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Benefits of Mind Wandering for Learning in School Through Its Positive Effects on Creativity

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There is broad agreement among researchers to view mind wandering as an obstacle to learning because it draws attention away from learning tasks. Accordingly, empirical findings revealed negative correlations between the frequency of mind wandering during learning and various kinds of learning outcomes (e.g., text retention). However, a few studies have indicated positive effects of mind wandering on creativity in real-world learning environments. The present article reviews these studies and highlights potential benefits of mind wandering for learning mediated through creative processes. Furthermore, we propose various ways to promote useful mind wandering and, at the same time, minimize its negative impact on learning.

Keywords: mind wandering, creativity, divergent thinking, incubation effect, school learning, creative problem solving

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INTRODUCTION

Mind Wandering (MW) is commonly conceived as a loss of mental focus on a given primary activity in favor of thoughts that are unrelated to this activity (Smallwood and Schooler, 2006; Smallwood and Schooler, 2015). For example, while reading a book for school, one may start to think about some event in the past or ruminate about a current problem. This definition implies that shifting one's mental focus to something other than the current task is likely to be detrimental for task performance. Indeed, a large number of studies have shown reduced task performance due to MW in various domains of cognitive functioning (e.g., Smallwood et al., 2006; McVay and Kane, 2009; Galéra et al., 2012; Unsworth et al., 2012; Stawarczyk and D'Argembeau, 2016). The range of related observations spans from lower reaction times and more errors in in laboratory tasks, to weaker performance in everyday activities such as safely driving a car in a concentrated manner (Galéra et al., 2012) or actively engaging in a conversation without being distracted (Unsworth et al., 2012). Most relevant to this article is the observation that particularly performance in educational contexts seems to be negatively associated with the occurrence of MW (e.g., Dixon and Bortolussi, 2013). For example, several studies found negative effects of MW on text comprehension in university students (e.g., Lindquist and McLean, 2011; Risko et al., 2012; Unsworth and McMillan, 2013; Wammes et al., 2016; Soemer and Schiefele, 2019, 2020) as well as secondary school students (e.g., Soemer et al., 2019).

Likewise, MW has been found to affect learning during lectures (Hollis and Was, 2016; Kane et al., 2021).

Despite these negative effects of MW on learning, several other studies have found positive effects of MW on learning-related constructs, in particular on creativity (e.g., Baird et al., 2012; Agnoli et al., 2018). Since creativity is commonly considered as beneficial for learning (e.g., Dollinger, 2011; Lee et al., 2014; Leopold et al., 2019), previous research linking MW to reduced task performance might indeed miss potentially useful aspects of MW for learning that are mediated through creative processes. Thus, in the following, we present a more balanced view on MW highlighting both its well-known detrimental effects and its potential benefits on learning with a particular focus on creativity.

MIND WANDERING

According to a common definition (Smallwood and Schooler, 2015), MW is a phenomenon consisting of three characteristics: (1) There is a primary task to be carried out. (2) The mind is losing focus of the primary task and follows, instead, thoughts that are unrelated to the primary task. (3) This shift of attention is self-generated and not triggered by an external stimulus (e.g., acoustic or visual distractors in the environment).

Noteworthy, MW shows some overlap with the phenomenon of "daydreaming" (Klinger, 2009; McMillan et al., 2013). Both constructs involve internally generated thoughts that are not cued by an external event. However, in contrast to MW, the definition of daydreaming does not presuppose a concurrent primary task; in other words, daydreaming also includes situations such as having a walk in the park or riding a bus. In an early approach, Singer (1966) identified different styles of daydreaming, one of which was labeled "positive constructive daydreaming." This style of daydreaming is characterized by playful, wishful imagery, and creative thought. Moreover, positive constructive daydreaming was later related by Singer to the arousal of positive emotions and the efficiency of future plans (see McMillan et al., 2013). Singer also identified two less "beneficial" daydreaming styles: "guilty-dysphoric daydreaming" and "poor attentional control," the latter corresponding to what is typically associated with the term MW nowadays. Importantly, these latter two styles of daydreaming were found to be associated with negative consequences in a wide variety of domains and were not related to creativity (e.g., Huba et al., 1977, 1981). Interestingly, however, contemporary research on the more narrowly defined construct of MW has rarely made a comparable distinction between positive and negative forms of MW, although it is theoretically possible to do so, as we will argue below.

On the other hand, MW researchers have differentiated between forms of MW with regard to their intentionality (i.e., intentional vs. spontaneous MW) and situation-specificity (situation-specific state-level vs. dispositional trait-level MW; e.g., Soemer et al., 2019). Spontaneous MW involves an unintentional und uncontrollable shift of an individual's attention from the primary task to self-generated thoughts, whereas intentional MW is considered to be induced deliberately or at least tolerated whenever it occurs spontaneously (that is, individuals do not try to focus back on the primary task once they notice, see Seli et al., 2016a). State-level MW means that individuals' MW occurs only in specific situations but this may be context-induced and not a general trait of an individual. In contrast, trait-level MW refers to the fact that some individuals have a relatively stable (high or low) level of MW when working on various tasks. Accordingly, trait-level MW shows considerable definitional overlap with the aforementioned construct of daydreaming, the former being a slightly more restricted form of the latter.

Mentioning daydreaming in this article, which otherwise focuses specifically on MW, is important for two reasons. First, research on daydreaming illustrates that it has long been suspected that creativity may be related to an individual's propensity to pursue internally generated mental content (e.g., Singer and Antrobus, 1963). Second, the primary focus of daydreaming research on the individual differences level highlights the need for greater differentiation in modern MW research on this topic. This includes identifying commonalities and differences of the above-mentioned subtypes of MW (e.g., state-level vs. trait-level MW) and examining their potentially diverse relationships to other constructs (e.g., for a contrasting effect of state vs. trait level MW on reading comprehension, see Soemer et al., 2019), which includes creativity. For convenience reasons, however, we will equate daydreaming with trait-level MW throughout the remainder of this paper.

CREATIVITY AND ITS MEASUREMENT

Creativity has been characterized as the ability to create something novel, unique, or unusual (summarized as "original") that is considered to be useful, appropriate, or fitting (i.e., efficient; Runco and Jaeger, 2012). Individual differences in creativity seem to be strongly connected to individual cognitive characteristics such as intelligence and, in particular, "divergent thinking" (Guilford, 1967). Due to its continuing importance in creativity research, we will address divergent thinking first. However, relying solely on divergent thinking as a measure of creativity has its flaws, as explained below. Therefore, this review introduces another facet of creativity, namely *creative problem solving*, in order to look on creativity from a different perspective and to offer an alternative way of measuring it. At the end of this chapter, we will elaborate on the creative process.

Divergent Thinking

Divergent thinking is characterized by generating a large number of possible answers to a given problem. In contrast, "convergent thinking" is directed at producing the single best answer to a given problem (Guilford, 1967). Some authors use the term "divergent thinking" synonymously with the term "creativity" (e.g., Frith et al., 2021), whereas others consider creativity to be a much broader construct that entails divergent thinking as one of its facets (e.g., Lubart et al., 2013; Silvia, 2015). Because of its ease of measurement and relevance for creativity, however, divergent thinking has been widely used as the main measure of creativity, as is also the case in most of the research being discussed in the following.

For a proper evaluation of the following studies, it is essential to recognize some of the flaws in the measurement of creativity in the sense of divergent thinking. These flaws originate in the assessment methods that were developed by Wallach and Kogan (1965) based on the work of Guilford (1957). Notably, Wallach and Kogan (1965) basically equate creativity and divergent thinking. Their test battery relies on evaluating the creativity (or divergent thinking) of individuals in terms of the "uniqueness" of their answers to a given problem. For example, the "unusual uses task" (also known as the "alternative uses task") requires the participants to name multiple unique unusual uses for different every-day objects, such as a brick or an empty bottle. Each response that is given by no other participant is judged as being "unique" and the answering person is awarded one point. This traditional method of measuring creativity/divergent thinking has been criticized (cf. Silvia, 2015) but is used until today (e.g., Baird et al., 2012).

There are two main problems with the traditional measure of creativity. First, the traditional measure only accounts for the originality facet of creativity but ignores the efficiency facet (Runco and Jaeger, 2012). For a comprehensive measure of creativity, it is necessary to evaluate if a given answer is not only unique but also appropriate or useful. Second, the uniqueness of each response is inversely related to the number of participants being tested, because each participant increases the chance for a repetition.

In an alternative approach to divergent thinking, Torrance (1966, 1974, 2008) addresses the problem of neglecting the efficiency facet of creativity through adding other factors (e.g., fluency and elaboration) to the measurement that also account for appropriateness. The Torrance Tests of Creative Thinking (TTCT; Torrance, 1966, 1974, 2008) measures divergent thinking using a variety of tasks, such as the unusual uses task. In addition to the creativity facet *originality*, the TTCT assesses response characteristics such as the amount of relevant details provided (i.e., *elaboration*) and the number of interpretable, meaningful, and pertinent responses (i.e., *fluency*). Moreover, another factor, *flexibility*, refers to the number of distinct categories to which relevant responses can be assigned. Noteworthy, all of these dimensions (with the exception of originality) implicitly include a verification of the efficiency facet (e.g., for the dimension fluency: "Are the responded details really pertinent?"). However, the creativity facet efficiency still seems neglected, given its indirect implementation through these dimensions. Originality, in contrast, is a discrete dimension of the TTCT by itself and receives therefore more attention in this approach. More recent approaches to assess creativity/divergent thinking suggest other ways to avoid the problems of the traditional method. On the one hand, Smeekens and Kane (2016) addressed the need for more appropriate task instructions. Accordingly, Beaty et al. (2014b, p. 1189) suggested to ask participants "to come up with something clever, humorous, original, compelling, or interesting." This type of instruction seems more likely to motivate participants to produce responses that are both original and appropriate, whereas the traditional method emphasized uniqueness (Torrance, 2008) and quantity of answers. On the other hand, researchers have suggested procedures to assess the aspect of appropriateness more directly. This can be accomplished by letting expert raters independently judge the appropriateness (in addition to the originality) of the participants' responses (Silvia, 2015). As an example, Amabile (1982) has developed the Consensual Assessment Technique (CAT) for rating the creativity of a wide variety of products (see Baer and Kaufman, 2019).

Creative Problem Solving

Creative problem solving can be described as the ability to successfully engage in problems whose solution demands to gain a deeper insight into the problem itself by restructuring the mental representation of that problem (cf. Weisberg, 2015; He and Wong, 2021). In more detail, a first attempt to solve those kind of problems usually fails due to insufficient or hidden information that is needed for solving (i.e., it is a so-called ill-defined problem; DeYoung et al., 2008). In order to restructure the initial mental model of the problem one must rephrase the own problem-solving approach by changing the viewpoint on the problem after realizing that the initial approach will not lead to the solution (see Beaty et al., 2014a). Furthermore, ill-defined problems could be conceived of as the antithesis to well-defined problems. While well-defined problems consist of clear specifications for the three elements of the problem space, namely (a) the problem situation, (b) rules and strategies to solve the problem and (c) the characteristics of the goal state, ill-defined problems are missing at least one of these elements (Newell and Simon, 1972). Tasks that capture creative problem-solving ability through ill-defined problems are referred to as *insight problems*. One example for a verbal insight problem is "A man in a town married 20 Women in the town. He and the women are still alive, and he has had no divorces. He is not a bigamist and is not a Mormon and yet he broke no law. How is that possible?" (Solution: The man is the minister who married the 20 women to their respective husbands; Weisberg, 2015, p. 7). In addition to such verbal-only formulated insight problems other insight problems provide additional visual input (e.g., a sketch) that must be processed for solving the problem (e.g., the pigpen problem; Lin et al., 2012).

Characteristic of insight problems is only one solution is correct, in contrast to divergent thinking tasks in which a person is supposed to generate as many answers as possible. Moreover, contrary to divergent thinking tasks that overemphasize the originality facet of creativity but neglect the efficiency facet, creative problem solving tasks such as insight problems assess both facets of creativity since there is only one correct answer that is actually original. In conclusion, one needs to compensate for the missing parts of the problem (i.e., the missing specifications of the problem situation, the solving mechanisms and/or the goal state) in order to solve ill-defined problems such as insight problems, whereas misspecification is not a problem in divergent thinking tasks.

The Creative Process

One common approach to conceptualize creative processes is the classic four-stage model of the creative process (Wallas, 1926), which many contemporary models of creativity are based on (e.g., the componential model of creativity, Moriarty and VandenBergh, 1984; Amabile, 1996). As its name suggests, the classic model divides the creative process into four stages that ultimately lead to a creative output: *preparation*, *incubation*, *illumination* and *verification*. Although an individual usually proceeds through the stages sequentially one by one, Wallas stated that returning to former stages is possible if the problem to be solved requires this.

According to Wallas (1926) the preparation stage serves to preliminarily analyze, define and set up a given problem using problem-relevant knowledge and analytical skills. Noteworthy, individuals carry out these steps consciously, whereas in the following incubation stage the mind starts to work unconsciously on the problem. This second stage is characterized by taking a break from the problem and turning attention to other subjects. However, while being engaged in something different, the mind is still working on the "old problem" in a hidden way, forming many trains of associations, rejecting most of them as being useless but sometimes encountering a promising idea. When this happens, the next stage, illumination, begins and the formerly hidden idea breaks through into consciousness accompanied by a feeling of sudden enlightenment. The last stage, verification, serves to refine, develop and evaluate the produced idea. This stage proceeds in a fully conscious way again.

THE CONTRIBUTIONS OF CREATIVITY TO SCHOOL LEARNING

Our assumption of a positive effect of MW on learning through enhanced creativity presupposes a significant relation between creativity and learning. Substantial evidence for this relation has been provided in the past. For example, in their meta-analysis, Gajda et al. (2017) reviewed the data from 120 studies and reported an average correlation between creativity and academic achievement of $r = 0.22$. The authors identified two influential moderator variables: the type of creativity measure (e.g., self-reports vs. standardized tests) and the type of learning measure (e.g., grade point average vs. subject knowledge tests). It was found that the relation between creativity and learning performance was stronger when creativity was assessed through standardized tests (e.g., the TTCT; Torrance, 1966, 1974, 2008; Divergent thinking tasks, such as the unusual uses task; Wallach and Kogan, 1965) than through self-report scales. On the other hand, they found a weaker association between creativity and learning performance when the latter was measured as grade point average compared to standardized achievement tests. In conclusion, Gajda et al. suggested the development of more precise measurement instruments that are better suited to investigate the nature of this relationship between creativity and learning. In accordance with this suggestion, Karwowski et al. (2020) presented a new instrument to measure both creativity and learning [Creativity and Learning in School Achievement Test (CLISAT)] that particularly differs from other instruments for measuring creativity and learning by using a domain-specific assessment. Accordingly, the CLISAT measures both creativity and learning in a particular school subject related domain, such as math or language, while using school-based material. To give an example for a math task, one task from the test demands students to match the correct grid of a cuboid out of four alternatives with a given three-dimensional illustration of a cube. Accordingly, a creative task in the same domain asks the students to divide different forms into parts of equal size.

While validating psychometric properties (e.g., validity and reliability measures) of the CLISAT on 2,372 students of primary and middle school, Karwowski et al. (2020) used their instrument for a further investigation of the association between creativity and learning. They found that having academic knowledge particularly in math was inductive for creative performance in tasks of the same domain (i.e., math). However, for language they could not find evidence for this association. On the other hand, creativity performance in both math and language-related tasks positively predicted academic performance in tasks of the same domain. Intriguingly, in the case of math, particularly weak task performance was predicted by the creativity measure. Regarding this finding, Karwowski et al. assume that having high creativity skills could particularly be beneficial in generating and testing solutions to easy mathematical problems, since these allow various approaches. In contrast, difficult mathematical tasks would be more limited to be solved by only one correct approach. In the domain of language the domain-specific creativity measure predicted performance in language-related tasks over the whole difficulty range. Given these findings, the authors propose a mutual relationship between creativity and school learning.

Some other work pinpointed the significance of creativity for other domains than general learning. In his review regarding the importance of creativity for mathematics Mann (2006) elaborates over the meaning of an additional promotion of creativity for (gifted) students of mathematics. The author concludes that particularly in mathematics, traditional teaching relying on methods involving demonstration and practice using closed problems with predetermined answers, will rather produce computational experts that lack the ability to use their skills in meaningful ways. Thus, although it may seem counterintuitive at first, mathematics in particular could benefit from having an antithesis (i.e., a creative perspective) to the logical, predefined ways of approaching a problem. In contrast to mathematics, the connection between creativity and writing appears more obvious. For example, there is evidence, that the amount of time spent with reading and writing activities of university students is associated with them showing better creative performances (Wang, 2012). Intriguingly, this study also indicated that just having a positive attitude toward reading and writing activities is connected to better creative performances. Moreover, particularly the writing in foreign languages may be connected to higher creative performances (Wang, 2012; Niño and Páez, 2018).

Concludingly, despite the positive evidence for a stronger relation between creativity and school learning, a number of open questions remain. These refer in particular to the unresolved causal nature of the creativity-learning relation. In our present theoretical analysis, however, we regard a reciprocal relationship to be most probable. As has been argued by Gajda et al. (2017), the process of being creative would ultimately lead to learning outcomes and the process of learning will ultimately result in creative outcomes.

MIND WANDERING AND ITS RELATION TO CREATIVITY

Mind Wandering and Divergent Thinking

In one of the first studies directly addressing the relation between MW and creativity, Baird et al. (2012) examined whether MW could account for the well-known enhancement of creative problem solving after a break. In what we will call "incubation paradigm" in the following (Sio and Ormerod, 2009), participants are confronted with a problem they have to solve within a given period of time. In terms of the four-stage model (Wallas, 1926), this confrontation can be classified as the first stage of the creative process, preparation. After expiration of the given time, the participants are offered an intervening break during which they do not process the task. This part constitutes the incubation stage of creative process. When the break is over, the participants continue to process the initial task again. Intriguingly, participants' ability to come up with sudden intuitive solutions to creative problems is usually found to be improved through this break (i.e., the incubation effect). Furthermore, a recent meta-analysis found the incubation effect to be stronger when the break is filled with a mentally non-demanding task (Sio and Ormerod, 2009). In terms of the four stage model manipulating the incubational stage through providing a non-demanding filler task can be regarded as a kind of enhancement of the idea-generating effect that is typically associated with this phase. Baird et al. (2012) tried to replicate the incubation effect and hypothesized that the better performance after a break may be associated with a higher frequency of MW. According to their hypothesis, being engaged in a non-demanding filler task during the break would increase the likelihood that participants engage in MW (which is consistent with the finding that MW is more frequent in non-demanding relative to demanding tasks; e.g., Smallwood et al., 2003a; Seli et al., 2018). More MW, in turn, would promote creative processes that are associated with creative problem solving. In their study, participants were randomly assigned to one out of four experimental groups. The groups differed in the filler task that participants had to perform during the break and thus, in the demands of the tasks. In particular, participants of one group had to perform a low-demanding reaction-to-a-stimulus task that was expected to maximize MW and thereby promote problem solving during the incubation break. Participants of the other three groups performed a highly demanding n-back task (Kirchner, 1958), no task or had no break at all. After the break, participants were asked to estimate how frequently their minds lost focus from the filler task (i.e., MW frequency). The main task in this study was the unusual uses task (Wallach and Kogan, 1965) that was presented before and after the break. Indeed, the results showed the highest MW rates for participants occupied with the low-demanding task when compared to the participants of all the other groups. Furthermore, participants of the low-demanding task group showed the highest improvements in their amount of responses in the primary task after the incubation break when compared to their performance before the break. Baird et al. (2012) suggest that the higher MW frequency in the low-demand task group may lead to better creative insights (during the incubation break) which, in turn, is reflected in better results on the main task (i.e., the unusual uses task). Noteworthy, thoughts related to the main task did not differ between the groups meaning that these thoughts could not account for performance differences between groups.

While suggesting a close relationship between MW and creative processes, the positive association between MW frequency and creative performance does not necessarily imply a causal relationship between the two constructs, because MW was not directly manipulated between groups. On the other hand, it should be noted, that an experimental manipulation of MW is difficult to achieve (however, for an attempt to experimentally induce MW see McVay and Kane, 2013). Additionally, Baird et al. (2012) concluded that an increase in MW frequency during a break facilitates the incubation effect as a single element of the creative process (see also Wallas, 1926), but not creative problem solving in general. In addition to that, we argue that the unusual uses task used by Baird et al. is not ideal for measuring creative problem solving due to its neglect of the appropriateness facet of creativity that is best measured with insight problems (cf. He and Wong, 2021). Instead, the authors showed a connection between MW and divergent thinking that is technically not a measure of creative problem solving, although it can be considered a component of creativity. Smeekens and Kane (2016) argued that the applied manipulation of the task (i.e., alternating the demands) could certainly explain both the increase in the frequency of MW and also improvements in divergent thinking, in line with prior studies (e.g., Smallwood et al., 2003b; Sio and Ormerod, 2009). Critically, the conclusion that MW causes this increase in divergent thinking would not be compelling based on this experimental design.

Mind Wandering and Its Relation to Creative Problem Solving

Another study supporting the hypothesis that MW relates to creativity was conducted by Tan et al. (2015). This study likewise utilized the incubation paradigm to trigger creative solutions, while examining participants' MW activity. However, in contrast to the work of Baird et al. (2012), this study did not manipulate the filler task; that is, all participants had to perform the same relatively non-demanding version of the "sustained attention response task" (SART; Robertson et al., 1997). Furthermore, this study used a different main task as a measure of creativity (i.e., creative problem solving), the number-reduction task (Wagner et al., 2004) that required participants to match numbers and respond in a rule-based fashion by returning another number until the seventh response of each trial was given. Participants were informed that only the seventh response would be scored, while the former responses served to determine this last one.

Crucially, there was a hidden mechanism that generated the numbers meaning that the participants were able to shortcut the whole trial; that is, they could simply submit their seventh response number early. Tan et al. (2015) assumed that only those participants who figured out the hidden mechanism were able to reliably submit the correct seventh number early. In addition, participants were asked at the end of the experiment what rules (if any) they applied to determine the seventh response. As a result, participants that discovered the hidden rule had more frequent MW occurrences than participants that did not, while participants of both groups did not differ in various control variables (e.g., working memory capacity, motivation and meta-awareness for MW). These results suggest that the SART is a suitable filler task to improve creative output during the incubation period in addition to the reaction to a stimulus task used by Baird et al. (2012). Moreover, Tan et al. showed that in addition to divergent thinking also creative problem solving can be promoted through performing a non-demanding task during the incubation stage of creative process. However, given the absence of any experimental manipulation of MW in this study, evidence for a causal relation between MW and creativity is still lacking.

Subtypes of Mind Wandering and Their Relations to Both Components of Creativity

Another important study by Agnoli et al. (2018) supports the hypothesis that MW is positively associated with creativity while extending the findings of Baird et al. (2012) and Tan et al. (2015) in two ways. First, the study succeeded in generalizing previous findings on the relation between MW and creativity to a novel paradigm. Instead of using the incubation paradigm, creativity was assessed both as a trait through a questionnaire that asked participants about accomplishments in 10 different domains of creativity such as creative writing or culinary arts (i.e., Creative Achievement Questionnaire; Carson et al., 2005) and by the so-called "titles task" (Guilford, 1968). This task measures divergent thinking by requiring participants to produce multiple alternative titles for widely known movies or books. On the other hand, everyday MW (i.e., trait-level MW) was measured by the Five Facets Mindfulness Questionnaire (FFMQ; Baer et al., 2006) and two self-report scales that differentiated between intentional and spontaneous MW (MW-D and MW-S; Carriere et al., 2013). One advantage of the Creative Achievement Questionnaire is that it inquires about accomplishments of the past in a standardized way, which makes it largely objective and independent from the ongoing study. Furthermore, the questionnaire measures creativity on a relatively stable trait level, not in a particular situation. This trait-level measure is complemented by the titles task that captures situation-specific creativity (i.e., divergent thinking). A second extension of previous findings consists of differentiating between intentional and spontaneous MW (e.g., Seli et al., 2016b) and relating these two forms of MW to creativity. Indeed, the authors found different associations between intentional and spontaneous MW, on the one hand, and situation-specific creativity (i.e., divergent thinking), on the other. That is, intentional MW was positively related to their measure of divergent thinking, whereas spontaneous MW was negatively related to divergent thinking. However, they did not succeed in finding a relation between MW and trait-level creativity.

Similarly, to Agnoli et al. (2018) a study from Preiss et al. (2016) showed positive correlations between trait-level MW and measures of creativity. They investigated whether trait-level MW can be associated with both divergent thinking and creative problem solving. Whereas the former was measured with the unusual uses task (corrected for appropriate answers), the latter was measured with a test, in which participants were presented with three words to which they had to find a matching word. Participants had to consider a given rule for the matching of the words. For instance, one rule was to find a word that can be used to produce a meaningful compound word with each of the three presented words (e.g., the response word "stone" for the words "mile," "age," and "sand"; see Bowden and Jung-Beeman, 2003). Trait-level MW was measured using the Daydreaming Frequency Scale from the Imaginal Processes Inventory (IPI; Singer and Antrobus, 1966/1970). The results showed trait-level MW to be a predictor of both creativity measures even when fluid intelligence and a measure of participants' existing reading problems were taken into account. This result suggests that a differentiation of the MW construct into a state-level and a trait-level form could be useful to further investigate the MW-creativity relationship. However, it should be noted that this study only provides evidence for a correlational association between trait-level MW and measures of creativity, and it did not take into account state-level MW.

Studies That Contradict a Connection Between Mind Wandering and Creativity Measures

In contrast to those studies that found positive evidence for a connection between MW and creativity there are several other studies showing null results (e.g., Smeekens and Kane, 2016; Frith et al., 2021). Interestingly, a study from Smeekens and Kane (2016) directly addressed the results from Baird et al. (2012) and contrasted them with their own findings. Like Baird et al. (2012), their study used an incubation paradigm. However, although their study design matched that of Baird et al. (2012) closely, Smeekens and Kane (2016) failed to replicate the results within three relatively similar experiments, one of them being an approximate replication of Baird et al. (2012) study. However, both studies differed in a number of details, because Smeekens and Kane used an online measure of mind wandering compared to a retrospective questionnaire used in Baird et al. (2012) study. Additionally, the study from Smeekens and Kane differed from Baird et al. (2012) study in the instructions given to participants, the assessment of divergent thinking (i.e., a subjective assessment was used) and some minor details. The authors reported that there was no evidence for a positive association between the frequency of MW during an incubation period and an improvement in divergent thinking after that break. These null results were considered by the authors to be more credible than the findings from the study of Baird et al. (2012) because of a number of methodological problems in the latter study, such as measuring MW in a retrospective way that, in their view, may be inaccurate due to memory biases and mental aggregation errors.

Similarly to Smeekens and Kane (2016) and Frith et al. (2021) did not find evidence for a positive relationship between state-level MW and divergent thinking. Their main study goal, however, was to examine whether attentional control can account for the well-known association between fluid intelligence and creativity (see also Silvia, 2015). Here, attentional control is defined as "overarching term that incorporates various complex control processes responsible for regulating goal-directed thought and behavior" (Frith et al., 2021, p. 2). It was assessed through three laboratory measures of attentional restraint (see McVay and Kane, 2012; Kane et al., 2016). Furthermore, this study defines MW as being a failure of attentional control. Therefore, an investigation of the effect of mind wandering on divergent thinking was of minor nature. State-level MW was measured by thought probes. Using this setup, Frith et al. did not find a significant relation between MW and divergent thinking when fluid intelligence and attentional control were controlled for.

It should be noted, however, that the study of Frith et al. (2021) used a relatively demanding task during the incubation break, in contrast to the majority of previous studies examining the relation between MW and creativity. As we will argue below, this might be a crucial difference between this study and other studies, because task difficulty is known to affect intentional and spontaneous MW differently (e.g., Seli et al., 2016b; Soemer and Schiefele, 2019). Furthermore, the MW measure was not differentiated (e.g., in its intentionality) and only state-level MW was assessed.

Summary and Evaluation

The existence of a relationship between MW and creativity is a controversial issue based on currently available research. On the one hand, it is theoretically well conceivable that MW has positive impacts on creativity because it consists of self-generated contents (e.g., mental images, elaborations, metacognitive thoughts) that could potentially be important for a task at hand that requires some degree of creativity. In line with this hypothesis, early daydreaming research beginning in the mid of the last century as well as a number of contemporary studies have provided evidence for a positive relationship between two components of creativity—divergent thinking and creative problem solving—and MW (e.g., Singer, 1966; Baird et al., 2012; Preiss et al., 2016; Agnoli et al., 2018). On the other hand, some recent studies have reported null results suggesting that the circumstances under which positive associations can be found still need to be examined in more detail (e.g., Smeekens and Kane, 2016). In addition, it is well known that MW occurring during task execution can be detrimental to task performance in various domains (e.g., Smallwood et al., 2008; Galéra et al., 2012; Soemer and Schiefele, 2019), so why should this be different for tasks that require creative processes?

Evaluating the results of the above reviewed studies, it appears that the relationship between MW and creativity will not be as simple as stating that MW that occurs during a task requiring creative processing would directly bring improvements for that task. Instead, we propose that one needs to distinguish between different forms of MW and examine whether these forms differ in their relationship with creativity (i.e., whether some of them show more positive or negative correlations than others). Particularly, two meaningful distinctions of MW were suggested in some MW studies: the intentionality of MW (e.g., Forster and Lavie, 2009; Carriere et al., 2013; Seli et al., 2015a,b; Agnoli et al., 2018; Soemer and Schiefele, 2020) and the trait-level vs. state-level distinction (e.g., Preiss et al., 2016; Soemer et al., 2019). We propose that the omission of such distinctions could at least in part be responsible for the contradictory results of the aforementioned studies.

Regarding the intentionality dimension, there is evidence that intentional and spontaneous MW exert different effects on divergent thinking, an important dimension of creativity. Specifically, the study of Agnoli et al. (2018) suggests that the intentional (but not the spontaneous) form of MW may be positively related to divergent thinking. For this reason, studies examining the relation between MW and creativity are more likely to find supportive evidence if they particularly focus on intentional MW and set up conditions in which intentional MW becomes the dominant form of MW. One factor affecting the balance between intentional and spontaneous MW, for example, are the demands of a task; that is, easy tasks are more likely to shift this balance to intentional MW, whereas difficult tasks are more likely to do the opposite (e.g., Seli et al., 2016b). For this reason, studies that use a highly demanding filler task for the incubation period are less likely to find evidence for a positive relation between MW and creativity. This may in fact be one of the primary reasons for Frith et al. (2021) failure to demonstrate a positive association between MW and creativity.

Regarding the second meaningful distinction between trait-level and state-level MW, the majority of recent studies has primarily focused on the latter. Indeed, general MW research has highlighted the detrimental effects of state-level MW while carrying out a given primary task, on performance in that task (e.g., Soemer et al., 2019), contrary to some studies in the field of creativity. However, one crucial difference here is that studies on MW in other fields (including learning) examined the effects of MW on the same task during which it occurred (e.g., the effect of MW during reading on later comprehension). The incubation paradigm used in many studies on the relation between MW and creativity, in contrast, examined the effects of MW while executing a filler task on a primary task that requires some degree of creativity.[1] Moreover, the filler task of the incubation period provides an optimal moment for MW to occur without having negative effects, since the performance in that task itself is not important. On the other hand, MW during the incubation period could have positive effects on creative performance that seem to outlast the break. However, this is in contrast to the performance

[1] Interestingly, a MW episode that occurs during the filler task may be classified as on-task behavior with regard to the primary task in this paradigm, if the episode deals with topics of the primary task.

in most other fields that demands one's sustained attention (e.g., driving a car, reading a text for an exam, following a conversation) that could be distracted and therefore be interfered by MW over the whole time. Eventually, state-level MW might not be as detrimental in creative domains that include an incubation period as it is for other domains. Distinguishing between MW at the state level and at the trait level in future research could help to find some evidence for this hypothesis.

In terms of trait-level MW, Preiss et al. (2016) showed that students' trait-level MW was positively associated with two scores of creativity suggesting that the more MW the participants experienced in their daily lives, the more creative they were. This finding is in-line with earlier daydreaming research that showed positive associations between measures of daydreaming and creative problem solving (e.g., Singer, 1966; Huba et al., 1977). Interestingly, the results of a recent study by Soemer et al. (2019) suggests that trait-level MW might actually have opposite effects on a given primary task. Replicating previous studies on MW during reading, they found a negative association between state-level MW and comprehension, whereas trait-level MW had two opposing effects on comprehension. First, there was a negative effect mediated by state-level MW meaning that trait-level MW was positively associated with state-level MW which in turn had a negative effect on comprehension. Second, there was a direct *positive* effect of trait-level MW on comprehension. Soemer et al. (2019) hypothesized that trait-level MW, like daydreaming, is composed of different dimensions (i.e., positive-constructive, poor attention etc.). Accordingly, the direct positive effect of trait-level MW might be related to elaborative processes occurring during reading; that is, individuals scoring high on their trait-level scale of MW presumably engaged in more elaborative processes during reading which, in turn, improved comprehension. This would be in accordance to findings of the daydreaming research that showed the positive-constructive type of daydreaming to be associated with the exploration of ideas and openness to new experiences (e.g., to allow for new unfamiliar thoughts; Tang and Singer, 1997). Unfortunately, to our best knowledge, no study has yet investigated the relationships between trait and state MW with creativity simultaneously.

Finally, it should be noted that each of the studies that investigated the association between MW and creativity was based on the hypothesis of an existing association between those constructs. However, a general caveat interpreting studies that fail to find evidence for a relation between MW and creativity is that non-significant hypothesis tests, as important as they may be, do not support the null hypothesis of no relation between MW and creativity. This is because the general framework of null hypothesis significance testing (NHST) does not allow for accepting the null hypothesis upon a non-significant result (see Nickerson, 2000, for a thorough discussion).

EDUCATIONAL IMPLICATIONS

Overall, the reviewed body of research suggests that creativity is positively related to, at least, certain forms of MW. Creativity in turn, is known to promote various forms of learning (e.g., Hattie, 2009; Karwowski et al., 2020). We thus argue that educational practitioners should not blindly aim at reducing MW during a session but they should pay attention to the conditions that promote "beneficial" MW. In the following, we will make a number of suggestions on how to accomplish this.

One particular outcome of the reviewed studies is that breaks can help finding solutions to tasks requiring divergent thinking or gaining insight into a problem (i.e., creative problem solving). This outcome may not sound entirely new. Generations of teachers and learners have intuitively known that making a break and refresh one's mind can lead to the solution of a problem (Wallas, 1926). On the scientific side, early experimental research by the Russian psychologist Zeigarnik demonstrated that individuals who take a break from a given task and engage in task-unrelated activities (such as playing) will remember better what they did before the break than individuals that complete their task before the break (Zeigarnik, 1927). More recent research in this field suggests that breaks may serve as incubation periods for creative problem solving and, therefore, should be introduced into classroom sessions (Rae, 1997; Webster et al., 2006). In terms of the four-stage model of creative process (Wallas, 1926), breaks provide space for the second stage, incubation, so the absence of a break during a creative task would be tantamount to skipping this important second phase of the creative process. Moreover, most learning tasks in school are treated "uninterruptable," such as reading a long text to its end in order to earn the break first. In contrast, it might be useful for teachers to look for a suitable place for a short break within the learning material that allows learners for creative incubation and process what they have learned so far.

Going beyond the previous literature, however, a main contribution of the studies reviewed here is that they reveal MW as a potential mediator process for the effect of an incubation period for creative problem solving. Furthermore, some studies suggest that the activity carried out during the incubation period is an important factor to consider. In particular, this activity should be easy enough to allow for sufficient levels of MW (Baird et al., 2012). Similarly, performing in no activity during the incubation period does not contribute to MW. A task too difficult, however, could not only hinder the creative idea generation during incubation stage of creative process but also shift the proportion of beneficial intentional MW to a more detrimental form, spontaneous MW (Seli et al., 2016b). Taken together, these findings highlight the importance of choosing an activity (in contrast to having no activity) with an easy level of difficult, to perform during a break. Fortunately, it has been found that easy to realize stimulus-response tasks can improve MW occurrence during incubation periods (e.g., Baird et al., 2012). On the other hand, tasks such as the SART are also capable of stimulating MW (Tan et al., 2015), but they are limited to the laboratory and are hardly applicable in educational settings. It seems not too difficult to find other tasks that meet both requirements, meaning that they are beneficial to MW as well as easy to implement into breaks. However, unless there are any new findings, the scope of application is primarily limited to creative performance in divergent thinking tasks and insight problem solving. It remains to be evaluated whether these results can also be transferred to real teaching situations, as an earlier examination showed no evidence for a relation between performance in solving insight problems and real-world creative achievement as well as creative behavior (Beaty et al., 2014a).

GENERAL CONCLUSION

MW is often considered as an obstacle to performances in various domains of learning and cognitive functioning in general. However, many researchers have pointed out that MW occurs too often in daily life to simply represent a mere dysfunction of our brain (e.g., Mooneyham and Schooler, 2013; Schooler et al., 2013; Smallwood and Andrews-Hanna, 2013). Indeed, like these researchers, we argue that MW may actually serve an important cognitive function in our lives. One of these functions is to facilitate creative output in form of divergent thinking and creative problem solving, as suggested by several reviewed studies on the relation between MW and creativity. We further argue that because creativity is an important predictor of learning in various contexts, specific forms of MW occurring at the right time may actually promote certain learning tasks, in particular, when these tasks require original and appropriate solutions (i.e., creative problem solving).

That being said, evidence to support our claim is somewhat indirect and limited to the incubation paradigm and two subdomains of creativity (i.e., divergent thinking and creative problem solving). We therefore suggest that results from studies using the incubation paradigm should be transferred to more realistic learning contexts. In addition, future research addressing the relationship between MW and creativity should pay more attention to the different forms of MW.

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All authors listed have made a substantial, direct, and intellectual contribution to the work, and approved it for publication.

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