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Mind-wandering as an exploratory response to boredom

Corinna S. Martarelli[1] & Ambroise Baillifard[2]
[1] Faculty of Psychology, UniDistance Suisse, Brig, Switzerland
[2] EDUDL+, UniDistance Suisse, Brig, Switzerland

Abstract

In this chapter, the link between mind-wandering and boredom is introduced and defined. Despite the intuitive overlap between the two constructs, there is scarce empirical research that directly tests and theorizes their association. However, mind-wandering as a possible response to boredom, fits perfectly with current functional accounts of boredom. According to such accounts, boredom is conceptualized as a signal that a task at hand is not worth the effort. When no behavioral alternatives are available, an option that is always accessible is to let the mind wander. We suggest that mind-wandering is an exploratory response to boredom especially when a change in activity is not possible or not desired. We take into account different forms of mind-wandering as possible response to boredom, focusing in particular on spontaneous and deliberate mind-wandering. We then propose that the experience of boredom during mind-wandering can be explained by the intended level of control, rather than by the perception of control per se. Finally, we hope that the ideas presented here will inspire future research on the various possible ways in which boredom and mind-wandering might be related.

Mind-wandering as an exploratory response to boredom

Imagine feeling bored when reading a book on a long-distance train ride. The landscape outside the window might catch your eyes. Your mind might begin to wander spontaneously, such as by moving freely from one unrelated topic to another. Suddenly, you become aware of your mind wandering and want to get back to the book. However, you feel bored and can no longer manage to involve yourself with the book. In search for something more rewarding you look outside the window, and you might deliberately engage in a parallel train of thought, such as planning your weekend. In this case, your boredom might disappear for a while.

Most of us are familiar with this link between boredom and mind-wandering, which has been the subject of debate and empirical investigation in psychological research and related fields. Is mind-wandering triggered by the experience of boredom, or vice versa? What are the antecedents of boredom? One's own thoughts, the situation (i.e., the book or the train ride)? How does boredom relate to personal intentions? What are the consequences of boredom?

Despite our familiarity with these concepts, there is only scarce empirical research that directly tests and theorizes the link between boredom and mind-wandering. In the first part of this chapter, we will introduce these constructs and review the literature that investigates them. In the second part, based on the reviewed literature, we propose a working model of mind-wandering as a possible response to boredom. Boredom triggers exploratory behavior, and we propose that mind-wandering is an exploratory response to boredom when a change in activity is not possible or not desirable. Our proposed model calls for future research on this overlooked link between boredom and mind-wandering.

Boredom and mind-wandering share some (but not all) features

Although in the beginning phases of research on mind-wandering, the role of boredom was taken into account (see Singer & Antrobus, 1963, 1966), there has been a surprisingly low number of studies jointly investigating both constructs. In their seminal work on mind-wandering, Singer and Antrobus (1966) developed the Imaginal Processing Inventory (IPI), an exhaustive questionnaire of 344 items that comprises 28 subscales measuring the various aspects of the phenomenon, such as absorption in daydreaming or the acceptance of daydreaming, but also boredom susceptibility or the need for external stimulation. Based on the results of factor analyses in several studies, the authors reduced the questionnaire to its short form (Short Imaginal Processing Inventory or SIPI; Huba et al., 1982). This 45-

item questionnaire comprises three subscales: *positive-constructive daydreaming*, *guilty-dysphoric daydreaming*, and *poor attentional control*. Whereas the first subscale reflects vivid daydreams oriented toward the future and problem solving (as well as a general acceptance of daydreaming), the second and third factors have a more negative valence. Interestingly, the *poor attentional control* factor is characterized by a general tendency to boredom and distraction associated with spontaneous thought. This seminal work suggests different routes between boredom and mind-wandering (especially between boredom and deliberate mind-wandering and boredom and spontaneous mind-wandering respectively).

Despite this early evidence – and the intuitive evidence of a link between boredom and mind-wandering – research investigating these constructs concurrently is still in its beginning stages. A search in the SCOPUS database (restricted to the title, abstract, and keywords) performed in March 2022 with the terms "boredom" and "mind-wandering" found 27 entries when compared to the around 6,000 entries when searching for the term "boredom" alone, and around 1,500 entries returned when searching for the term "mind-wandering" alone. Before reviewing the literature that investigates both constructs concurrently, we provide a short description of theories of boredom and mind-wandering, as well as the phenomenology of these constructs, with the aim of highlighting the similarities and differences between the two constructs.

Boredom. Boredom has been described as the desire to want to engage in an activity, but being unable to engage in any activity (Eastwood et al., 2012). Boredom occurs when the task at hand does not match one's individual abilities (Danckert & Merrifield, 2018; Eastwood et al., 2012) and/or is meaningless (Moynihan et al., 2020; van Tilburg et al., 2013; van Tilburg & Igou, 2012). Boredom is a disengagement-related process, and its function is to signal that attentional resources should be invested elsewhere (Bench & Lench, 2013; Elpidorou, 2018). Whereas in the past, little function had been ascribed to boredom, current models highlight and build upon the role of boredom in goal-directed behavior. We refer the interested reader to chapters *XXX* in this book devoted to theoretical approaches to boredom.

Goal-directed behavior has been investigated in the explore-exploit dilemma (Cohen et al., 2007; Gittins, 1979), in which individuals have to decide whether to exploit a situation (e.g., pursue a research project) or explore other situations (e.g., initiate new collaborations) that might be more rewarding. Currently, there has been increased interest

in the explore-exploit dilemma linking boredom with exploration (Agrawal et al., 2021; Bench & Lench, 2013; Bieleke & Wolff, 2021; Gomez-Ramirez & Costa, 2017; Kurzban et al., 2013; Wolff & Martarelli, 2020). In functional theories of boredom, the function of boredom is to disengage individuals from the task at hand to explore alternative options; in other words, the experience of boredom calls for exploration. Thus, boredom has been conceptualized as a self-regulatory mechanism that helps one to find a balance between exploitation and exploration (Danckert, 2019). However, if the signal of boredom is not taken into account by changing the activity or reengaging attention in the ongoing task, one might get trapped in the experience of boredom, which is an aversive one (Martarelli, Wolff, et al., 2021) that is distinctive from other emotional states, such as apathy, frustration, anhedonia, or depression (Goldberg et al., 2011; van Tilburg & Igou, 2017).

The experience of boredom is further characterized by a lack of control (Mugon et al., 2018), which is reflected in the strong negative relationship between boredom proneness and trait self-control (Wolff et al., 2020). Mirroring the negative relationship between the two constructs, self-control is associated with a plethora of positive outcomes – it is essential in goal achievement (Inzlicht et al., 2021) – whereas boredom has a negative connotation (e.g., Spaeth et al., 2015). This dark side of boredom partially shadows its adaptive function, which leads us to seek new opportunities for more rewarding activities, ideas, and knowledge. Despite the value of exploitation and engagement, people do not always apply self-control to remain engaged with the task at hand (Wiesner et al., 2021), and current models based on the costs and benefits of goal-directed behavior (Kurzban et al., 2013) have highlighted the functional role of boredom, which is to trigger exploration behavior (Wolff & Martarelli, 2020). For further theorizing on the link between boredom and self-control we refer the interested reader to Chapter *XXX* of this book.

Notable recent exceptions notwithstanding (Tam et al., 2021; see also Elpidorou, 2021) theoretical accounts of boredom focus on boredom as a signal to redirect attention in the external world. However, boredom not only triggers attention to shift outward towards alternative activities, but also inwards towards alternative thoughts. In their *boredom feedback model*, Tam et al. (2021) highlighted three routes the effect of boredom can take: attention shifts out, attention shifts in, or attention shifts back to the task at hand to reestablish task engagement. In this model, internal shifts of attention, such as mind-wandering, are also accounted for. The conceptualization of this internal route is a theoretical example of how mind-wandering can be identified as a strategy for copying with boredom (Harris, 2000;

Kane et al., 2007). Another innovative dimension of Tam et al.'s (2021) model is the distinction between cognitive resources and the intention to deploy them. The authors suggest that rather than pure attention, it is the intention (desire) to attend that has to be taken into account. The attentional component refers to the congruence between the demands of the task and the individual's attentional resources (Eastwood et al., 2012; Westgate & Wilson, 2018), whereas the intention to attend refers to the willingness to engage in an internal or external activity (Crane, 1998). For example, if a student's mind wanders spontaneously during a lecture and they have no intention to attend to the class (i.e., congruence between the level of attention and the intended attention), then no boredom will occur. However, if the student would like to attend to the class, boredom might occur (along other sensations, such as for example frustration). To summarize, in Tam et al.'s (2021) model, boredom is conceived as a result of the discrepancy between actual and desired levels of engagement.

Mind-wandering. The study of mind-wandering corresponds to the emergence of cognitive psychology in the 1960s (see, e.g., Singer & Antrobus, 1966, mentioned above). In this respect, Singer and Antrobus's (1966) seminal work focused on the phenomenological properties of mind-wandering; however, it was only later, beginning in the 2000s, that research about mind-wandering increased rapidly. During this second wave of mind-wandering study, researchers started to triangulate methods, concurrently using self-report, behavioral, and neurological measures (Hawkins et al., 2019) and thus promoting a rapid advancement of the field. During this period, researchers focused on investigating the neural underpinnings of mind-wandering (e.g., Mason et al., 2007; Smith et al., 2009). It is also during this period that the default mode network (a network comprising the prefrontal regions, cingulate cortex, and hippocampal areas, among others) was revealed (Raichle et al., 2001), which is active when individuals are at rest and engaging in mind-wandering.

Various definitions of mind-wandering have been proposed, with the terms of *task-unrelated thought* (Giambra, 1995), *stimulus-unrelated thought* (Antrobus, 1968; Teasdale et al., 1995), and *spontaneous thought* (Christoff et al., 2016) being used most frequently. Indeed, during mind-wandering episodes, attention is directed to self-generated thoughts and drifts away from the external environment (see Smallwood & Schooler, 2015 for a review). Other terms that have been used apart from mind-wandering (Smallwood & Schooler, 2006) are daydreaming (Klinger & Cox, 1987) and self-generated thought (Smallwood & Andrews-Hanna, 2013) to name just a few. While several definitions have been

discussed within the field of mind-wandering research, the authors do not always agree (see Christoff et al., 2018; Seli et al., 2018 for recent debates). Classical definitions of mind-wandering draw upon an uncontrolled shift of attention away from an ongoing task. However, individuals can let their minds wander deliberately during an ongoing task. To understand this distinction, Christoff et al. (2016) have thus proposed that there are two constraints on thought – *automatic* constraints and *deliberate* constraints. Whereas automatic constraints operate outside of cognitive control (e.g., sensory or affective salience), cognitive control implements deliberate constraints. The authors define mind-wandering as a form of thought with a range from low to medium automatic and deliberate constraints, thus accounting for several nuances in the intentionality of mind-wandering.

Findings of various studies have revealed that mind-wandering is pervasive (Killingsworth & Gilbert, 2010), essentially future-oriented (Smallwood et al., 2009; Stawarczyk et al., 2011), problem-solving oriented (Leszczynski et al., 2017), and influenced by personal goals (Stawarczyk et al., 2013). Another important phenomenological dimension that has attracted much attention in recent years is the intentionality of mind-wandering, with researchers taking account of whether individuals spontaneously shift attention to task-unrelated thought or whether they engage purposefully in other thoughts (Golchert et al., 2017; Seli, Carriere, et al., 2015; Seli et al., 2016). The distinction between deliberate and spontaneous mind-wandering was introduced in the seminal work of Giambra (1995). In several low-control tasks, he observed that deliberate mind-wandering occurred more frequently than spontaneous mind-wandering. However, the higher frequency of deliberate mind-wandering might be explained by the ease of the tasks. Current work suggests instead that mind-wandering occurrences vary during a primary task as a function of individual cognitive resources, the demands of the task, and the intention to attend to the task (McVay & Kane, 2009; Rummel & Boywitt, 2014). Finally, mind-wandering appears to be a mixture of spontaneous and deliberate thoughts (Kane et al., 2007).

In light of these observations, several theories of mind-wandering have been proposed (see Smallwood & Schooler, 2015 for a review). For example, the *attentional decoupling hypothesis* distinguishes between disengaged processes, when attention is decoupled from perception and directed toward inner worlds (i.e., mind-wandering), and engaged processes, when attention is directed toward the external world (Schooler et al., 2011). If this perceptual decoupling of attention occurs during an activity, it generally leads to a worsened performance on the task at hand (Smallwood et al.,

2008). There is a large body of evidence indicating that mind-wandering impairs current activities, such as those performed in academic contexts (Wammes et al., 2016) or while reading (Schad et al., 2012).

Next to attentional theories, models that also take into account motivational aspects have been developed. The *executive control failure x concerns model* of McVay and Kane (2010) integrates the restless mind of Smallwood and Schooler (2006) with the idea of current concerns, thus taking into account that the mind frequently wanders to personal concerns (see also Engert et al., 2014). Interestingly, Mooneyham and Schooler (2013) mention relief from boredom as a possible function of mind-wandering. They suggest that, while bored with the task at hand, an option is to explore inner worlds. The function of mind-wandering would thus include self-regulation (relief from boredom when executing a necessary task, e.g., hanging laundry, waiting), and making subjective time pass faster; what this means is that mind-wandering might accelerate the perception of time during boring tasks. While time seems to pass slowly when bored (Witowska et al., 2020), time seems to speed up during episodes of mind-wandering (Mooneyham & Schooler, 2013).

Finally, researchers have highlighted the benefits of mind-wandering not only in terms of mood regulation, but also because it facilitates creativity (Agnoli et al., 2018; Baird et al., 2012; Zedelius & Schooler, 2016) and mental exploration (Irving, 2016; Sripada, 2018). In this vein, Sripada (2018) proposed a model of mind-wandering in terms of exploration, as opposed to goal-directed thinking (exploitation). In Sripada's view, the explore-exploit dilemma also occurs at a mental level, with individuals mind-wandering to learn and discover new paths, and then think intentionally about what they have discovered in order to maximize reward. In this approach, mind-wandering is considered to occur spontaneously, and with ease; in other words, thoughts come to mind with low effort and low control, and they are free to flow (Fox & Christoff, 2018).

Boredom and mind-wandering. In the previous paragraphs, we briefly summarized the various features of boredom and mind-wandering as well as theories of both constructs. Based on this literature, the overlap between the constructs is striking; however, it has become clear that the constructs do not share all properties and correlates. Table 1 highlights the similarities and differences between boredom and mind-wandering in terms of attention, meaning, control, arousal, valence, effort, perception of time, correlates, costs, benefits, and neural underpinnings. In considering the intuitive link

between boredom and mind-wandering, it is not surprising that the similarities outnumber the differences; however, differences do still exist (see italics writing in Table 1).

While there is agreement that boredom is a rather negative experience (van Tilburg & Igou, 2017), the experience of mind-wandering can be a positive one (Smallwood & Andrews-Hanna, 2013). However, there is a bulk of empirical evidence showing a negative impact of both boredom and mind-wandering in different domains – when individuals are not engaged in a primary task (Pekrun et al., 2010; Wammes et al., 2016). Activation of the default mode network has been revealed across many studies, particularly in mind-wandering research (e.g., Mason et al., 2007) but also in the literature on boredom (Danckert & Merrifield, 2018). There is also evidence of the benefits of boredom and mind-wandering, especially when it comes to creativity (Baird et al., 2012; Harris, 2000). However, these results are by far less numerous when compared to the research highlighting the negative consequences of boredom and mind-wandering. Furthermore, there has not been much unanimity among researchers in whether there is a link between creativity and boredom and mind-wandering respectively (see replication failures, inconsistent results, especially as concerns the mind-wandering – creativity relationship, e.g., Murray et al., 2021)[1].

Some of the differences between the constructs seem to suggest that mind-wandering is a possible response to boredom (e.g., time passes slowly during the experience of boredom, and time flies during mind-wandering episodes; there is a lack of meaning during the experience of boredom, while meaning can be found during mind-wandering, and mind-wandering can be used to regulate mood; boredom is linked to the sensation of effort, while the mind wanders with ease). When it comes to similarities, attention failures[2] characterize both boredom (Danckert & Merrifield, 2018;

[1] A very recent study (Irving et al., 2022) investigated the relationship between mind-wandering and creativity by using a boring video and an interesting video as experimental variable. The authors found a relationship between mind-wandering and creativity but only in participants that watched the interesting video. In this condition, participants that reported more mind-wandering performed better in a subsequent creativity task (they generated more creative ideas in the alternate uses task, e.g., they generated more alternative uses for a brick). It seems that some constraints support productive mind-wandering; the external environment can give information that is included in the mind-wandering process and by being partly engaged with the external world, some less productive forms of mind-wandering might be inhibited. Further, in Study 1, the authors also found a main effect of their manipulation. The ideas generated during the boring video were semantically more distant (this is a measure of originality) than the ideas generated during the interesting video. Overall, these results suggest that boredom can directly affect the creativity process by triggering exploration behavior (i.e., during a boring task, individuals are triggered to think at something else) but that activities only lead to creative mind-wandering under certain specific circumstances.

[2] For an alternative conceptualization of boredom as a failure of attention see Chapter 2 in this book. The authors propose that despite the observed link between boredom and attentional failures, attentional disengagement should not be considered a failure. Indeed, it is the function of boredom to disengage attention from a situation that is not rewarding any more.

Hunter & Eastwood, 2018; Merrifield & Danckert, 2014) and mind-wandering (Cheyne et al., 2009; Christoff, 2012; Mrazek et al., 2012). However, it remains unclear to whether failure in attention gives rise to boredom, or vice versa. Whether it is boredom that triggers mind-wandering, or the other way around, is an open issue. In the next few paragraphs, we review the literature that investigates both constructs concurrently.

	Boredom	**Mind-wandering**
Attention	Difficult to engage with the outer and *inner world* (Eastwood et al., 2012)	Difficult to engage with the outer world (Smallwood et al., 2008)
Meaning	Lack of meaning (van Tilburg et al., 2013)	Lack of meaning (Seli, Cheyne, et al., 2015; but, see *finding* meaning in Smallwood & Schooler, 2015)
Control	Lack of control (Mugon et al., 2018; Pekrun, 2006)	Lack of control (McVay & Kane, 2009; but see *deliberate* mind-wandering in Seli et al., 2016)
Arousal	Low, *high,* and *mixed* arousal (Danckert et al., 2018)	Low arousal (Unsworth & Robison, 2018)
Valence	Aversive state (van Tilburg & Igou, 2017)	Aversive (Killingsworth & Gilbert, 2010), *mixed,* or *positive* state (Stawarczyk et al., 2013)
Effort	*High* effort (Bieleke et al., 2021)	*Low* effort (Christoff et al., 2016)
Perception of time	Time passes *slowly* (Witowska et al., 2020)	Time passes *quicky* (Mooneyham & Schooler, 2013)
Correlates	E.g., procrastination, rumination, and depression (e.g., Li et al., 2021; Todman, 2003)	E.g., procrastination, rumination, and depression (Smallwood, O'Connor, et al., 2007)
Costs	Worse performance in cognition (e.g., memory; Blondé et al., 2021), daily life (e.g., education; Pekrun et al., 2010), substance abuse (Weybright et al., 2015), problematic Facebook use (Donati et al., 2022), and driving (Steinberger et al., 2017)	Worse performance in perception (Kam et al., 2011), cognition (e.g., memory; Garlitch & Wahlheim, 2020; Martarelli & Ovalle-Fresa, 2021), daily life (e.g., education; Smallwood, Fishman, et al., 2007; Wammes et al., 2016), and medicine (Smallwood et al., 2011)
Benefits	Creativity (Harris, 2000), *prosocial behavior* (van Tilburg & Igou, 2017), *curiosity* (Martarelli et al., 2022), and exploration (Geana et al., 2016)	Creativity (Baird et al., 2012; Gable et al., 2019), *autobiographical planning* (Baird et al., 2011), *prospective memory* (Mason & Reinholtz, 2015), and *regulation of emotions* (Ruby et al., 2013)
Neural underpinnings	Default mode network (Danckert & Merrifield, 2018)	Default mode network (Mason et al., 2007)

Note. Aspects of boredom and mind-wandering. References are not meant to be exhaustive, but illustrative. Italics highlight the differences between boredom and mind-wandering.

Previous research investigating whether a lack of attention is a cause or a consequence of mind-wandering has come to mixed conclusions. For example, Hunter and Eastwood (2018), used a classical sustained attention to response task (SART; Robertson et al., 1997), in which participants are presented with single digits ranging from 1 to 9 and asked to press the space bar each time they see a digit, but to withhold the press when seeing a specific digit (e.g., the digit 9). The authors found that attentional errors were associated with levels of boredom reported before and after completing the different blocks of the task. Despite being unable to satisfactorily manipulate boredom, they carried out an explorative analysis, suggesting that attention failures may cause boredom rather than the other way around. This is an interesting finding because it suggests that not only does boredom trigger mind-wandering, but also that mind-wandering itself can be boring. This finding is consistent with other studies that found a positive association between boredom and mind-wandering, assessed with self-reported thought probes during ongoing tasks (e.g., Blondé et al.,

2021; Danckert et al., 2018). In one study, Vannucci et al. (2017) investigated the impact of verbal cues on the frequency and temporal focus of mind-wandering episodes. Participants also had to rate how concentrated they were, as well as their levels of boredom, after executing a vigilance task. The researchers found higher levels of boredom reported in the condition without cues when compared to the condition with cues; however, the levels of concentration were not affected. These findings suggest that the relationship between boredom and mind-wandering might not always be linear, but rather more complex and situation dependent.

To our knowledge, research investigating *state* boredom and mind-wandering has not assessed both spontaneous and deliberate mind-wandering but were limited to classical definitions of mind-wandering. However, studies investigating the link between boredom and mind-wandering on a trait level have relied on the spontaneous-deliberate distinction. For example, Isacescu et al. (2017) found that boredom-prone individuals also scored higher on the spontaneous and deliberate mind-wandering scales (Carriere et al., 2013). Importantly, they found a significant difference between the correlations: the association between boredom and spontaneous mind-wandering was stronger than the association between boredom and deliberate mind-wandering. This differential association was replicated in a recent study by our group (Martarelli, Bertrams et al., 2021). Using a network analysis approach, we showed that the three constructs reflect distinct dimensions, with stronger positive associations between boredom and spontaneous mind-wandering than between boredom and deliberate mind-wandering. These results make sense, given that both boredom and mind-wandering (especially spontaneous mind-wandering) are characterized by reduced agency in one's behavior (Raffaelli et al., 2018) and low cognitive control in one's thought (Christoff et al., 2016). Furthermore, these results seem to suggest that deliberate mind-wandering, reflecting *engagement* with one's own thoughts, might be a good candidate for counteracting the experience of boredom. To the extent that this research considers trait variables, it remains open whether, on a state level, mind-wandering might work as a route out of the experience of boredom.

Mind-wandering as a possible response to boredom

You don't throw your time away, sitting still
I'm in a chain of memories, it's my will
—John Frusciante (2001, Going Inside)

Based on the distinction between spontaneous and deliberate mind-wandering (Carriere et al., 2013; Seli et al., 2016), it seems that not all types of mind-wandering are equally associated with boredom. A plausible explanation is that

spontaneous mind-wandering happens with ease (demanding relatively low cognitive control). The experience of boredom can arise in situations where an individual has low control because of internal or external constraints. Indeed, lack of control has been proposed as a key factor in the experience of boredom (e.g., Pekrun et al., 2010). Continuing to be engaged with a boring task, is self-control demanding by it-self; thus, it makes sense that there may be stronger associations between boredom and spontaneous rather than deliberate mind-wandering given that spontaneous mind-wandering is less control demanding than its deliberate counterpart. In line with Tam et al. (2021), we propose that beyond control, the key component of the experience of boredom is personal acceptance, or the congruence between an individual's current cognitive control and her/his intended control. The experience of mind-wandering is qualitatively different if one is in a situation with plenty of time (e.g., while riding a train) and enjoys the spontaneous moving of the mind or even gives direction to the wandering mind (as exemplified in the above lyric of John Frusciante) when compared to a situation where one has to finish a monotonous task, and the thoughts drift away spontaneously, thus hindering the correct execution of the task. In the first scenario, exploring inner worlds will reduce/eliminate the experience of boredom, whereas in the second scenario, the person will struggle with the experience of boredom and the related effort to maintain and return attention to the task I hand. In this latter situation, boredom might cause a lack of attention, and the lack of attention might increase the experience of boredom in its turn.

Boredom and different types of thought. The mixed findings reviewed in the previous sections suggest that the relationship between boredom and mind-wandering is complex and bi-directional. In Figure 1, we illustrate the proposed link between boredom and mind-wandering.

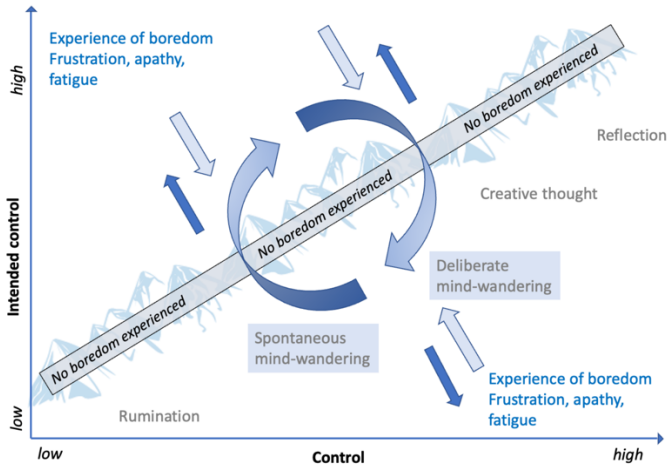

Figure 1. Boredom and different types of thought.

On the x-axis, we depict the current levels of cognitive control of the thoughts, ranging from low to high (see Christoff et al., 2016). For example, rumination is uncontrolled, whereas reflection is controlled thought. The different types of thought reported here are not meant to be exhaustive, but illustrative. Other types of thought that vary in the level of control, such as hallucinations, visual memories, fantasies, diffuse thinking, goal-directed thinking, or self-reflection, are not depicted in the graph.

On the y-axis, we depict the intended level of cognitive control of thoughts. In line with the boredom feedback model of Tam et al. (2021), we propose that the experience of boredom results from a discrepancy between the actual level of control and the desired one. The diagonal line represents a correspondence between actual and intended levels of control – thus, no boredom is experienced. We represent this line with mountains, to highlight the fact that it is not a place where we rest endlessly. Sooner or later, we can make the experience of boredom (in the areas outside of the mountains line). Indeed, as soon as there is a discrepancy between actual and intended levels of control, boredom can occur, and the experienced type of thought is no longer perceived as satisfactory. If the mind wanders spontaneously when faced with a given primary task, and this actual level of control corresponds to the intended level of control, then no boredom is experienced (i.e., the diagonal of the figure). However, if the intended level of control becomes higher, then the experience of boredom may arise. We suggest that depending on the intended level of control, spontaneous mind-wandering can be a relief from boredom (when there is no wish to be more in control) or a reinforcer of boredom (when there is a wish to be more in control). Discrepancies give rise to boredom, and the experience of boredom can reinforce this discrepancy. In the case of rumination – a dysfunctional form of spontaneous thought (Christoff et al., 2016) – desiring to control the thoughts but not being able to do so might elicit several negative states, including e.g., boredom and feelings of depression thus leading to a negative cycle that might be difficult to interrupt (see upper-left part of the figure). Another example for the upper-left part of the figure is wanting, for example, to reflect on a complicated matter when faced with a given primary task but being unable to invest the intended level of control. This situation might elicit boredom accompanied by the sensation of fatigue. On the other side of the spectrum, (see lower-right part of the figure) we have underchallenging situations, that might lead to the experience of boredom. Boredom might be accompanied by other sensations and emotions, depending on the individual and the situation (which are mutually dependent upon each other, i.e., person-situation interaction, Mischel & Shoda, 1995).

Mind-wandering (especially spontaneous mind-wandering) happens with ease; thus, a possible (and we argue the most probable) response to boredom during a primary task when no satisfactory behavioral alternatives are available is mind-wandering. Indeed, mind-wandering can be understood as an explorative response to the signal of boredom. Thoughts change in their levels of control (balance between uncontrolled and controlled thoughts) and mix (there are no distinct boundaries), which is in line with current theorizing, that suggests that controlled and uncontrolled thoughts can co-occur; goal-directed thinking on a meta-analytic stance has, for example, been shown to guide spontaneous mind-wandering (Fox & Christoff, 2014). Engaging with spontaneous mind-wandering is effortless (Christoff et al., 2016), and being engaged with something reduces boredom by definition. Boredom might work as an exploratory mechanism that pushes the individual into new thoughts (and possible future activities). The arrows in the figure signal that spontaneous and deliberate mind-wandering wax, wane, and combine in order to respond to the trigger of boredom. Further, depending on the congruence between the actual and intended levels of control, the experience of mind-wandering can be satisfactory.

Variables not represented in the figure but worth considering are those related to the primary task (e.g., individual automaticity in a primary task, characteristics of the task [e.g., in terms of value], individual experience with the task, etc.).

Mind-wandering as an exploratory response to boredom. We tested this hypothesis in unpublished data of our lab (Martarelli, Weibel, & Wolff, https://osf.io/7v5uw/). In this virtual reality study, 66 participants visited 9 times a virtual waiting room (4 minutes each visit) and were asked about their waiting experience after each visit. Among other variables we asked the participants about their experience of boredom and of spontaneous and deliberate mind-wandering. Here we report two mixed model analyses, with boredom and timepoint (9 visits) as well as the interaction boredom by timepoint as fixed effects and by-participant random intercept. The dependent variable was mind-wandering (spontaneous and deliberate mind-wandering). The results revealed a significant main effect of boredom; the more participants made the experience of boredom the higher was mind-wandering ($b = 0.213$, $SE = 0.101$, 95% CIs [0.015, 0.412], $p = .036$ with spontaneous mind-wandering as dependent variable, and $b = 0.287$, $SE = 0.102$, 95% CIs [0.087, 0.487], $p = .005$ with deliberate mind-wandering as dependent variable). The results also revealed a significant

main effect of timepoint; the later the timepoint the higher was mind-wandering (b = 0.239, SE = 0.045, 95% CIs [0.152, 0.327], p < .001 with spontaneous mind-wandering as dependent variable, and b = 0.194, SE = 0.045, 95% CIs [0.106, 0.281], p < .001 with deliberate mind-wandering as dependent variable). Most importantly, the analyses revealed significant interactions between boredom and timepoint of the visit (b = -0.057, SE = 0.015, 95% CIs [-0.086, -0.028], p < 0.001 with spontaneous mind-wandering as dependent variable, and b = -0.045, SE = 0.015, 95% CIs [-0.073, -0.016], p = 0.003 with deliberate mind-wandering as dependent variable). We report the plots of the interactions in Figure 2.

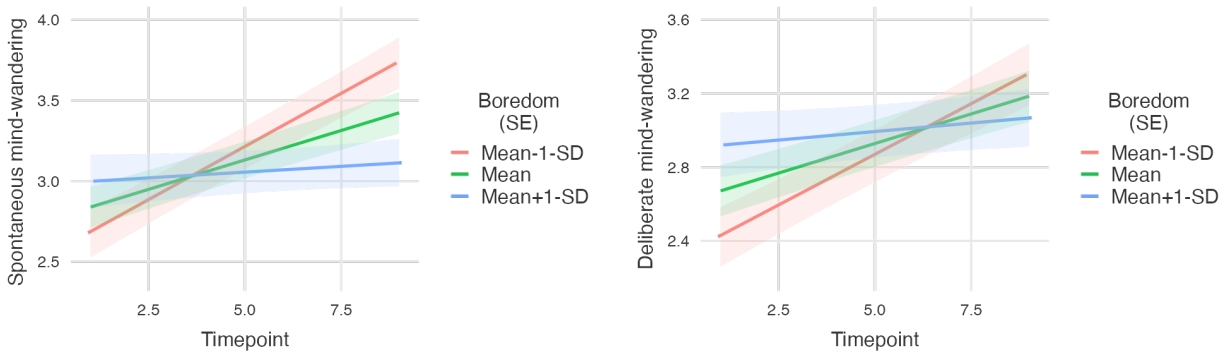

Figure 2. N = 66. A graphical representation of the interaction between boredom and timepoint (9 visits of a virtual waiting room). Boredom is an average score of 4 items assessing the experience of boredom (example item "I found the waiting boring"). Spontaneous mind-wandering ("I noticed that my mind spontaneously wandered away", see Figure on the right side) and deliberate mind-wandering ("I deliberately wandered away with my thoughts", see Figure on the left side) were assessed with single items. All items were measured with 5-point Likert scales and higher values are indicative of higher experienced boredom and mind-wandering respectively.

These results suggest that over time some participants might have used mind-wandering as a strategy to reduce boredom among others. Indeed, changes in mind-wandering (both spontaneous and deliberate) over time were observed but only in low and middle bored participants (one standard deviation below the mean, and at the mean of boredom). These results are promising however, it has to be taken into account that the analysis is exploratory, and the data of correlative nature.

Based on theoretical and preliminary empirical evidence we propose that mind-wandering is an exploratory response to boredom when no other satisfactory activity is available. We suggest that this is consistent with theory, and we call for future research to investigate the link between boredom and mind-wandering. In our model on the potential interplay between boredom and self-control (Wolff & Martarelli, 2020), we propose that boredom signals whether one should search for a more rewarding behavioral alternative. In other words, the function of boredom is to engage individuals in

alternative goal-directed behavior (see also Kurzban et al., 2013). Here, we extend this cost-benefit approach to determine optimal behavior and suggest that not only do the opportunity costs of alternative tasks have to be taken into account, but also the opportunity costs of alternative modes of thought (Sripada, 2018).

When defining thought in an exploitation/exploration framework, controlled thought corresponds to exploitation, and spontaneous mind-wandering corresponds to exploration (Sripada, 2018). Individuals might be more likely to discover novel paths and ideas during mind-wandering, rather than goal-directed thought. Indeed, it has been suggested that mind-wandering supports learning and creativity (Sripada, 2018).

While research and theorizing on boredom essentially highlight the inability to engage with the external world, the authors agree that boredom also signals disengagement with inner worlds (Eastwood et al., 2012). What does it mean to be disengaged with inner worlds? A quote from Hugh Prather (1970) illustrates well the internal disengagement that can occur during the experience of boredom. He writes, "I notice that when I am bored I think I am tired of my surroundings but I am really tired of my thoughts." We propose that it is important to consider the thought's intended level of control (see Figure 1). Our minds rarely stop to wander – even without boredom as a trigger signal – thus, the difference resides in us willing our minds to wander (in a given direction) or not. Being disengaged with outer and inner worlds despite our intention to be focused can lead to the experience of boredom. If the mind wanders from one unsatisfactory idea to another, the experience of boredom may deepen. When no future change seems possible, individuals might remain bored. However, shifting attention from one topic to another might work as an exploratory phase, before engaging in goal-directed thinking (e.g., simulating possible scenarios) or switching to other more rewarding tasks.

Conclusion and future directions

Throughout this chapter, we have argued that there is an intricate relationship between boredom and mind-wandering. We have also argued that mind-wandering might be the most probable response to boredom. Despite the observed correlation between boredom and mind-wandering (e.g., Blondé et al., 2021), this proposition warrants investigation. What happens to the thoughts when one is trapped in a boring situation and no behavioral alternative is available? Is mind-wandering the most probable response to boredom when no change in overt activity is possible or desirable? How

does boredom impact the phenomenology of mind-wandering? Further, it is important to clarify the complex and bi-directional relationship between boredom and mind-wandering, as well as how the two states evolve over time. What is the timing and duration of the experience of boredom and of mind-wandering episodes? How do we access consciously to them? Is one indicative of the other? We think that high-temporal resolution studies assessing both boredom and mind-wandering repetitively could help to track the dynamics of boredom and different types of thought. Next to using self-report measures, finding distinct behavioral, physiological, and neuronal markers of both constructs could advance research in the field. This approach could reveal under which conditions and in which contexts boredom and mind-wandering are related and work as cause and/or consequence for the occurrence of each other. To complicate matters further, interindividual and intraindividual (over time) differences in the boredom / mind-wandering relationship can be expected. Studies with a high-temporal resolution (trial-by-trial assessment) will be critical to reveal these interindividual and intraindividual differences. More generally, this approach could also help in better understanding how subjective experiences of boredom and mind-wandering map onto neurophysiological data collected with objective methods.

In this chapter we have also suggested that boredom via mind-wandering (or directly) might lead to positive (e.g., creative thinking) or negative (e.g., rumination) outcomes. It is certainly needed more research (including experimental manipulation) to understand these different routes. Indeed, it could, for example, be interesting to study mind-wandering as a possible tool to reduce feelings of boredom and to discover new paths (Stan & Christoff, 2018).

To conclude, we want to highlight one more time that several points made in this chapter are preliminary and speculative and need further investigation. We hope that this chapter will bring together two lines of research that currently evolve quite separately, these are the scientific investigation of boredom and mind-wandering. We think that this would be beneficial for a deeper understanding of subjective inner worlds in terms of sensations and thoughts.

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