Chapter 14
Thought Dynamics: Which Role for Mind Wandering in Creativity?

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Abstract For a long time, mainstream psychological research on cognitive processes has been focused on the investigation of externally-oriented cognition, namely deliberate processes generated in response to cues provided by the experimenter and associated with specific experimental paradigms. During the last two decades, there has been a surge of interest in both psychology and neuroscience toward the investigation of internally-oriented cognition, and, among the different kinds, a growing interest has been devoted to mind wandering (MW), which represents a shift in the contents of thought away from an ongoing task and/or from events in the external environment, toward internal mental contents. By definition, MW is characterized by a flow of thought, and it occurs without a fixed course or a drive to reach a specific goal. Creative thinking also involves dynamic shifts between different information and mental states. Does mind wandering contribute to creativity? Here we briefly review mixed findings on the association between MW and creativity and we outline a new multidimensional dynamic approach, in which the associations between different kinds of MW (i.e. spontaneous and deliberate) and different forms of creativity are considered. Practical implications of this approach are discussed.

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14.1 Introduction

For a long time mainstream research has been focused on the investigation of externally-oriented and deliberate cognitive processes, associated with specific cognitive tasks (*task-centric view of mental processes*, Christoff et al. 2016, p. 1). This task-centric view of mental processes contrasts with our everyday life experience. In many situations of daily life, as for example while reading a book, attending a lecture, or driving, we may notice, to our dismay, that our attention drifts away from the primary task and the external environment and our mind starts wandering elsewhere towards internal thoughts, such as memories, current concerns, prospective thoughts, whose content is unrelated to the ongoing task. Usually, it takes some time (ranging from seconds to minutes) to bring our attention back to the primary task and the external environment. We refer to this *"shift in the focus of attention away from the here and now towards one's private thoughts and feelings"*(Smallwood et al. 2007, p. 818) as mind wandering, hereafter MW.

By definition, MW is characterized by a flow of thought, and it occurs without a fixed course or a drive to reach a specific goal. As we briefly review in the following, the functional and neural processes engaged in MW are becoming reasonably well established. However, as argued by Smallwood (2013), any comprehensive account of MW is expected to address and explain both the dynamics of the initial occurrence of MW as well as its maintenance-continuity over time (i.e., the process-occurrence framework; Smallwood 2013).

Recently, a series of studies have started addressing the key question of the neurocognitive mechanism by which MW arises: *Why* does the mind start wandering? And *how* does this mental state arise? To this regard, an important contribution has been provided by research studies on individual differences in MW, which introduced a crucial distinction between different types of MW, namely spontaneous and deliberate MW. The difference between the two is in the mental dynamics underlying the onset of the experience of MW: how attention shifts from external to internal information, how the change in mental state occurs, whether it occurs spontaneously or, somehow, under the individual's mental control.

The shift form external to internal information, as well as the involvement of implicit thinking processes and explicit control processes (e.g., Beaty et al. 2016) are key questions also in the study of creative thinking. Creative thinking involves indeed dynamic shifts between different information and mental states. Does mind wandering dynamics contribute to creativity? This is the question we will address in this chapter. As we will outline in the next paragraphs, identifying the processes that stimulate the initial occurrence of MW (its onset) and distinguishing between different kinds of MW, on the basis of the different dynamics of thought, can improve our understanding of how MW might contribute to different processes underpinning creative thinking.

14.2 Functional and Neural Mechanisms of MW

The phenomenon of MW has been first studied by a handful of researchers almost 50 years ago (e.g., studies on daydreaming in the 1960–1970s, Antrobus et al. 1966; Klinger 1971; Singer 1966), but only during the past two decades, it has received a widespread scientific attention, with a dramatic surge of interest in psychology and neuroscience. Our understanding of MW greatly benefited from the use of the "strategy of triangulation" (Smallwood and Schooler 2015), whereby self-reports, behavioural measures and physiological measures are combined together in the same study to make inferences about covert mental experiences.

Converging evidence suggests that MW is a ubiquitous and pervasive mental activity, common across different cultures and groups (see for a review, Smallwood and Schooler 2015). Experience sampling studies have indeed shown that people spend between 25% and 50% of their daytime engaged in MW (e.g., Killingsworth and Gilbert 2010), and the frequency of MW might even increase during well-practiced tasks (e.g., driving, reading) (Mason et al. 2007).

Neurocognitive research has clearly shown that MW is far more than a failure to constrain attention to perception, but it is instead a remarkable mental activity, which entails complex higher-order functional and neural mechanisms. An important functional mechanism involved in MW is the disengagement of attention from perception (known as *perceptual decoupling*): when the mind wanders, the attention is internally directed and the processing of sensory input is strongly decreased. This reduction has been observed in a range of physiological responses, such as pupil dilation, eye blink, and recording of event-related potentials (ERPs) (see for a review, Smallwood and Schooler 2015). Perceptual decoupling contributes to maintaining MW state insulating the internal train of thought from the distracting influence of external information, but it can, eventually, lead to a poor performance in tasks (e.g., increase in the number of errors).

Self-reports of the content of MW episodes suggest that, during MW, individuals tend to engage in *mental time travel*, mainly wandering into the personal past (involuntary recollections of autobiographical memories) and future (planning and simulation of future events). The contents of MW episodes are also mostly *self-related* and centred heavily on subjects' current concerns and goals, consistent with the notion that its thematic content is mostly driven, directly or indirectly, by the individual's goal or current life concerns, especially when taking an appropriate action toward the goal is not possible (Klinger 1971, 2013).

Neuroimaging studies (e.g., Christoff et al. 2009) provides support for these claims, showing that periods of MW involve high activations in the major hubs of the "default mode network" (DMN) as well as in executive prefrontal areas. This observed parallel recruitment of executive and default network regions – two brain systems that are often found to act in opposition – is consistent with the prevalence of a self-referential processing and with the relevance of current concerns and unresolved issues in the first-person reports, and may reflect an ongoing (if unconscious) effort to address them.

14.3 Why and How Our Mind Starts Wandering: Spontaneous and Deliberate MW

As argued by Smallwood (2013), any comprehensive account of MW is expected to address and explain the process of the initial occurrence of MW (i.e., the mental shifts between state of external and internal focus) as well as its maintenance-continuity over time (i.e., the processes that ensure the continuity of an internal train of thought once initiated, the process-occurrence framework; Smallwood 2013). *Why* does the mind start wandering at that specific moment? And *how* does this mental state arise?

The question of "*why*" is concerned with the identification of the processes and events that directly influence and control the occurrence of MW. One of the reasons for the inability to determine the onset of MW is the difficulty in causally linking MW to a preceding event that triggers the onset of MW (i.e., imperative stimulus; Smallwood 2013). In the MW literature MW episodes have been mainly described as self-generated (e.g., Smallwood 2013) and stimulus-independent (Antrobus 1968), terms that emphasize their independence from external stimuli and ongoing actions. However, during the last few years, increasing evidence has been reported suggesting for a role of external stimuli in MW (McVay and Kane 2013; Plimpton et al. 2015; Song and Wang 2012; Vannucci et al. 2017).

For example, in the experience sampling study by Song and Wang (2012), in most MW samples (88%) participants could report the trigger for the MW and nearly a half was reported to be associated with internal (49%) and half with external (51%) cues. Using an experimental paradigm, Plimpton et al. (2015) and Vannucci et al. (2017) could show that the majority of reported MW experienced during a monotonous vigilance task had an identifiable external trigger, and, in most cases, the trigger was one of the task-irrelevant verbal cues presented on the screen during the task.

How does the mind start wandering? How does the attentional shift from external to internal information occur? How does the change in mental state occur? To this regard, an increasing number of studies has demonstrated the importance of distinguishing between spontaneous (without intention) and deliberate (with intention) MW (see for a review, Seli et al. 2016c). The difference between these two kinds of MW stems from the mental dynamics underlying the onset of the experience of MW: whether the attentional shift (external-internal) occurs spontaneously or, somehow, under the individual's mental control. Specifically, in cases of deliberate MW, attention is *intentionally shifted* from the focal task to internal thoughts, whereas in cases of spontaneous MW, task-unrelated thoughts *capture one's attention*, triggering an uncontrolled shift from the task at hand to other trains of thought.

An important contribution understanding the two kinds of MW has been provided by research on individual differences in MW. Although MW is a ubiquitous and pervasive mental activity, a number of studies reported high inter-individual variability in the frequency of MW (for a review, see Smallwood and Schooler 2015), and the stability of these differences over time and across different contexts

(i.e., in the laboratory and in everyday life, Ottaviani and Couyoumdjian 2013), suggests that MW is a relatively stable characteristic of the individuals.

Recently, Carriere et al. (2013) developed and validated two self-report scales assessing individual differences in trait levels of spontaneous and deliberate MW, the Mind Wandering-Spontaneous (MW-S) and the Mind Wandering-Deliberate (MW-D) scales, respectively. A series of studies has shown that, although the MW-S and the MW-D scales were positively correlated (*rs* ranging from .30s to .50s in Carriere et al. 2013), they are differentially associated with a number of psychological traits. In their seminal paper, Carriere et al. (2013) found that individual differences in spontaneous, but not deliberate, MW were uniquely and positively associated with self-reported fidgeting and self-reported propensity to act mindlessly. Moreover, the MW-S scale was moderately associated with attentional distraction (as measured by the Attentional Control-Distraction scale) and difficulties with attentional shifting (as measured by the Attentional Control-Shifting scale), whereas only small correlations with the same measures were found for the MW-D scale. Subsequent studies provided further evidence that the tendency to spontaneous MW may reflect difficulties in controlled processing: spontaneous but not deliberate MW was associated with attention-deficit/hyperactivity disorder (ADHD) symptomatology (Seli et al. 2015b) and with higher reports of obsessive-compulsive disorder (OCD) symptoms (Seli et al. 2016a). In a recent study Seli et al. (2015a) have shown that spontaneous and deliberate MW had opposing unique associations with some aspects of mindfulness: specifically, rates of deliberate mind wandering uniquely and positively predicted the tendency to be non-reactive to personal inner experiences, whereas spontaneous mind wandering negatively predicted the same dimension. Conflating the two kinds of MW as well as the different dimensions of mindfulness would likely produce underspecified, confounded, or even misleading conclusions.

A very recent study by Vannucci and Chiorri (2018) has shown that the two kinds of MW are also differentially associated to two distinct motivational dispositions related to self-consciousness: spontaneous MW was associated to self-rumination, whereas deliberate MW was associated to self-reflection. Previous studies on the two subtypes of self-consciousness have consistently shown that self-reflection is an openness-related self-focus, mainly motivated by intellectual curiosity and need for cognition, whereas self-rumination is a neuroticism-related self-focus (Trapnell and Campbell 1999). However, the results of this study showed that spontaneous and deliberate MW were uniquely predicted by self-rumination and self-reflection, respectively, and not by more general traits such as neuroticism and need for cognition.

Recently it has been also shown that two types of mind-wandering are related to their corresponding state-levels when assessed in the laboratory and that during easy task, deliberate MW is more frequently reported than is spontaneous MW (Seli et al. 2016b). Even more interesting, the two kind of MW have been also found to be distinguishable in terms of their neural associates (Golchert et al. 2017).

In their seminal study, Golchert et al. (2017) used multi-modal magnetic resonance imaging (MRI) analysis, to examine the cortical organisation that underlies inter-individual differences in spontaneous or deliberate MW. The authors found that participants who reported higher rates of deliberate mind-wandering tended to

show a pattern of heightened integration between the default mode network (DMN) and regions of the fronto-parietal network (FPN). This pattern was observed primarily in prefrontal regions, including the medial prefrontal cortex and the anterior cingulate cortex, as well as in regions of the rostral and dorsolateral prefrontal cortex. By contrast, participants who reported higher rates of spontaneous mind-wandering showed cortical thinning in regions of the right parietal cortex, which encompassed adjacent regions of both the DMN and the FPN. As the authors conclude "these results support the hypothesis that more effective communication between regions of the DMN and the FPN is associated with MW that is more aligned with an individual's intentions" (p. 233).

Globally, these findings consistently demonstrate that spontaneous and deliberate MW are different cognitive experiences and that different cognitive mechanisms might play a role in prompting the arising of these two types of MW experiences.

14.4 The Dynamics of Creative Thinking: Which Role for MW?

The complex dynamics defining MW find a conceptual parallel in the dynamic shifts between different mental states during the creative thinking process. The thinker's mind indeed goes through a series of distinct mental states during her/his attempt to generate potential original and effective ideas (Corazza 2016). A number of models to describe the different mental states and constituents defining the creative thinking process have been proposed, such as the four-stages model by Wallas (1926), the articulation of the mental abilities by Guilford (1950), the eight dynamic stages with the elimination of all non-conscious elements from the model by Mumford et al. (1991), the Geneplore model (Finke et al. 1992), or the DIMAI model (Corazza and Agnoli 2015), just to citing a few. Even if creative thinking is usually ascribed in the common sense to a unspecific generative attitude, where the thinker is consumed in front of the challenging goal of generating a new idea, reality and empirical evidence depicted creative thinking as a complex dynamical phenomenon where idea generation is only a phase of the process, which furthermore involves inter-relations between lower-order cognitive, emotional, and attitudinal components. However, as stated elsewhere (Corazza and Agnoli 2015, 2018), should we simplify the creative thinking process to the maximum possible level, we would describe at least three necessary macro-states: gathering and structuring of information elements, ideation, and verification of the effects. Each of the three states is defined by higher-order functional mechanisms and by lower-order cognitive and motivational components.

The role of attentive mechanisms in particular have been highly explored in relation to the first two macro-states defining the process (Carson et al. 2003; Mendelsohn 1976; Necka 1999). Attentive processing seems emerging as central in the shift between the two states, representing a sort of gate either for the recruitment of exter-

nal information or for the exploration of internal thoughts. A wide breadth of attention, which allows a large range of stimuli into the thinking process through the mechanism of *irrelevance processing* (Agnoli et al. 2015), seems to produce benefit for the creative performance, in that it has been hypothesized to allow a much larger pool of associations during the creative activity (Simonton 1988). An externally-directed attention able to detect a wide range of stimuli seems to be essential in defining the first macro-state of the creative thinking process, i.e., gathering and structuring of information elements. An active debate exists instead on the role of attention during the ideation mental state. A shift towards an internally directed attention is currently the most accreditated hypothesis in the scientific literature. Empirical evidence comes in particular from the neuroscientific research, which showed stable effects by brain activities associated to an internally directed attention focus during creative ideation. Event-related alpha synchronization, specifically, has been repeatedly demonstrated over the frontal and posterior cortical sites during ideation, in particular during ideation associated to divergent thinking (Fink and Benedek 2014; Neubauer and Fink 2009). Is has been suggested that this increase in alpha activity may reflect active top-down inhibition of task-irrelevant brain regions, such as the inhibition of long term semantic memory or the inhibition of vision-related regions, in order to inhibit the processing of irrelevant stimuli (Jensen et al. 2002). This brain activity in different cortical regions seems therefore to subsume a dynamic activity under the control of an attentive focus which acts as a strong controller of the process itself (Mastria et al. 2018). However, as shown in a recent study by Benedek et al. (2014), the increase of alpha activity over the parietal regions might be associated to the strength of task-focused attention rather than reflecting only the direction of the attention (internal vs. external). The enhancement of alpha activity over the right parietal region might be interpreted as a measure of the depth of the ongoing mental imagination process, representing therefore a valid proxy of the cognitive processes specific for creative ideation (Benedek et al. 2014), even if recent evidence has been provided also on the role of the enhancement of beta activity over this brain region for creative imagination and creative cognition (Agnoli et al. 2018b).

How interfering information or thoughts can influence the process is therefore a highly debated issue in the creativity literature. According to some authors the handling of apparently irrelevant information is a core constituting function in the creative thinking process (Agnoli et al. 2015; Carson et al. 2003; Corazza and Agnoli 2015; Simonton 1988). Mind wandering seems to represent a particularly informative mental activity in this sense, since it concerns the shift in the focus of attention from a defined task or activity towards thoughts and feeling not related to the ongoing activity. Moreover, the recent distinction between spontaneous and deliberate MW might represent a new interpretative key to understand the role of the control over the introduction of information during different phases of the creative thinking process. However, controversial anectodal evidence exists on the role of mind wandering for creativity. Virginia Wolf just before the writing of "To the lighthouse" wrote "*My summer's wanderings with the pen have … shown me one or two new dodges for catching my flies. I have sat here like an improviser with his hands ram-*

bling over the piano" (Wolf 1980, p. 37). Getting lost in our own thoughts might therefore represent a fruitful mental activity to promote the generation of original ideas. Contrary to the experience described by Virginia Wolf, Schopenhauer reported that he was unable to filter out incidental sound and that this inability was shared by many other eminent creators: "*Distinguishing minds have always shown extreme dislike to disturbance in any form, as something that breaks in on and distracts their thoughts*" (Schopenauer 1900, p. 163). According to this latter experience, a creative mind should be focalized, and un-focused thoughts are detrimental to the creative ideation.

14.5 A First Proposal to Explore the Relationships Between Spontaneous and Deliberate MW and Creative Thinking

The relationship between MW and creativity is not however a new topic in creativity research. The role of this mental activity has been indeed explored in a series of studies. However, echoing the contrasting anecdotes emerging from the experience of great creators of the past, the results of the research on the relationship between MW and creative cognition appear to be inconsistent (Baird et al. 2012; Hao et al. 2015). On the one hand, some studies have shown that taking a break involving an undemanding task characterized by a high level of unrelated thoughts might improve creative performance as measured by classic divergent thinking tasks (Baird et al. 2012; Gilhooly et al. 2012). These results have been explained by means of MW's increase in unconscious associative processing, which produces a spreading activation conducive to higher creative performance (Baird et al. 2012). On the other hand, evidence has reported that MW during creative idea generation might be detrimental to creative thinking, as measured by a classic divergent thinking task (Hao et al. 2015). Given that creative idea generation has been shown to involve a top-down executive process characterized by many control processes (inhibition of interfering stimuli, inhibition of dominant but not novel responses, judging and refining of initial ideas, etc.), these results seem to confirm that MW can be considered a control-resource consuming process.

Even if apparently contrasting, these results might not be incompatible. As we previously said, the creative thinking is not an unitary phenomenon, but it is instead characterized by a complex process involving both implicit associative processes and explicit control processes (Beaty et al. 2016), and MW might inversely influence these different processes. Moreover, as we reviewed above, MW is not a unitary and homogeneous class of experiences. The distinction between spontaneous and deliberate MW is fundamental, especially in the light of the important role of focused and de-focused attention during different phases of the creative thinking process. We indeed hypothesize that the dynamics characterizing the two forms of MW could potentially give new insight for the comprehension of the dynamic organization of the creative process.

Based on this hypothesis, in a recent seminal paper, we investigated for the first time the distinct contributions of spontaneous and deliberate MW to creative achievement and creative ideation (Agnoli et al. 2018a). In the study, we took into account the complexity of both constructs. As for MW, we assessed separately spontaneous and deliberate MW. As for creativity, we did not measured only creative ideation, but we also assessed a general form of creativity, which could give us indications on the effect of MW on real-word creativity. We indeed used both a creative-thinking performance index (i.e., response originality on a divergent thinking task) and a general index of creative success (i.e., creative achievement as measured by the Creative Achievement Questionnaire; Carson et al. 2005).

A total of 77 undergraduate students enrolled at the University of Firenze (Italy) took part in the study. Each participant completed the Mind Wandering: Deliberate and Mind Wandering: Spontaneous scales, that measure everyday deliberate and spontaneous MW, respectively (Carriere et al. 2013; Italian validation in Chiorri and Vannucci in press) and The Five Facets Mindfulness Questionnaire (FFMQ; Baer et al. 2006; Italian adaptation by Fossati et al. 2013), a self-report questionnaire composed of five subscales assessing different facets of a general tendency to be mindful in daily life: observing (i.e., attending to sensations, perceptions, thoughts and feelings), describing (i.e., labeling feelings, sensations and experience with words), acting with awareness, not judging inner experience, and being nonreactive to inner experience. Two measures of creativity were also administered, that is Creative Achievement Questionnaire (CAQ; Carson et al. 2005), a widely used measure of creative accomplishments, and The Titles Task (Guilford 1968), a measure of participants' divergent thinking ability.

The results of our study showed the unique and interactive role of MW and mindfulness dimensions in predicting creative performance and creative achievement. MW dimensions interacted indeed with mindfulness dimensions in predicting the two indexes of creativity. Here, for the purposes of the present chapter, we will however discuss only the main direct results of spontaneous and deliberate MW on creative thinking. When originality and creative-achievement variances were predicted in a single model, taking into account the within nature design used in our study, spontaneous and deliberate MW were significant direct predictors of originality. Specifically, deliberate MW emerged as a main positive predictor, whereas spontaneous MW was negatively associated with originality.

The control over the MW state can be considered a central element in the creative production insofar as it may increase response originality by introducing thought not apparently related to the creative focus into the thinking process. Spontaneous MW was, on the contrary, detrimental to originality, suggesting once again that control of the thinking process is a central requirement for creative thinking. The importance of deliberate metacognitive controls over the creative process has been already highlighted by past research. Feldhusen (1995) suggested that metacognition (i.e., control over goal setting, planning, use of cognitive processes, etc.) is one of the main prerequisites for creative thinking. As previously mentioned, the ability to control the switch of attention from the actual focal task could be considered a main mechanism to manage the introduction of irrelevant information into the divergent thinking pro-

cess (i.e., irrelevant processing; Agnoli et al. 2015), which is a main attentional mechanism yielding higher originality. On the contrary, the lack of control over the introduction of information during the ideative phase of the process can be detrimental to the creative performance. This result seems to be particularly in line with the neuroscientific studies on creative ideation, where an increase of alpha activity in the posterior region has been explained as accounting for a shielding mechanism of sustained internally-directed attention that prevents external stimuli from interfering with internal processes (Benedek et al. 2014, 2016). More generally, the opposite pattern, which was obtained with the two kinds of MW, might, at least in part, contribute to explaining the mixed findings reported in the literature on the association between MW and creativity (Baird et al. 2012; Hao et al. 2015).

Interestingly, the two MW dimensions are associated in our study to the responses originality in a divergent thinking task, a measure of individual creative potential (Runco and Acar 2012). We can therefore assume that the beneficial (in the case of deliberate MW) and detrimental (in the case of spontaneous MW) effects of MW can be expressed in the whole phenomenological representation of creative potential, from personal expressions to the most outstanding achievements of creative thinking. Creativity is not indeed limited to those individuals who achieve success as a results of their creative acts, but a broad consensus exists in literature on the fact that creative potential is widely distributed (Beghetto and Kaufman 2007; Runco and Richards 1998; Sternberg et al. 2004). We believe in particular that the deliberate use of MW can find expression also in everyday creative acts, i.e., in the phenomenon defined by Beghetto and Kaufman (2007) as "mini-c" creativity. According to this vision, any information coming from the environment is not received passively, but it is interpreted and transformed by the individual through a personal lens on the basis of past experiences and personal histories, so that it assumes a new personal meaning (Beghetto and Kaufman 2007). In every personal creative act, the individual chooses to act differently, to interpret and transform reality according to her/his personal vision, to ignore convention, so that she/he can, using discretion (Runco 1996), chose deliberately to let the mind wander in order to include new and unexpected environmental information into the thinking process. Distraction becomes therefore a tool in the hand of the creative person that helps to maintain, using Stein's (1953) words, "permeable boundaries that separate the self from the environment".

14.6 Concluding Remarks and Future Developments

The control over internally-directed mental processes seems essential to understand the role of MW on creative thinking. The dynamics defining and distinguishing spontaneous and deliberate MW emerged indeed in our study to be discriminant in predicting creative performance. However, this multidimensional approach to MW should join a dynamic approach to the creative thinking process. Although speculative at present, we indeed believe that the distinction between spontaneous and deliberate MW might be even more informative if the different phases of the

creative thinking process are taken into account. We can indeed suggest that the two dimensions of MW might play a different role during the distinct phases of creative process. On the basis of our previous findings and of the results of research showing the role played by internally- and externally-oriented attention, we could expect that spontaneous and deliberate MW can reveal new aspects of the dynamics defining the three macro phases of the creative thinking process, gathering and structuring of information elements, ideation, and verification of the effects. While most of the research has explored the ideation phase, it would be particularly important to show the effect of the two distinct mental processes during the other phases of the process, and dynamically explore how their involvement can define or predict the final creative performance.

Moreover, in considering the different roles of intentional and spontaneous MW in creativity, it should be noted that intentionality (and spontaneity) is not restricted to the onset (initial occurrence) of a MW episode. As pointed out by Seli et al. (2016c) "*intentional mind-wandering can also manifest as an allowance of the continuation of a previously unintentionally progressing episode. […] Similarly, unintentional mind-wandering can manifest as an intended episode of mind-wandering that has gone beyond an intended stopping point*" (p. 9). The control over the distribution of attentional resources might dynamically change over time. Elucidating these processes can improve our theoretical understanding of the interactions between MW and creativity and it will be a very important avenue for future research.

Future studies on the association between MW and creativity will benefit from the adoption of a neuro-phenomenological approach, that combines first-person measures/experience sampling of MW and creativity processes with measures of neural activity. Clarifying how the different types of MW and subprocesses of creative thinking interact in our brain could improve our understanding of the functional roles of MW in creativity. In particular, exploring the association between MW and the alpha brain activity emerging as central during the ideational phase of the creative thinking process (Benedek et al. 2014, 2016) could potentially explain whether the internally directed processes characterizing this creative phase are associated to the mental mechanism of wandering in "*one's private thoughts and feelings*"(Smallwood et al. 2007, p. 818).

Beyond having important theoretical implications, these fine-grained neurocognitive look at MW and creativity will have also important implications for applied research in educational and professional (i.e., workplace) contexts. For a long time, research on MW has focused almost exclusively on detrimental effects of MW in educational/learning and professional contexts (e.g. Risko et al. 2012; Smallwood et al. 2011). Mind wandering during lectures has been investigated with laboratory studies, presenting thought probes during video-recorded lectures (e.g., Risko et al. 2012; Szpunar et al. 2013) and with classroom studies, presenting thought probes during lectures, and other class-related activities (e.g., discussions, problem-solving activities, students presentation).

Globally, these studies have shown that frequent MW during lectures is associated with decreased lecture quiz scores (r = .32, Risko et al. 2012) and impaired later retention of information from the lecture (e.g., Lindquist and McLean 2011;

see Schacter and Szpunar 2015 for a review). Although the frequency of MW has been found to be reduced during more engaging "active learning situations" (e.g., problem-based small-group discussions), it occurs also during these activities 15–25% of the time (e.g., Geerlings 1994). On the basis of these findings, applied research aimed at developing methods (e.g., mindfulness meditation) and educational practices (i.e., taking notes, interpolated memory tests) to reduce MW during lessons (see for a discussion, Kane et al. 2017).

However, recent studies have shown that not all types of MW have the same effects on learning performance. For example, in a very recent study Kane et al. (2017) have found that off-task thoughts which are not focused on the here-and-now of the ongoing lecture but related to the lecture topics (e.g., thoughts related to the course themes) positively predicted learning ($r = .26$, with scores on the post-test). The only study (Wammes et al. 2016) in which intentional and spontaneous MW were assessed separately reported that rates of intentional MW negatively correlated with quiz scores at the end of the lecture ($r = -.21$) whereas rates of spontaneous MW correlated with final exam score ($r = -.20$), suggesting that the two types of MW might have different effects on learning performance.

Moreover, all these studies focused on the effects of MW *during* a lecture on learning performance of the lecture contents, and they did not investigate whether trainings of MW might have more general beneficial effects on academic achievement and scholastic success in educationally relevant contexts.

To this regard, our findings on the association between MW and creativity highlight the importance for future research to examine the possibility of developing methods to increase MW under certain conditions and to study the effects of this increase on the creative performance and academic achievement.

For example, future studies should investigate whether MW trainings, in which students learn making room for intentional MW during monotonous and repetitive tasks, might increase both the level of meta-awareness and control over MW and their creative performance. Moreover, given the positive association between creative thinking abilities and academic achievement (Beghetto 2016; Gajda et al. 2017), training intentional MW might also indirectly affect scholastic success, through the mediation of enhanced creative ideation.

This approach however can only be assumed adopting a dynamic framework to the study of creativity and MW, which does not consider the two phenomena as static mono-dimensional constructs, but as complex thinking processes which mutually and dynamically define each other.

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