUT (Guilford, 1957; Kudrowitz & Dippo, 2013). The main adaptation of the task was the amount of time given to complete the trial. On the initial trial, participants were given 90 s to type as many alternate uses for either a "brick" or a "paperclip: as they could, which is shorter than in the previously mentioned studies. We used this short interval because our goal was not only to test divergent thinking capability as a general trait, but also to examine the in situ experience of generating new solutions to the AUT during the incubation period. By limiting the AUT time before incubation, participants were less likely to have exhausted their ideas before incubation, and thus differences were more likely to reflect ideas generated during incubation. All participants were randomly assigned to one of these two AUT items. We used this between-subjects design to ensure that participants would not be able to develop different strategies across trials, such as simply ignoring the video.

Incubation (Constraint Manipulation: Boring Versus Engaging)

During a 3-min incubation period, participants were randomly assigned to a boring or engaging activity. This manipulation was designed to test our primary prediction: namely, that mind wandering should be most beneficial for idea generation during moderately engaging, compared with boring, activities. Following past studies, participants in the boring condition watched a video of men folding laundry (Danckert & Merrifield, 2018; Merrifield & Danckert, 2014), whereas participants in the engagement condition watched a clip from the movie *When Harry Met Sally* (Gilman et al., 2017; Gross & Levenson, 1995; Schaefer et al., 2010). Both videos were trimmed to be similar in length (about 3 minutes), a time-frame long enough to successfully induce affective states (Gilman et al., 2017; Gross & Levenson, 1995; Schaefer et al., 2010) and allow participants to generate creative ideas.

Postincubation AUT

After the incubation period, participants were given a short interval (45 s) to record AUT answers that they thought of during the incubation period. Specifically, we asked "Did you think of any additional alternate uses of your item DURING the course of the video? If so, please list them below. You will only have a short period of time!" Our instructions and relatively short postincubation interval were designed to encourage participants not to generate new ideas after the incubation period. This allowed us de-confound two potential effects of constraints and mind wandering. First, constraints and mind wandering may affect the process of incubation itself, as measured by ideas generated during the incubation interval. Second, constraints and mind wandering may prime participants to think differently for a short time after incubation, as measured by ideas generated after the incubation interval. Because our research question concerned the process of incubation itself, we modified the traditional method of AUT in order to capture only the ideas that were generated during the 3-min incubation interval. This involved keeping the window for responses intentionally very short, so that participants did not have time to generate any additional AUT responses in the time window. We note up front that this adaptation will likely change the amount (and thus distribution) of possible AUT responses, such that we expect to be much lower. That is, some participants may not have thought of any additional AUT answers during the video, creating a zero-inflated and positively skewed distribution compared with the traditional AUT scoring.

AUT Scoring

Creative idea generation typically requires (a) the generation of many—(b) some novel—ideas. Thus, we scored the AUT in two ways, corresponding to each requirement of creative idea generation. First, we recorded a raw count of how many additional ideas were produced in the postvideo AUT time period. Second, answers were scored for their originality: that is, the semantic distance between each generated word and the original word cue (i.e., "brick" or "paperclip"). Semantic distance scoring was completed using SemDis (Beaty & Johnson, 2020), an automated open-source application. For the SemDis analysis, we did not alter responses beyond correcting any misspellings so that words would be recognizable. The distance scores for each word were averaged for each participant for each AUT response window (i.e., two scores per person). SemDis was computed with the settings: remove fillers and clean, use all semantic spaces, and use a multiplicative compositional model. Specifically, we used the average semantic distance score (SemDis_*M*) across the following five semantic spaces: cbowukwacsubtitle, cbosubtitle, cbowBNCwikiwac, GLoVe, and TASA. Because some participants provided alternate uses in the form of multiword phrases, we needed to specify a compositional model in the SemDis application. We used the multiplicative model which calculated the product of the words in a phrase into a single value, as opposed to the additive model which summed up the words into a single value. The multiplicative model has indicated higher correlation with human scoring of creativity (Beaty & Johnson, 2020; Mitchell & Lapata, 2010). When presenting our results, we use the term *idea generation* to refer to the number of ideas generated and the terms *originality* or *semantic distance* to refer to whether those ideas are novel. We use the term *creative idea generation* to refer to the process that requires both components.

Freely Moving Thought

Three times during the incubation period, we interrupted participants and asked whether their thoughts were "moving around freely" and asked them to rate their experience on a scale ranging from 1 (*not at all*) to 7 (*very much so*). Experimenters read the following instructions to operationally define freely moving thought: "Your thoughts move around freely when there is no overarching purpose or direction to your thinking. Instead, your thoughts drift from one thing to another without focusing on anything for too long." Participants rated their engagement in this type of thought on a scale ranging from 1 (*not at all*) to 7 (*very much so*). A summary of these questions and the rating scales were on a handout that participants kept throughout the study.

Participants answered a total of three probes throughout the video (spaced roughly 1 min apart). All participants received probes at the same location in the video. Previous behavioral (Mills et al., 2018; Smith et al., 2018) and electrophysiological (Kam et al., 2021) studies indicate that one can use this probe and instructions to measure freely moving thought.

Control Variables

We also included a set of control variables such as demographics, trait boredom, and verbal fluency that were measured using online versions of self-report questionnaires. Verbal fluency was measured as a control given its relationship with things like intelligence and divergent thinking (i.e., someone's verbal ability may influence their ability to generate responses on a verbally dominant task; Benedek et al., 2012; Silvia et al., 2013). These included the Boredom Proneness Scale (BPS; Craparo et al., 2013) and a semantic verbal fluency (SVF) animal-naming task (Abreu et al., 2013).

Statistical Approach

All statistical analyses were completed using the statistical software R. Significance testing was done using the *car* package and is presented using F and chi-square tests to determine if the effects explained the significant variance in the dependent variable (Fox et al., 2013). Models were constructed using Welch's t tests and linear regressions, except postvideo idea generation scores where the distribution was nonnormally distributed and thus likely to influence the distribution of the residuals in a linear regression. With this in mind, and in line with previous work (Myszkowski & Storme, 2021), we constructed Poisson regressions for postvideo idea generation; however, we note that results display the exact same pattern if negative binomial models are used.

Results

Group Level Differences

To ensure that participants in our boring and engaging conditions were comparable, we compared the divergent thinking scores (number of ideas and semantic distance) across the two groups in the preincubation period (i.e., before they watched the video). Welch's independent samples t test were used, as we do not assume the groups have the same variance, and thus the degrees of freedom will vary. There were no differences between the two conditions on the number of ideas generated, $t(214) = .721$, $p = .472$, 95% CI [−.851, .395], $d = -.10$. There was also no difference in semantic distance scores in the preincubation period, $t(205) = .081$, $p = .936$, 95% CI [−.017, .019], $d = .01$. Finally, there was not a difference between verbal fluency across the video conditions, $t(210) = .139$, $p = .890$, 95% CI [−1.06, 1.22], $d = .02$.

Although there were no differences across the video conditions, there was a difference in the preincubation semantic distance scores based on the AUT item assigned (brick vs. paperclip), $t(138) = -5.57$, $p < .001$, 95% CI [−.067, −.032], $d = .81$, where participants had higher semantic distance in the paperclip condition ($M = .94$, $SD = .04$) compared with the brick ($M = .89$, $SD = .08$). There was no significant difference in the number of ideas generated based on the AUT item, $t(204) = 1.38$, $p = .169$, 95% CI [−.188, 1.06], $d = .19$. We therefore included AUT item as a control variable as an additional check in Experiment 1.

Manipulation Check

In line with previous studies of mind wandering (Baird et al., 2012; Danckert & Merrifield, 2018; Eastwood et al., 2012; Isacescu et al., 2017; Raffaelli et al., 2018), a linear regression revealed more freely moving thought ($B = -.884$), $F(1.4, 215) = 21.6$, $p < .001$, 95% CI [−1.26, −.509], $d = .63$, in the boring condition ($M = 3.48$, $SD = 1.49$) than the engaging condition ($M = 2.60$, $SD = 1.30$). We take this finding to be a manipulation check, indicating that our video conditions and freely moving thought probes generate results that are broadly consistent with the past literature (see Study 2 for more direct manipulation checks). However, a primary question was necessarily about the volume of mind wandering, but rather which conditions may lead to the more "productive" form of mind wandering. That is, which conditions lead to forms of mind wandering that facilitate creative idea generation?

Idea Generation

We thus test whether freely moving thought positively predicts the number of ideas that participants generated during the video, and whether the boring/engaging condition moderates this effect (as per Prediction 1). We constructed a Poisson regression model by regressing the number of ideas generated on freely moving thought, boring/engaging condition, and their interaction term.

As predicted, we found a significant interaction between freely moving thought and the boring/engaging condition ($B = .303$, $\chi^2 = 7.26$, $p = .007$, 95% CI [.083, .523]). Freely moving thought positively predicted idea generation in the engaging condition ($B = .216$, $\chi^2 = 6.40$, $p = .011$, 95% CI [.051, .381], $\beta = .309$). In contrast, there was no relationship found between freely moving thought and idea generation in the boring condition ($B = -.087$, $\chi^2 = .1.39$, $p = .228$, 95% CI [−.234, .060], $\beta = -.136$).

There was no significant relationship of freely moving thought ($B = -.089$, $\chi^2 = .532$, $p = .239$, 95% CI [.051, .059]), and no main effect of condition ($B = -1.02$, $\chi^2 = .274$, $p = .600$, 95% CI [−.178, −.265], $d = .10$). Numerically, there appears to be a slight benefit for the participants in the boring condition ($M = .77$, $SD = .95$) compared with those in the engaging condition ($M = .68$, $SD = .91$). However, we note that this main effect is not significant.

We repeated these analyses under three different conditions to determine whether the finding was robust after including verbal fluency as a covariate to control for the fact that some people may simply find it easier to generate more words after the video, controlling for AUT item (brick vs. paperclip) given the differences we observed in our general random assignment checks; and trying the same interaction with a negative binomial model rather than a Poisson regression. The patterns of results and significance levels did not change for any reported findings.

Semantic Distance

Idea generation represents the sheer number of ideas produced, whereas semantic distance taps into how original' the ideas were. Participants in this analysis were only included if they generated at least one answer during the postvideo AUT ($N = 101$; 46.5% of the data included in the preceding analyses). A linear regression was computed for semantic distance using the same model structure. There was no evidence of an interaction between the boring/engaging condition and freely moving thought ($B = .015$, $F = 1.40$, $p = .239$, 95% CI [−.011, .040]). Freely moving thought was also not related to semantic distance scores ($B = -.007$, $F = .011$, $p = .915$, 95% CI [−.023, .009]). However, we did observe a significant main effect of condition on semantic distance ($B = -.087$, $F = 5.14$, $p = .026$, 95% CI [−.172, −.002], $d = .46$): Participants in the boring condition ($M = .95$, $SD = .08$) had higher semantic distance scores compared with those in the engaging condition ($M = .91$, $SD = .10$). These effects did not change after controlling for verbal fluency.

Discussion

We found evidence that mind wandering facilitates creative idea generation, but only during a moderately engaging activity that places some constraints on thought (Prediction 1). This is consistent with recent theories, on which people generate a larger number of creative ideas when they strike a balance between focused, linear thinking and unbounded, random associations. Specifically, we confirm a prediction of those theories: that mind wandering should be most beneficial in contexts that place moderate constraints on thought. Additionally, participants generated more unusual ideas after a boring activity than an engaging one. But in line with our Prediction 2, the benefits of boredom were likely not driven by mind wandering alone, since freely moving thought did not lead to more or more unusual ideas in the boring condition. Together, these results suggest that different kinds of thinking drive creative incubation during engaging and boring tasks. Whereas engaging tasks lead to productive mind wandering, boring tasks may be beneficial because they allow one to oscillate between periods of focused and unbounded thought (Ellamil et al., 2012; Girn et al., 2020).

Experiment 2

Experiment 2 addressed two limitations of Experiment 1. First, participants in experiment 1 were not told that they would be returning to the AUT, which was also the case in past studies of incubation and mind wandering (Baird et al., 2012; Mann & Cadman, 2014; Park et al., 2019). We were therefore unable to assess whether the benefits of incubation were due to spontaneous processing, or because participants knowingly chose to think about the task. This knowledge may be especially beneficial in the boring condition, where participants could be using constrained thought to generate creative ideas. In contrast, this knowledge may be less beneficial in the engaging condition. Here, we found benefits of freely moving thought, which may have arisen spontaneously rather than intentionally. To test the effect of this knowledge, participants were either given a "vague" or "explicit" indication that they would be returning to the task. Second, participants in Experiment 2 reported whether they found the video engaging, which served as a manipulation check to confirm that our videos successfully induced boredom and engagement.

Method

Participants

Students ($N = 118$; 79% female; age $M = 18.9$, $SD = .91$) participated from the same university as in Experiment 1. We estimated this sample size using G*Power based on the effect size found in experiment 1 ($d = .459$, one-tailed $\alpha = .05$, power = .80), which suggested we needed at least 120 participants.[3] By the end of the semester, we collected 118 and decided to analyze the data at this point.

[3] Future researchers should account for exclusions—participants dropped because they did not yield answers—when calculating sample size using out methods. The fact that we did not account for exclusions is unlikely to have led to a Type 1 error (since our results replicate across two studies) or Type 2 error (since we are, if anything, underpowered).

Instruction Manipulation

The instruction manipulation occurred directly before the boring/engaging video began. In the vague condition, instructions read as follows: "Thank you for completing the first part of this task, you are now going to watch a short video." Whereas the explicit condition instructions read as follows: "Thank you, this task is going to be put on hold for now while you watch a short video, and then you will come back to it." This instructional condition was randomly assigned to each participant.

Manipulation Check

We did not include a manipulation check in Experiment 1 since we wanted participants to move directly from the video task to the postvideo AUT. However, in Experiment 2 we included a manipulation check to provide some assurance that our manipulations were successful. Once the video ended, participants were immediately given a single manipulation check item asking them to rate how they felt while watching the video on a scale ranging from 1 (*extremely bored*) to 7 (*extremely engaged*).

Materials and Procedure

The methods for Experiment 2 were identical to Experiment 1, except the instruction manipulation and manipulation check.

Results

Group-Level Differences

We found no group-level differences between the video conditions in the number of ideas generated for the AUT preincubation, $t(115) = -.077$, $p = .939$, 95% CI [−.903, .834], $d = .01$. There was also no difference in preincubation between the two instruction conditions, $t(110) = -.082$, $p = .417$, 95% CI [−1.23, .515], $d = .15$. The same patterns were observed for semantic distance scores: video condition, $t(97) = -.185$, $p = .854$, 95% CI [−.028, .023], $d = .03$; instruction condition: $t(112) = .555$, $p = .058$, 95% CI [−.018, .036], $d = .10$. We also observed no differences in participants fluency across the two manipulations: video condition, $t(116) = .274$, $p = .785$, 95% CI [−1.37, 1.81], $d = .05$; instruction condition: $t(109) = .056$, $p = .575$, 95% CI [−1.15, 2.07], $d = .10$. Finally, there was no difference in the number of ideas generated between the two assigned AUT items, $t(114) = .026$, $p = .979$, 95% CI [−.432, .444], $d = .00$, but similar to Experiment 1, there was a difference in semantic distance scores across the two items, $t(74) = -3.09$, $p = .002$, 95% CI [−.065, −.014], $d = .61$. We will thus include this in our control analyses in Experiment 2.

Manipulation Checks

To directly test whether our video manipulation was effective, we compared self-reported engagement by condition. People in the engaging video condition ($M = 5.07$, $SD = 1.20$) reported being significantly more engaged than people in the boring condition ($M = 2.08$, $SD = 1.28$), $t(116) = -13.1$, $p < .001$, 95% CI [−3.44, −2.53], $d = 2.41$. This successful induction is consistent with previous studies using similar procedures to elicit boredom (Danckert & Merrifield, 2018; Gross & Levenson, 1995).

Similar to Experiment 1, a linear regression revealed that participants in the boring condition ($M = 3.83$, $SD = 1.40$) reported significantly higher levels of freely moving thought compared with participants in the engaging condition ($M = 2.93$, $SD = 1.31$; $B = -.898$, $F = 12.4$, $p < .001$, 95% CI [−1.39, −.403], $d = .66$). We again take this finding to be a manipulation check, insofar as our results are broadly consistent with the past literature. Freely moving thought was not significantly related to instruction condition (i.e., whether participants expected to return to the task ($F = .812$, $p = .369$, 95% CI [−.784, .631]) or the interaction between instruction condition and boring/engaging condition ($F = .654$, $p = .554$, 95% CI [−1.29, .699]).

Idea Generation

Our main finding in Experiment 1 was an interaction between freely moving thought and the boring/engaging condition. To assess whether these results replicated in Experiment 2, we constructed a similar Poisson model. Specifically, we regressed the number of ideas generated on freely moving thought, video condition, instruction condition, and their corresponding set of interaction terms. As in experiment 1, we found a significant interaction between freely moving thought and video condition ($B = .351$, $\chi^2 = 8.04$, $p = .005$). Post hoc tests revealed that freely moving thought was, once again, positively related to idea generation in the engaging condition ($B = -.076$, $\chi^2 = 5.86$, $p = .016$, 95% CI [.053, .475], $\beta = .374$). This relationship was not observed in the boring condition ($B = -.076$, $\chi^2 = .868$, $p = .351$, 95% CI [−.239, .087], $\beta = -.078$).

We also found no overall relationship between freely moving thought and idea generation ($B = -.085$, $\chi^2 = .542$, $p = .462$, 95% CI [−.291, .122]), nor was there a significant two-way interaction between instruction condition and freely moving thought ($B = -.425$, $\chi^2 = .383$, $p = .536$) or three-way interaction between freely moving thought, boring/engaging condition and instruction condition ($B = .654$, $\chi^2 = .434$, $p = .510$).

We did, however, observe a main effect of the boring/engaging video condition on idea generation ($B = -1.72$, $\chi^2 = 8.05$, $p = .005$, $d = .52$): Participants in the boring condition ($M = 1.34$, $SD = 1.36$) generated about twice as many ideas as those in the engaging condition ($M = .729$, $SD = .925$). This main effect is also consistent even if all other terms are excluded from the model ($p = .001$). Although this trend appeared numerically in experiment 1, the stronger effect in the current experiment may be due to the change in instructions, such that participants in Experiment 2 knew they were returning to the AUT task. There was, however, no main effect of the instruction condition ($B = .069$, $\chi^2 = 1.43$, $p = .233$, $d = .117$). All results presented are robust even after repeating the regressions with fluency and AUT item as covariates, as well as when using a negative binomial model.

Semantic Distance

We finally investigated effects on semantic distance. Participants in this analysis were only included if they generated at least one answer ($N = 68$; 58% of the data included in the preceding analyses). Unlike Experiment 1, a linear regression revealed no significant differences between the boring/engaging conditions; participants in the boring condition ($M = .915$, $SD = .099$) had similar semantic distance scores compared with those in the engaging condition ($M = .904$, $SD = .094$; $B = .044$, $F = .157$, $p = .693$, 95% CI [−.131, .219], $d = .12$). Freely moving thought was again not related to semantic distance scores ($B = .009$, $F = .109$, $p = .742$, 95% CI [−.020, .038], $\beta = .118$), and there was no evidence of any interactions ($p > .4$). Thus, although participants generated more content in the boring condition, the content itself was not necessarily more creative (as assessed by semantic distance).

Discussion

Experiment 2 replicates the central finding from Experiment 1 under different instructional conditions by which participants knew that they would return to the creativity task.

Specifically, we again found that mind wandering—as measured by freely moving thought—facilitates idea generation, but only during a moderately engaging activity that places some constraints on thought (Prediction 1). We now found that participants generated more ideas after a boring activity than an engaging one, but this effect was not driven by freely moving thought (Prediction 2). Interestingly, participants in the boring condition generated more semantically distant ideas in experiment 1 and more overall ideas in Experiment 2, suggesting that foreknowledge increases the quantity of ideas but not necessarily their quality. Future research is needed to determine why participants in the boring condition no longer had more semantically distant ideas in Experiment 2. One possibility is that participants knew they would return to the AUT in Experiment 2, and therefore focused on generating a high number of ideas, which decreased the originality of each idea (as measured by semantic distance). Another possibility is that the results in Experiment 1 were due to chance, since they were only marginally significant ($p = .045$). Further replication studies are necessary to decide between these interpretations. Experiment 2 also included a manipulation check, which showed that the engaging condition led to more self-reported engagement than the boring condition.

General Discussion

Can I come up with creative ideas by mind wandering? This question has captivated the popular imagination and artists (Breton, 1924/1969; Schulkind, 1976), as well as the pages of theoretical (Christoff et al., 2016; Fox & Beaty, 2019; Girn et al., 2020; Sripada, 2018; Williams et al., 2018) and empirical (Agnoli et al., 2018; Baird et al., 2012; Gable et al., 2019; Leszczynski et al., 2017; Tan et al., 2015) journals in cognitive science. Yet conceptual (Smeekens & Kane, 2016; Steindorf et al., 2021) and direct replication (Murray et al., 2021) studies have found an insignificant relationship between mind wandering and creative idea generation, casting doubt as to whether the two are related after all.[4]

Our results help to reconcile this important but perplexing literature. Across two studies, we find that mind wandering (defined as *freely moving thought*) is positively correlated with creative idea generation, but only during engaging activities rather than boring ones (Prediction 1). Our work significantly advances the literature on mind wandering and creativity in two ways. First, we are the first to empirically study how a central form of mind wandering—freely moving thought (Christoff et al., 2016; Irving, 2016; Irving et al., 2020; Irving & Glasser, 2019; Seli et al., 2018)—relates to creative idea generation. Various theoretical models posit that freely moving thought and the divergent thought processes that people use to generate creative ideas belong to the same family of cognitive processes, since both involve a broad, associative, and exploratory mode of thinking (Christoff et al., 2016; Girn et al., 2020; Irving, 2021; Sripada, 2018). But we are the first to empirically test these predictions. In contrast, previous studies have investigated only the relationship between creativity and task-unrelated thought (Baird et al., 2012; Gable et al., 2019; Leszczynski et al., 2017; Smeekens & Kane, 2016; Tan et al., 2015), a broad category that includes not only freely moving mind wandering but various forms of focused, linear problem solving (Christoff et al., 2016; Irving, 2016; Irving et al., 2020; Irving & Glasser, 2019; Seli et al., 2018).

Second, we are the first to study the relationship between mind wandering and creative incubation during moderately engaging activities. Anecdotal evidence suggests that moderately engaging activities such as showering, doing the dishes, or "walking round Tavistock Square" may lead to particularly productive episodes of mind wandering. Yet previous laboratory studies were unable to assess this hypothesis, since they investigated the relationship between creative incubation and mind wandering during an extremely boring attention task: the SART (Baird et al., 2012; Leszczynski et al., 2017; Smeekens & Kane, 2016; Tan et al., 2015). Perhaps it is unsurprising that such boring activities do not always lead to creative varieties of mind wandering, as per Smeekens and Kane (2016). After all, the popular sentiment suggests creative ideas come in the shower, not on the couch. Indeed, both our studies indicate that freely moving thought is correlated with creative idea generation only during an engaging activity (i.e., watching a scene from *When Harry Met Sally*), rather than a boring one (i.e., watching two men fold laundry).

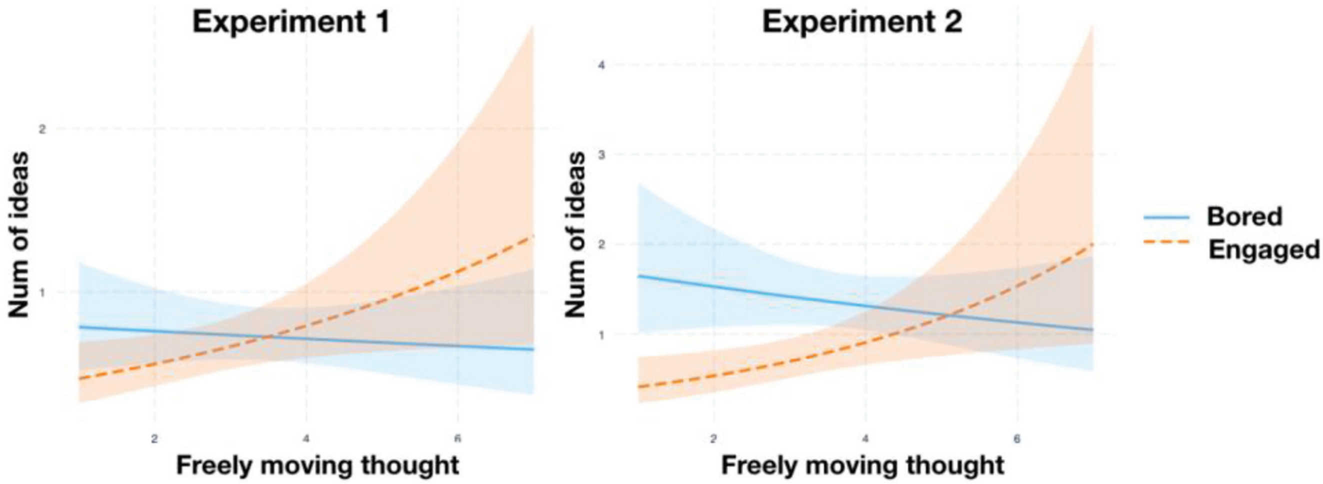
Our results suggest two explanations for why past research has found an inconsistent relationship between mind wandering and creativity. First, past researchers did not study a central form of mind wandering, that is, freely moving thought, which theoretical models link to creativity. Second, past researchers did not study mind wandering during moderately engaging activities, when our results suggest that it is most likely to be productive. We overcome both limitations by identifying both the context and kind of mind wandering is that most closely associate with creative idea generation.

Our results raise a question: Why does mind wandering increase the number of creative ideas during moderately engaging activities but not boring ones? The dynamic theory of mind wandering provides a potential explanation (Christoff et al., 2016; Irving, 2016, 2021; Irving et al., 2020; Irving & Glasser, 2019; see Figure 1). According to this theory, mind wandering and creative thinking are both forms of spontaneous thinking. Spontaneous thinking is subject to relatively weak constraints from the control and salience networks and is thus free to meander broadly to loosely related

[4] Hao et al., 2015 even claimed to find a negative relationship between mind-wandering and creative idea generation, though they use summative originality scores that can be confounded with fluency (Forthmann et al., 2020) and vary from study-to-study (Reiter-Palmon et al., 2019).

Figure 1

Creative Idea Generation by Freely Moving Thought and Condition (Bored, Engaged) in Experiments 1 and 2



Note. The shaded regions are 95% confidence intervals. See the online article for the color version of this figure.

ideas, which can be particularly useful in the generation phase of creative thinking (Girn et al., 2020).[5] Yet constraints are not all or nothing, and instead come on a gradient between pure, random associative thinking and focused, linear thought. Creative idea generation falls in the middle of this gradient: unconstrained enough to allow for a broad exploration of semantic space, but not wholly random, for otherwise one's ideas would not be relevant to the problem at hand (Beaty et al., 2017; Christoff et al., 2016; Irving, 2016). Consistent with this model, Stokes and others have argued that constraints can improve creativity through limiting options (Haught-Tromp, 2017; Stokes, 2001). For example, Cubists generated new styles of painting though constraints by not allowing their paintings to include a single viewpoint or intact objects (Stokes, 2009).[6]

Likewise, moderately engaging activities may lead to productive, creative mind wandering because they place *external constraints* on thinking. Activities such "walking round Tavistock Square" (1882–1941; p. 81) or watching a movie scene allow for mind wandering because they are not overly demanding. Yet during these activities, the subject likely directs some attention to a semantically rich environment: for example, you are more likely to (intermittently) focus on an engaging clip from *When Harry Met Sally* than a boring video of men folding laundry. This could make mind wandering more useful in (at least) two ways. First, doing so could help draw novel associations between ideas. When an engaging environment occupies some of the mind-wanderer's attention, external stimuli may cue the activation of a broad range of stored representations in semantic and episodic memory. But because the subject's thoughts are freely moving, she could draw novel associations between those activated representations instead of simply focusing her attention on the task.

Second, if the subject's engaging environment constrains where her mind wanders, this could inhibit forms of mind wandering that are unlikely to generate creative ideas. In boring environments like sitting on a couch or watching men fold laundry, for example, our minds can wander to quotidian concerns like our daily to-do lists (Baird et al., 2011; Klinger, 1971; Mac Giolla et al., 2017; Morsella et al., 2010) or unrealisticfantasies (Klinger, 1971). Such contents are likely not germane to creative problems like the AUT. In contrast, engaging environments like Tavistock Square might prime our minds to wander to topics other than our routine concerns, but which are still grounded in reality. Our mind wandering may therefore become more fertile grounds for creativity.

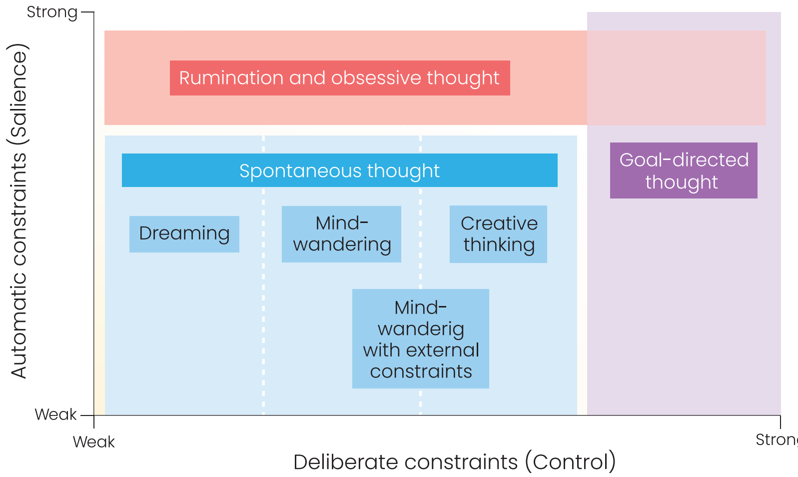
A caveat is in order. Our study was simply designed to test whether freely moving thought helps to generate creative ideas in engaging contexts. We have sketched two information processing models that could explain this "shower effect": external constraints might enhance mind wandering by (a) helping to draw

[5] Like dual-process theories of creativity (e.g. Sowden et al., 2015; Zhang et al., 2020), the dynamic theory proposes a neural model of the classic distinction between generation and evaluation stages of creativity (Ellamil et al., 2012; Girn et al., 2020; Simonton, 1999). But the models differ in important respects. While a full discussion is outside the scope of this article, consider two examples. First, dynamic theorists (Irving, 2016) proposed that the spontaneous/constrained distinction is orthogonal to the division between "reflective" Type 2 processes (that use working memory) and "automatic" Type 1 processes (that do not; Sowden et al., 2015; Evans & Stanovich, 2013). This is for two reasons. First, automatic processes like obsessive thinking can be highly constrained (Christoff et al., 2016; Irving, 2016). Second, working memory can exercise a kind of "meta-control" (Irving, 2021) that supports spontaneous thought (Smallwood & Schooler, 2006; Christoff et al., 2016; Fox et al., 2015; Smallwood, 2010; though see McVay & Kane, 2010). The spontaneous/constrained distinction is also distinct from Zhang et al.'s (2020) distinction between mechanisms that promote flexibility vs persistence. Both theories talk about "meta-control," but they mean something different. Zhang et al. (2020) proposed that meta-control promotes flexibility by maintaining multiple competing goal representations. Dynamic theorists instead argue that meta-control promotes spontaneity by inhibiting first-order control (Arango-Muñoz & Bermúdez, 2021; Irving, 2021; Christoff et al., 2016).

[6] Recent research may also support our hypothesis that creative incubation benefits from moderate levels of constraint. Smith et al. (2022) found a U-shaped relationship between freely moving thought and creative incubation during a 0-back task. Specifically, moderate ratings of freely moving thought were associated with heightened creativity, compared with low and high ratings. Smith et al. did not find the same effect during a 2-back, which is unsurprising, since the 2-back is so difficult that it likely disrupts the normal flow of thinking.

Figure 2

On the Dynamic Theory of Mind-Wandering, Deliberate and Automatic Constraints Focus Thinking on a Narrow Range of Contents



Note. Thinking is spontaneous when constraints are relatively low. Creative thinking typically involves a moderate level of constraints–more than mind-wandering and less than goal-directed thinking. One interpretation of the "Shower Effect" is that moderately engaging activities place external constraints on mind-wandering, which facilitates creative idea generation. Adapted from Christoff et al. (2016). See the online article for the color version of this figure.

novel associations and (b) inhibiting unproductive thoughts. But our study was not designed to test these (or any other) information processing models. Future research is therefore required to provide theoretical and empirical explanations of the shower effect.

The present ideas are consistent with past theories of creative constraints, but expand upon them in a crucial way (Figure 2). Past theories predict that creative idea generation should benefit from moderate levels of *internally-generated* constraints (Beaty et al., 2017; Christoff et al., 2016), such as an artist's representation of her task space (Haught-Tromp, 2017; Irving, 2016; Stokes, 2001). In contrast, our study finds that creative mind wandering arises from moderate levels of *externally* imposed constraints, which one acquires from a moderately engaging activity. This may explain why empirical studies have found that activities like walking (Oppezzo & Schwartz, 2014) help to generate creative ideas, and therefore suggests a new avenue for producing ideas in the laboratory and everyday life. Our results also support recent work, which suggests that mind wandering can be engaged with one's external environment (Irving et al., 2020). Such coupled mind wandering may play an important functional role, insofar as it benefits from external constraints.

Our results also speak to the literature on boredom and creativity. Past research suggests that boredom—an aversive state—may have positive consequences insofar as it facilitates creativity (Gomez-Ramirez & Costa, 2017; Hamilton et al., 1984; Mann & Cadman, 2014).[7] We replicate past evidence that boredom leads to creative ideas, insofar as participants generated more (experiment 2) ideas after a boring incubation period, as compared with a moderately engaging one (participants also generated more novel ideas in experiment 1's boring condition, though this effect was marginally significant and could be due to chance). Furthermore, our results generalize these past results in two ways. First, we show that brief (3 minute) periods of boredom can aid creative idea generation, whereas past studies examined the benefits of long (12 to 30 minute) periods of boredom (Mann & Cadman, 2014; Park et al., 2019). Second, we are the first study to investigate the effects of boredom during an incubation phase, during which participants take a break from a creative problem to perform an unrelated activity.

Yet our results provide evidence *against* a prominent explanation of why boredom helps people generate creative ideas. Various researchers have hypothesized that boredom leads to creative ideas because it increases mind wandering (Mann & Cadman, 2014; Park et al., 2019; Elpidorou, 2018b; Gomez-Ramirez & Costa, 2017). Against this prediction, we found no significant relationship between mind wandering (i.e., freely moving thought) and creative idea generation while participants performed a boring task. If anything, there was a trend in the opposite direction, where constrained thought led to more ideas than freely moving thought during a boring task.

Why is mind wandering unrelated to creative idea generation during boring tasks? We propose two explanations, which are compatible with each other. First, mind wandering may be unproductive during a boring task, because one's thoughts are *not constrained enough.* Free from the constraints of a rich external environment, one's thoughts may wander to either quotidian concerns or unrealistic fantasies (see the preceding text), which are not relevant to one's creative problem. So freely moving thought may be less productive during a boring task, compared with an engaging one.

[7] Haager et al. (2018) show that some apparent benefits of boredom are confounded by practice, since practicing a creative task increases fluency *and* boredom. Our results are not confounded by practice, since all participants had equal explicit practice on the AUT.

Second, boring tasks may allow people to solve their creative problems with linear, goal-directed thinking. Indeed, various theorists have proposed that boredom is a beneficial state, not because it causes one's mind to wander, but rather because it motivates one to pursue a new (Bench & Lench, 2013) and more satisfying goal (Elpidorou, 2014, 2018a). Imagine, for example, that you are bored stiff, sitting on your couch on a lazy summer's day. You may relieve your boredom by picking up a problem you've been stuck on, and solving it in a linear, focused manner. Consistent with this, we found that participants who *knew* that they would return to the problem (experiment 2) generated more ideas in the boring condition than the engaging condition, but those ideas were not more creative (as measured by semantic distance). When participants lacked foreknowledge, in contrast, boredom had no effect on the *number* of creative ideas and only a marginally significant benefit for the *novelty* of creative ideas (experiment 1). This is consistent with our second prediction: that boredom is beneficial because it affords people time to knowingly work on a task. Future research should test this prediction in greater depth: for example, by explicitly measuring how often participants think about a creative problem when they are bored.

This may suggest that boredom is most beneficial when it motivated you to knowingly work on your goals, which can lead to more ideas (but not necessarily more novel ones). This result highlights an important fact about creativity. Both divergent, freely moving thinking and convergent, focused thinking can help to generate creative ideas. Indeed, many theorists have proposed that creative thinkers must oscillate between periods of divergent and convergent thinking (DeYoung et al., 2009; Ellamil et al., 2012; Girn et al., 2020; Simonton, 1999; Williams et al., 2018). Our results suggest that boredom may contribute as much to the convergent stages of creativity (where you knowing work on goals) as the divergent ones.

One question for future research is whether moderately constrained thoughts *prime* people to think more creatively for a short period of time *postincubation*. Our instructions and relatively short postincubation interval (45 seconds) encouraged participants to record only "additional alternate uses of your item DURING the course of the video" they watched during incubation. We used these instructions to measure the effect of moderately constrained thought on *the process of incubation itself*, as measured by ideas generated *during* the incubation interval. In contrast, our research question was not whether moderately constrained thinking *primes* subjects to be more creative for a short time after incubation, as measured by ideas generated *after* the incubation interval. Future research could address this question by modifying our protocol in three ways: (a) instruct participants to generate new alternative uses after the incubation period; (b) use a longer postincubation time interval; and (c) measure whether any priming effects are strongest immediately after the incubation interval, and how long those effects persist.

Our work illuminates new avenues for research into the relationship between mind wandering, creative idea generation, and affect. Many researchers have been attracted to a tidy story: more boredom, more mind wandering, more lightbulbs. Our results add to a growing body of evidence against that tidy story. We propose an alternative path from mind wandering to lightbulbs that is more nuanced, yet more plausible. Moderately engaging activities like walking may lead to a productive form of mind wandering, which is constrained by a semantically rich environment. Virginia Woolf said that "one day walking round Tavistock square I made up, as I sometimes make up my books, *To the Lighthouse*" (Schulkind, 1976, p. 81). Perhaps this is not because mind wandering took Woolf out of the world. Perhaps it is because mind wandering immersed her in it.

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