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RESEARCH REPORT

# People Mind Wander More During Massed Than Spaced Inductive Learning

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This article investigates the relation between mind wandering and the spacing effect in inductive learning. Participants studied works of art by different artists grouped in blocks, where works by a particular artist were either presented all together successively (the massed condition), or interleaved with the works of other artists (the spaced condition). The works of 24 artists were shown, with 12, 15, or 18 works by each artist being provided as exemplars. Later, different works by the same artists were presented for a test of the artists' identity. During the course of studying these works, participants were probed for mind wandering. It was found that people mind wandered more when the exemplars were presented in a massed rather than in a spaced manner, especially as the task progressed. There was little mind wandering and little difference between massed and spaced conditions toward the beginning of study. People were better able to correctly attribute the new works to the appropriate artist (inductive learning) when (a) they were in the spaced condition and (b) they had not been mind wandering. This research suggests that inductive learning may be influenced by mind wandering and that the impairment in learning with massed practice (compared to spaced practice) may be attributable, at least in part, to attentional factors—people are "on task" less fully when the stimuli are massed rather than spaced.

*Keywords:* spaced practice, massed practice, induction, mind wandering



It has long been assumed that although spaced practice promotes the kind of cognitive processing needed for remembering individual items (Cepeda, Pashler, Vul, Wixted, & Rohrer, 2006; Son & Simon, 2012), massed practice is preferable and facilitates inductive or conceptual learning. Rothkopf famously argued (see Kornell & Bjork, 2008) that although spaced practice is the friend of recall, it is the enemy of induction. But when this hypothesis was put to the test (Kornell & Bjork, 2008; Kornell, Castel, Eich & Bjork, 2010; Verkoeijen, & Bouwmeester, 2014; Vlach, Sandhofer, & Kornell, 2008; Wahlheim, Dunlosky, & Jacoby, 2011), support was lacking. For instance, Kornell and Bjork (2008) conducted an inductive learning task in which the participants were shown slides of the paintings of a number of minor artists to study, in either a massed or spaced order, and later were asked to generalize their learning to identify new paintings by the same artists. This task captures many of the essential features of what is meant by inductive learning. Clearly, if spacing is the enemy of induction, then people should have been less able to generalize their learning to the new paintings when the studied paintings had been presented in an interleaved manner instead of when they had been presented together under conditions of massed practice. Their results, and the results of subsequent studies, however, contradicted the expectation of Rothkopf's maxim, because spaced presentation resulted in superior induction. The present study sought not only to replicate this new and counterintuitive result using highly engaging works of art by known artists but also, more importantly, to shed light on a potential explanation.

There have been several explanations of the beneficial effects of spaced practice in item recall or recognition paradigms. The most prominent are (1) that the to-be-remembered item benefits from encoding variability from the surrounding items more under spaced than under massed practice because the different contexts experienced during spaced practice provide additional retrieval routes (Glenberg, 1979; Melton, 1970); (2) that retrieval of the previous instance of the item, which is assumed to occur upon the repetition of the item and to enhance memory, is more difficult under spaced than massed conditions, and retrieval difficulty is related to item learning (Storm, Bjork, & Bjork, 2008); and (3) that spaced practice recruits more attention (and hence encoding strength) than does massed practice (Greeno, 1970; Hintzman, 1974; Pavlik & Anderson, 2005). We do not wish to deny that the first and second explanations might contribute to item spacing effects. But it is not clear how the variable context idea applies when the stimuli are already always changing. Similarly, straightforward application of the retrieval difficulty notion depends on the particular to-be-tested items being retrieved, but it is not clear that this happens in the induction paradigm or that the difficulty

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differences that might ensue are at just the right, desirable level of difficulty to help learning. There are other promising approaches that are specific to the induction paradigm, such as the proposal that spacing facilitates category discrimination (Birnbaum, Kornell, Bjork, & Bjork, 2013; Carvalho & Goldstone, 2012; Kang & Pashler, 2012). However, the possibility that we explore here is that there are important attentional differences between the massed and spaced conditions.

The idea that was tested is that when many exemplars of a particular category—in this case works of art by a particular artist—are grouped together, as in a massed practice situation, people's attention may tend to lapse, resulting in mind wandering (Smallwood & Schooler, 2015). On the other hand, when the exemplars are spaced apart and interleaved with the works of other artists, attention may be sustained. Mind wandering is known to be influenced by the ease of materials (Feng, D'Mello, & Graesser, 2013), the level of processing (Thomson, Smilek & Besner, 2014), and person variables (McVay & Kane, 2012). It is possible, of course, that when people have to flit from artist to artist, their attention may wander: It is not empirically known whether mind wandering occurs more in the spaced or in the massed condition. The attentional explanation of the inductive spacing effect can be evaluated by assessing mind wandering and would suggest that there would be more mind wandering, and that mind wandering would be linked to worse inductive performance, in the massed condition. The failure to find attentional differences (or the finding of more mind wandering in the spaced condition) would point to other sources of the spacing advantage in induction.

At first glance it seems obvious that the more conscious attention that people pay to the items that are contributing to their inductive learning, the more they should induce. But some work on mind wandering has shown that this state may be beneficial for certain high-level creative modes of thought (Baird et al., 2012; Singer, 1975), one of which might be induction. It is conceivable that induction, of the sort needed to intuit who painted a particular work, may not require conscious attention and might even be harmed by strenuous conscious efforts. Reber (1967), in an experiment in which people were provided with many exemplars of grammatical strings generated by complex rules and were asked to inductively infer which new strings were grammatical, found that performance was enhanced by not doing the task too consciously. In this grammar-learning induction task, knowledge about category inclusion was better when the learning had been implicit. Perhaps, the present task is similar to the difficult inferential task that had been used by Reber. If so, then inductive inference might conceivably be harmed when people are too focally attentive. It is not completely a foregone conclusion, then, that being on task rather than mind wandering, in the present situation, would result in superior inductive learning. The predictions of this study—that inductive learning should be better when one is not mind wandering and that one may mind wander more under massed than under spaced conditions—are, thus, provisional.

We used a paradigm similar to that of Kornell et al. (2010) and measured attention by probing people about whether they were mind wandering during the study of the works of art. People were shown a series of images of paintings, drawings, or prints by various artists, in an either massed or spaced order block. From time to time the participants were interrupted to respond to a mind-wandering probe. When the probe appeared, they had to say whether they were mind wandering or on task. Later participants were given a test in which they were shown new exemplars of the studied artists' work, and they had to type in the name of the artist, indicating their inductive learning.

Our primary hypothesis, counterarguments notwithstanding, was that people would mind wander more when they were studying in a massed block, where all of a single artist's works were presented together, than when they were studying in a spaced or interleaved block, where individual works by different artists were interspersed. It is well known that mind wandering increases over time on task (e.g., Thomson, Seli, Besner, & Smilek, 2014). We therefore also expected an increase in mind wandering as people progressed through the task.

## Method

### Participants

The participants were 66 introductory psychology students at Columbia University and Barnard College who participated for course credit. The mean age was 22.70 ($SD = 6.93$). There were 35 females and 31 males. All procedures were reviewed and approved by the Columbia Internal Review Board for the protection of human subjects and conformed to the strictures of the American Psychological Association.

### Materials

The corpus of each of the 24 artists used consisted of 22 prints, drawings, or paintings accessed on the Internet and displayed on a computer screen via a Matlab program. All images were scaled to fit within a 700 × 500 pixel rectangle slightly above the middle of the screen on a black background, with the artists' first and last name printed in white capital letters below the image. We printed both names because some artists are known by both names, whereas others tend not to be. For example, Jasper Johns tends to be known by both names, whereas Rauschenberg's first name is, perhaps, not consistently used. Although we printed both the first and last name with each work of art, we asked for only the last name at test.

The artists used were Frida Kahlo, Eva Hesse, Tom Wesselman, Alice Neel, Terry Winters, Sonia Delaunay, Wayne Thiebaud, Richard Serra, Lee Krasner, Sam Francis, Louise Nevelson, Joan Mitchell, Helen Frankenthaler, James Rosenquist, Jasper Johns, Robert Motherwell, Cy Twombly, Robert Rauschenberg, Donald Sultan, Ellsworth Kelly, Francis Bacon, Isabel Bishop, Lucien Freud, and Frank Stella.

### Design and Procedure

The design was a 2 (condition: massed or spaced practice, within subject) × 2 (order of condition: massed first or second, between subjects) × 4 (quartile: first, second, third or fourth, within subject) × 3 (number of exemplars: 12, 15, or 18, within subject).

The works of 12 artists, randomly determined over participants, were assigned to be in the massed condition, and the other 12 artists were assigned to be in the spaced condition. Twelve, 15, or 18 exemplars were presented for each artist, a within-subject factor that was varied randomly within each quartile. The reason for including number of exemplars as a factor, rather than making the number of exemplars presented constant, was to prevent participants from being able to reliably anticipate the mind-wandering probe. Each exemplar was presented for 3 s, with a 1-s interstimulus interval. The mind-wandering probe—in which participants were asked on screen whether they were mind wandering or on task—appeared after the presentation of the all of the 12, 15, or 18 assigned exemplars of one artist in the massed condition (see footnote 1 for the yoked spaced condition). Thus, in the massed condition people would see, say, 18 images of Sam Francis's paintings and then a mind-wandering probe. Then they would get, say, 12 images of Frank Stella's paintings then a probe, and then, 15 images of, say, Joan Mitchell's works and then a probe. This would constitute the first of the two quartiles in the first half of the experiment. The three levels of the number of exemplars were randomly determined within each quartile. After completing the study of the first quartile exemplars, participants went straight on to the second quartile, still in the massed practice condition but with different artists. Then they completed the third and fourth quartiles, until all 12 artists in the massed condition had been studied.[1]

After study and the 12 mind-wandering probes, participants did a short distractor task in which they counted down by 3s from 3,078, and then they were tested. The test consisted of the random presentation of 48 new images—four per studied artist—and they were asked to type in the artist's last name for each. They then went on to the second half of the experiment, which was like the first but with the alternate spacing condition and different artists.

At the end of the experiment, participants reported on a 7-point Likert scale (a) how familiar they were with the artists and paintings, (b) how much they liked the paintings, and (c) how important art was in their daily lives. They also made judgments concerning whether they thought that spaced or massed practice was better for learning and on which condition they thought they had mind wandered more.

## Results

### Inductive Generalization Performance

Answers were computer-scored for exact match, but each response was also checked by a research assistant to count spelling mistakes as correct. The data reported are those for the human (lenient) scoring, though all of the results reported here also hold for the computer scoring. We conducted a 2 (condition: massed or spaced) $\times$ 3 (number of exemplars) $\times$ 2 (order) analysis of variance. We set a criterion of $p < .05$ and report all effects that were below that cutoff.

People performed better in the spaced practice condition than in the massed practice condition, $F(1, 64) = 78.69$, $p < .001$, $\eta_p^2 = .55$, replicating findings by Kornell and Bjork (2008). Ours was a replication with variation in procedural details: We used works of art that were by outstanding known artists and that were highly engaging, whereas Kornell and Bjork's paintings were mostly by unknown artists and were less aesthetically compelling.

The number of exemplars had a significant (and expected) effect on performance, $F(2, 128) = 4.94$, $p = .009$, $\eta_p^2 = .07$, such that mean performance was .34 ($SE = .024$) when they had studied 12 exemplars, .41 ($SE = .027$) when they had studied 15 exemplars, and .41 ($SE = .026$) when they had studied 18 exemplars. Studying 12 exemplars led to worse performance than did studying 15 exemplars, $t(65) = 2.64$, $p = .001$; 95% confidence interval (CI) [0.02, 0.11], $d = 0.32$, or 18 exemplars, $t(65) = 2.62$, $p = .011$; 95% CI [0.01, 0.11], $d = 0.32$. There was no difference in performance between the 15 and 18 exemplar conditions, and the number of exemplars did not interact with spacing condition or with order.

There was an effect of order such that participants who studied massed in the first half of the experiment performed better than did those who studied massed in the second half of the experiment, $F(1, 64) = 5.20$, $p = .026$, $\eta_p^2 = .08$. The interaction between condition and order was significant, $F(1, 64) = 22.30$, $p < .001$, $\eta_p^2 = .26$. As can be seen in Figure 1, performance increased for participants who went from massed practice in the first half of the experiment to spaced practice in the second; it decreased slightly for participants who went from spaced practice in the first half to massed practice in the second.

### Mind Wandering

Participants reported mind wandering to .31 ($SE = .023$) of the probes. Crucially, for our hypothesis, mind wandering occurred more frequently in the massed condition ($M = .36$, $SE = .028$) than in the spaced condition ($M = .26$, $SE = .026$), $F(1, 64) = 13.75$, $p < .001$, $\eta_p^2 = .18$.

There was an expected effect of time, such that mind wandering increased with quartile, $F(3, 192) = 24.79$, $p < .001$, $\eta_p^2 = .28$. There was an interaction between condition and quartile, $F(3, 192) = 5.28$, $p = .002$, $\eta_p^2 = .08$. As is shown in Figure 2, there was no difference in mind wandering between the massed and spaced conditions during Quartiles 1, 2, or 3, respectively, $t(65) = 0.96$, $p = .34$, 95% CI [−0.04, 0.11], $d = 0.11$; $t(65) = 1.75$, $p =$

[1] We yoked the materials of participants such that pairs of participants– one in the massed-first condition and one in the spaced-first condition– would get the exact same exemplars of paintings by the same artists in the first half of the experiment. For example, if an individual had Sam Francis, Frank Stella, Joan Mitchell, and nine other particular artists in the first half of the experiment, then the yoked participant would get the same exemplars for these same artists. The difference was that in the massed condition all of the works of a single artist were presented together, whereas for the yoked participants the 12, 15, or 18 works of each of the 12 artists would be interleaved. The entire deck of 180 works of art studied in the first half of the experiment was the same for the yoked partners, except that in the massed case the works were organized by artist whereas in the spaced case they were randomized. The yoked participants got the mind-wandering probes at exactly the same time in the sequence as did their yoked mate. So if the mind-wandering probes for the massed partner came after 18 paintings by Sam Francis, 12 by Frank Stella, and 15 by Joan Mitchell, then the yoked spaced partner's mind-wandering probes would come after 18 images, 12 images, and 15 images. The yoked partner would also see (the same) 18 Sam Francis works, 12 Frank Stella works, and 15 Joan Mitchell works, but in an interleaved order throughout all four quartiles. During the second half of the experiment, participants completed the opposite condition; that is, if they had studied in a massed fashion during the first half of the experiment, then they studied in a spaced fashion during the second half of the experiment, but they remained yoked. Different artists were presented in the first and second halves of the experiment. For half of the yoked participants, spacing and massing were swapped with the above constraints (resulting in two pairs of yoked participants), whereas for the other half, the artists who had been presented in the first and second halves of the experiment were swapped (resulting in another two pairs of yoked participants). The yoking and counterbalancing meant that we completed the full design every eight participants, resulting in eight replications over 64 participants. We scheduled several extra participants to ensure against no-shows and ended up with 66 participants. The "extra" participants were included in the analyses.

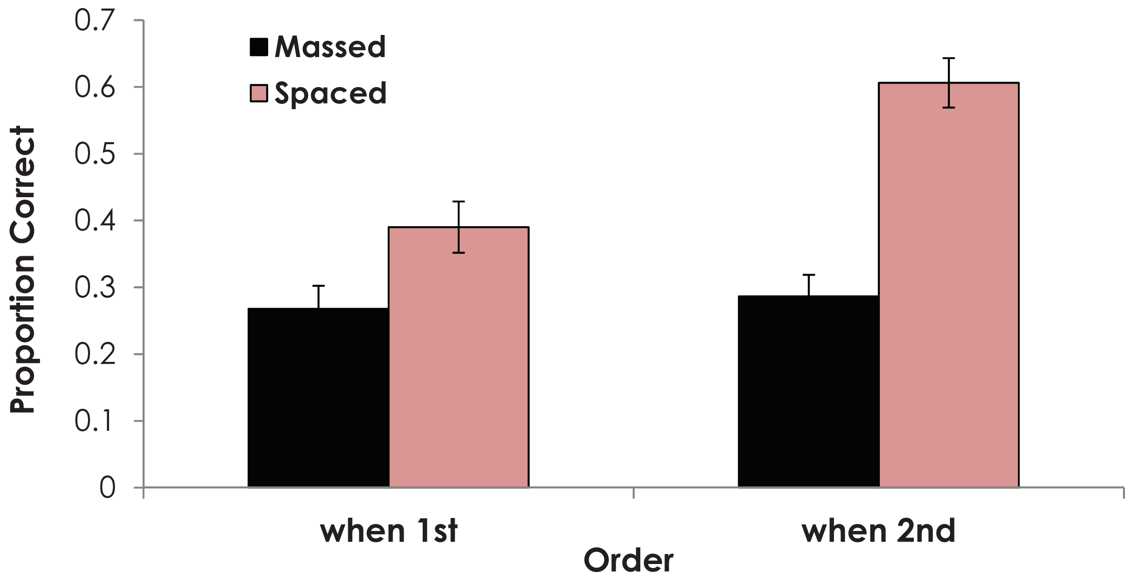


*Figure 1.* Leniently scored test performance with standard error bars. See the online article for a color version of this figure.

.084, 95% CI [−0.01, 0.17], $d = 0.22$; and $t(65) = 1.18$, $p = .24$, 95% CI [−0.04, 0.15], $d = 0.15$, whereas in Quartile 4 there was considerably more mind wandering in the massed than in the spaced condition, $t(65) = 4.79$, $p < .001$, 95% CI [0.14, 0.34], $d = 0.60$.

Neither the effect of Order nor the Order × Condition interaction was significant. However, there was a trend toward a three-way Condition × Quartile × Order interaction, $F(3, 192) = 2.45$, $p = .065$, $\eta_p^2 = .04$. Because it is of some theoretical and practical interest, this nearly significant interaction is shown in Figure 3. There are several interesting patterns shown by these data. First,

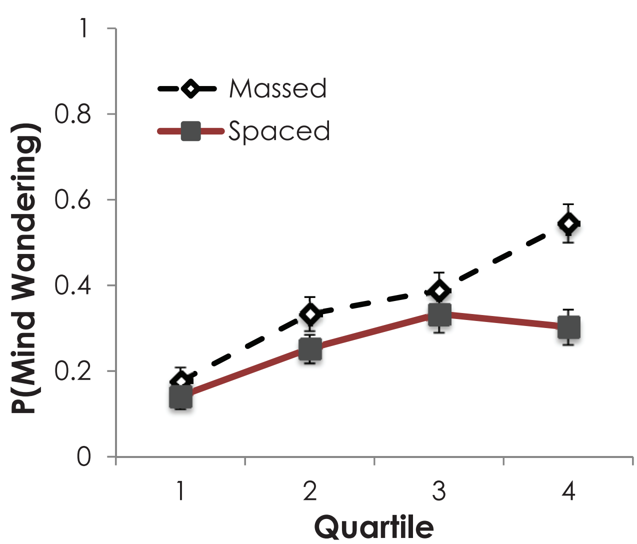


*Figure 2.* Proportion (P) of mind wandering by quartile. Error bars indicate standard errors of the mean. See the online article for a color version of this figure.

and importantly, the first quartile of the second half of the experiment always revealed a reversion to a low level of mind wandering, compared to the higher mind-wandering level seen in the fourth quartile of the first half of study. This decrease in mind wandering from the end of the first half of the experiment to the beginning of the second half of the experiment is consistent with Szpunar, Khan, and Schacter's (2013) results showing that interposing a test during the course of study results in a decrease in mind wandering. Here, too, there was release from mind wandering in the middle of the experiment—probably attributable to the test (but perhaps to the switch in the method of stimulus presentation). These data also suggest that when spaced practice occurred in the first half of the experiment, followed by massed practice, the increase in mind wandering in the massed list over quartiles was especially steep. Indeed, by the end of the massed condition, when it occurred in the second half of the experiment, the rate of mind wandering was over 60%. When, by contrast, massed practice was first and spaced practice occurred in the second half of the experiment, the increase in mind wandering over quartiles in that second half of the experiment was not great.

A criticism of our experiment could be that the mind-wandering probes in the massed condition always came after the last-presented exemplar for one artist, whereas this was not the rule in the spaced condition. In it, mind-wandering probes sometimes came after the final exemplars of the works of none of the artists, though, toward the end of the list, they could also occur after the presentation of all exemplars of the works of many artists. To investigate whether this difference in the frequency of last-presented category member in the interval monitored by the mind-wandering probe affected the results, we determined for each participant when, exactly, each of the last-of-the-category exemplars was presented in the spaced condition and binned these observations by the timing of the 12 mind-wandering probes. We then computed the relative frequency (out of 12) of last-presented

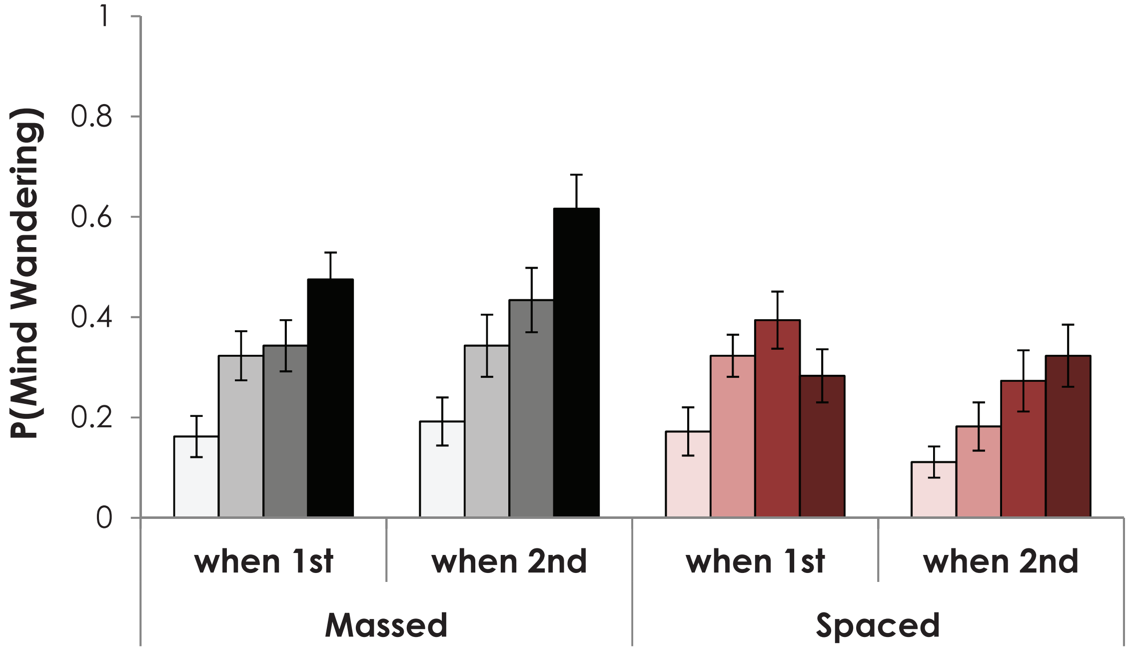


*Figure 3.* Proportion (P) of mind wandering in the massed and spaced conditions when massed practice occurred in the first half or second half of the experiment and when spaced practice occurred in the first or second half of the experiment. Increasingly dark bars give the proportions of mind wandering, in the first, second, third, and fourth quartiles (each consisting of three mind-wandering probes). Note that individual participants contributed to the "massed when 1st" and "spaced when 2nd" data or to the "spaced when 1st" and "massed when 2nd" data. Error bars indicate standard errors of the mean. See the online article for a color version of this figure.

exemplars in each of the 12 probe positions. We used the relative frequency distribution of the occurrence of last-of-the-category exemplars, for each participant, in the spaced conditions, to weight the mind-wandering reports that each participant gave at each probe position in both conditions, resulting in two weighted mind-wandering scores for each participant. Even when so adjusted, though, there was still less mind wandering in the spaced ($M_{spaced}$ = .32, *SE* = .05) than massed ($M_{massed}$ = .52, *SE* = .05) condition, $t(65) = 3.51$, $p = .0008$, $d = 0.43$, 95% CI [0.09, 0.31]. Indeed, if anything, the massed–spaced difference in mind wandering was larger when the results were adjusted to take the relative frequency of the presence of last exemplars in the interval in the spaced condition into account.

## Between-Subjects Correlations Between Mind Wandering and Performance

There was a negative correlation between participants' overall level of mind wandering and their later inductive generalization performance ($r = -.35$), $t_r(64) = 3.02$, $p = .004$, 95% CI [−.55, −.12]: Participants who mind wandered more learned less. We also analyzed the massed and spaced conditions separately, correlating condition-specific performance with proportion of mind wandering in that condition. There was a negative correlation between proportion of mind wandering and performance on artists studied in the spaced condition, $r = -.50$, $t_r(64) = 4.64$, $p < .001$, 95% CI [−0.66, −0.30], but the between-subjects correlation between mind wandering and performance in the massed condition, taken on its own, did not reach significance, $r = -.09$, $t_r(64) = 0.76$, $p = .45$, 95% CI [−0.33, 0.15].

## Conditional Probabilities of Performance as a Function of Mind Wandering

In the massed condition, we were able to examine the effect of mind wandering on inductive generalization about *particular* artists, because we knew for each artist whether the participants had mind wandered. The conditional probability of correct induction of the artist to the new paintings at time of test given that the person was mind wandering when studying those artists' exemplars was .21 (*SE* = .028); it was .30 (*SE* = .026) when they had not been mind wandering. These two were significantly different, $t(59) = 3.84$, $p < .001$, 95% CI [0.04, 0.13], $d = 0.50$, indicating a detrimental effect of mind wandering. Note that some participants reported no mind wandering, as is reflected in the degrees of freedom.

## Metacognitive Judgments and Preferences

The majority of participants had fairly accurate metacognitions concerning their performance. When asked in which condition they mind wandered more, 43 participants said the massed condition, 12 said the spaced condition, and 11 said there was no difference. When asked in which condition they had learned the artists' names best, 42 said the spaced condition, 18 said the massed condition, and 6 said no difference. This latter result contrasts with those of Zulkiply and Burt (2013).

Finally, there was a positive correlation between reported art liking and performance, $r(64) = .30$, $t_r(64) = 2.49$, $p = .016$, 95% CI [0.06, 0.50], as might be expected. There was also a correlation between participants' high ratings of the importance of art in their daily life and their performance on the induction task, $r(64) = .27$, $t_r(64) = 2.27$, $p = .027$, 95% CI [0.03, 0.48]. Participants self-reported knowing 1.48 artists on average ($SD = 1.79$). Self-reported artist familiarity was not correlated with performance, nor were any of the self-report measures correlated with mind wandering.

## Discussion

It has long been known that stimulus repetition results in habituation, with the attendant loss of attention to the repeated stimulus. Conversely, an orienting response is elicited to novel stimuli, with the attendant increase in attention (see Kahneman, 1973). These attentional principles would seem to have been at work in the present experiment—a plausible explanation of our results, but one that is vague. In response to the call of Smallwood (2013) urging more consideration of possible mechanisms underlying the shift to mind wandering, we suggest here that the kind of mechanism that has been proposed concerning when and why people stop studying one item and switch attention to another might bear on when people will stop studying and switch to mind wandering.

Several of the models of study time allocation proposed in the learning literature include stop rules concerning when people will cease to study the item at hand. The two most prominent rules are (1) the *learned to criterion* rule of the discrepancy reduction model (Dunlosky & Thiede, 1998) and (2) the *not learning fast enough* rule in the region of proximal learning model (Metcalfe & Kornell, 2005). The former says that people stop studying when they have reached an internal criterion indicating that the item is sufficiently learned. The latter says that people stop when the derivative of the perceived information uptake function approaches a small subjectively determined value, that is, when people perceive that they are no longer taking in new information. This can happen because they have learned the material or because it is too difficult to afford learning. But regardless of which rule one champions, both apply on a moment by moment basis, and both would result in more stopping in the massed than the spaced condition. Given that the immediately preceding items, in the massed condition, are highly informationally redundant with the current item, that redundant information contributes to nearness to the learning criterion and to the feeling of not currently uptaking much new information. Both models, then, predict that the stop rule conditions will be more satisfied in the massed than spaced condition. We suggest here that when the conditions of the stop rule are met, in the current situation, rather than switching to a different external stimulus, people might switch to internal thought, that is, they might start mind wandering. But once they switch to mind wandering they are no longer engaging in any processing of the to-be-learned items. With no processing, learning of the externally presented materials presumably ceases. Mind wandering itself, then, results in reduced learning, as many researchers (e.g., Risko, Anderson, Sarwal, Engelhardt, & Kingstone, 2012; Smallwood, Fishman, & Schooler, 2007) have shown. This would lead to a negative feedback loop: Lack of perceived learning of the to-be-remembered items results in stopping studying, which results in mind wandering, which results in lack of learning of the additional to-be-remembered items. Because the stop rule is more likely to be satisfied in the massed condition, this feedback loop occurs more in that condition.

This experiment replicated the finding that spaced practice results in better inductive learning than does massed practice. It also showed that people mind wandered more in the massed than in the spaced practice condition. These findings point to a complex attentional contribution to the difference in inductive learning that is observed as a result of massed versus spaced practice, whereby the perceived lack of learning in the massed condition may itself be a trigger to mind wander, but once engaged in mind wandering, further learning of the task at hand is likely to be precluded.

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