Chapter 9
The Time Has Come to Be Mindwanderful: Mind Wandering and the Intuitive Psychology Mode

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Abstract No matter how hard you try—pinching different parts of your body, slapping your face, or moving restlessly in your seat—you cannot prevent your mind from occasionally escaping from the present experience as you enter into a mental navigation mode. Sometimes spontaneously, others deliberately, your mind may move to a different time—you may see yourself running an experiment inspired by the chapter you just finished reading or you may imagine yourself on a quantum leap into the future as you fantasize about the delivery of your Nobel Prize acceptance speech. Your mind may move to a distinct space, for example, as you replay last weekend's party or anticipate a most desirable date, and may even venture into the mind of another (e.g., as you embody the mind of the author you are currently reading). Our minds can accomplish all this mental navigation in fractions of a second, allowing us to see ourselves or even impersonate different people across space and time. While teleportation and time travel may never be physically possible, our wandering minds are indeed very accomplished "time machines" (Suddendorf T, Corballis MC, Behav Brain Sci 30(3), 2007).

Keywords Mind wandering · Perceptual decoupling · Mental improvisation · Mental navigation

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Introduction

No matter how hard you try—pinching different parts of your body, slapping your face, or moving restlessly in your seat—you cannot prevent your mind from occasionally escaping from the present experience as you enter into a mental navigation mode. Sometimes spontaneously, others deliberately, your mind may move to a different time—you may see yourself running an experiment inspired by the chapter you just finished reading or you may imagine yourself on a quantum leap into the future as you fantasize about the delivery of your Nobel Prize acceptance speech. Your mind may move to a distinct space, for example, as you replay last weekend's party or anticipate a most desirable date, and may even venture into the mind of another (e.g., as you embody the mind of the author you are currently reading). Our minds can accomplish all this mental navigation in fractions of a second, allowing us to see ourselves or even impersonate different people across space and time. While teleportation and time travel may never be physically possible, our wandering minds are indeed very accomplished "time machines" (Suddendorf & Corballis, 2007).

The concept of mind wandering is still very fuzzy and heterogeneous. As such, distinct authors seldom agree on a common definition (Christoff et al., 2016; Seli et al., 2018). Despite this lack of agreement, the adoption of a family resemblances view of mind wandering, which embraces the heterogeneity of the phenomenon, is key to further advancing the field. Here, I define *mind wandering* as the process by which the mind decenters from the current task and stimulus conditions (Stawarczyk et al., 2011a), moving freely (Christoff et al., 2016) toward multiple space, time, and/or mind positions (Corballis, 2013).

In what follows, and as summarized in Fig. 9.1, we will maintain that first this wandering process represents our mind/brain's default mode. Second, we describe three distinct but interrelated psychological mechanisms involved in mind wandering—perceptual decoupling, mental improvisation, and mental navigation. Third, we argue that mind wandering has the core function of priming our minds into a psychosocial mode (i.e., a folk/intuitive psychology). Finally, we conclude by suggesting that maybe the time has come to move beyond what Corballis (2015) refers to as the "bad press" that mind wandering has been facing and start acknowledging the benefits of mind wandering.

Minds Wandering by Default

Let us begin by substantiating the claim that mind wandering constitutes our mind's default mode. Recently, Killingsworth and Gilbert (2010) published in *Science* the results of a real-time large-scale thought sampling report. Thought probes were sent to participants randomly throughout the day by means of a smartphone application, requiring participants to report on the content and nature of their thoughts. An

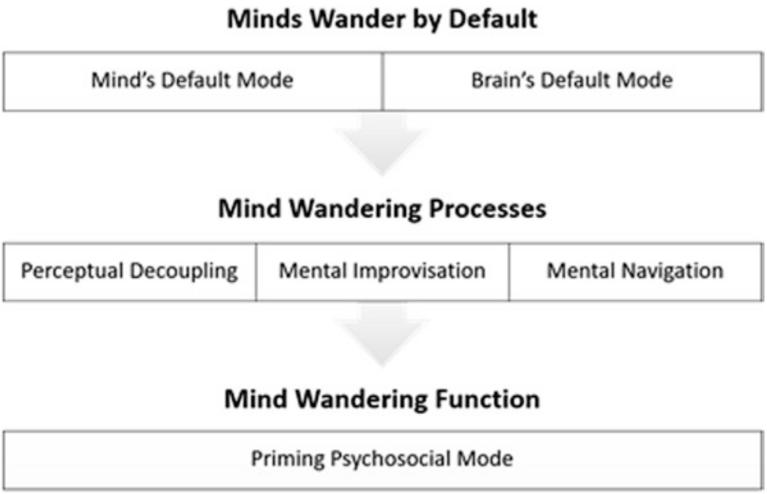

Fig. 9.1 Nature and functions of mind wandering

analysis of responses from 2250 adults confirmed that, for about half of the day (i.e., 47%), individuals reported to be mind wandering (i.e., "thinking about something other than what they were currently doing"). Interestingly, mind wandering was transversal to most of their daily activities. In fact, the nature of people's activities explained no more than 3.5% of the between-person variance in mind wandering.

The ubiquity of mind wandering is even more impressive if we move beyond daily wakeful activity. When we add dreaming to the equation, the prevalence of mind wandering increases dramatically. As defended by Fox et al. (2013), dreams, particularly during REM (Rapid Eye Movement) sleep (Mutz & Javadi, 2017), may be considered an extreme form of mind wandering (Andrews-Hanna et al., 2018; Domhoff, 2018), sharing common audio-visual, fantasy, and spontaneous activity (Christoff et al., 2016). This is likely the reason why mind wandering is often taken as synonymous with "daydreaming" (Regis, 2013; Stawarczyk, 2018). As in REM dreaming, waking mind wandering entails a process of spontaneous activity eluding the frontiers of space and time. Curiously, reports of impersonation have been reported in dreams as well in dreaming phenomenology (Schredl, 2019).

By default, both day and night, our minds wander. It is now widely acknowledged that the brain remains highly active during states of mind wandering. Marcus E. Raichle et al. (2001) coined the term *Default Mode Network* (DMN) to refer to a network connecting the medial frontal cortex with the posterior cingulate, precuneus and inferior parietal cortex, shown to be particularly active when individuals are not requested to perform a specific task in an fMRI (functional magnetic resonance imaging) environment (Raichle, 2010). In such task-negative (default) states, our brains sustain high levels of activity. Metabolically speaking, our brain is a very expensive organ. It spends about 10 times more energy than what would be expected from its volume and mass, such that the majority of its metabolism is associated with “off-task” and “stimulus independent activity” (70–80%). Conversely, it is estimated that “task-evoked activity” accounts for no more than 5% of the brain’s total energy consumption (Raichle, 2010).

There is now abundant evidence that our mind’s default mode (i.e., mind wandering) is supported by the brain’s DMN (Christoff et al., 2009; Kirschner et al., 2012; Mason et al., 2007). To illustrate, a recent study by Scheibner et al. (2017) confirms such evidence of DMN activity during mind wandering. In their study, participants were instructed to either focus on their own breathing (internal attention condition) or on tones (external attention condition) while fixating on a white cross. Once the cross turned red, participants were requested to report if they were either focused or mind wandering. Core regions of the DMN (medial prefrontal cortex, posterior cingulate cortex, and left temporoparietal junction) were significantly more active during instances of mind wandering than when participants reported being focused (either externally or internally). Relatedly, Stawarczyk et al. (2011b) also found that, when contrasted with being on-task, mind wandering was associated with clusters of increased activity in core DMN nodes (e.g., medial prefrontal, posterior cingulate, inferior parietal lobe). However, in addition, this activity was also evident in extended nodes of the DMN (e.g., parahippocampal cortex; inferior and medial temporal gyrus), indicating that core regions of the DMN interact with subnetworks, including the medial temporal lobe subsystem and the dorsal medial subsystem. Meta-analyses using Neurosynth (http://neurosynth.org) indicate that, while the core DMN nodes are engaged in self-referential processes, the medial temporal and dorsal medial subsystems are engaged in episodic memory and social cognition, respectively (Andrews-Hanna et al., 2014). As such, different DMN subsystems seem to be supporting mental processes that are prevalent during mind wandering (i.e., self-referential, episodic, and social cognitive processes). A recent study by Poerio et al. (2017) confirmed that the connectivity between and within different DMN subsystems supports the multicomponent nature of mind wandering, particularly with regard to perceptual decoupling and memory retrieval. Importantly, nodes of this DMN are often anti-correlated with nodes active during tasks requiring focused attention (Fox et al., 2005). However, we also note that executive networks are also known to be a neural correlate of off-task thinking (Dixon et al., 2017), including mind wandering (Christoff et al., 2009; Kam & Handy, 2014). Activity in these networks may seem counterintuitive, considering their recruitment during task-positive, goal-directed thought. However, recent studies indicate that executive networks also serve to regulate attention back and forth between the external environment and internal thoughts and are similarly recruited during mind wandering in order to sustain an internal train of thought (Christoff et al., 2016). Also an indirect confirmation of the role played by the DMN in mind wandering is the research confirming that extended regions of the DMN are involved during REM dreaming (Fox et al., 2013; Sämann et al., 2011). In sum, mind wandering constitutes the mind as well as the brain’s default mode. Different DMN subsystems seem to cooperate, allowing the mind to perceptually decouple and to venture into a mode of mental improvisation and mental navigation.

Mind Wandering Processes

As illustrated in Fig. 9.2, mind wandering depends on three interconnected processes: perceptual decoupling, mental improvisation, and mental navigation. The process can be triggered either by bottom-up (e.g., perceptual fatigue–Boksem et al., 2006) or top-down mechanisms (e.g., memory retrieval–Baird et al., 2011).

In our lab, we are currently studying the contribution of these three different mechanisms to the mind wandering process. We administered a large-scale questionnaire study in which we asked participants to answer questions concerning individuals' tendency to disengage from the environment as they mind wander, concerning the dynamics and variability of mind wandering thoughts, and concerning the general tendency to mind wander across space and time. Specifically, items from our *Mind Wandering Inventory* (Gonçalves et al., 2020) were intended to capture the following dimensions:

1. Perceptual decoupling (e.g., My mind often disconnects from what surrounds me)
2. Mental improvisation (e.g., My thoughts jump easily from one subject to another)
3. Mental navigation across time (e.g., My thoughts travel frequently through time–past or future), space (e.g., I often imagine that I'm somewhere else), and minds (e.g., I often imagine what others are thinking or feeling)

Moreover, we examined the relationship between trait levels of mind wandering assessed with the Mind Wandering Inventory and state mind wandering probed during a vigilance task (Dias da Silva et al., 2020) and have validated the questionnaire with neurophysiological electroencephalogram (EEG) data (Dias Da Silva, Gonçalves, & Postma, 2022).

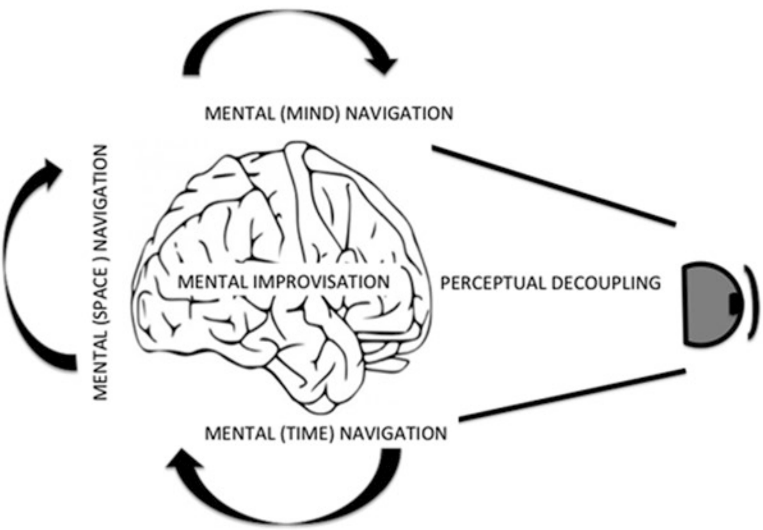

Fig. 9.2 Mind wandering processes

Perceptual Decoupling

Mind wandering entails at least some degree of perceptual decoupling. While decoupling from the immediate perceptual experience, the individual switches to an internal processing mode. This is illustrated by Smilek et al. (2010), who found that during a reading task, individuals tend to blink significantly more when reporting to be mind wandering. In addition, they found that during mind wandering periods, there were a smaller number of ocular fixations, suggesting that direct eye avoidance is associated with the elimination of external stimulation sources and priming of internal processing. Moreover, Bristow et al. (2005) demonstrate that eye blinking is associated with the deactivation of a fronto-parietal network responsible for visual attention. Together, these findings indicate that perceptual decoupling from the immediate experience represents an important component of mind wandering.

Also supporting the evidence for perceptual decoupling are studies which show that the amplitude of early (P1 and N1) and late (P3) perceptual evoked potentials are attenuated during mind wandering. Since both the P1 and N1 are early ERP components indexing processing during the sensory input stage, their reduction is taken as evidence for an inhibitory effect of mind wandering on external processing (Kam & Handy, 2013; Schooler et al., 2011). However, some recent findings show that, for low demanding attention tasks, individuals are able to maintain appropriate levels of alert, orienting and executive attention during mind wandering (Gonçalves et al., 2017a, b) without impacting early and late perceptual evoked potentials (Gonçalves et al., 2018b). As such, the effects of perceptual decoupling are dictated by task demands. These findings indicate that perceptual decoupling is an important, but not an absolute, condition for mind wandering. Individuals with higher executive resources (e.g., working memory) are able to maintain some degree of external processing while at the same time mind wandering (Smallwood & Schooler, 2015).

Mental Improvisation

In order to understand the function of mind wandering, it is important not only to look at the content but also to characterize the dynamics of thought. By investigating mind wandering over time, we can see that thoughts tend to evolve freely from one topic to the next, sometimes coming back to a core theme. For example, while writing an article, it may suddenly come to mind that there are a couple of emails that need to be answered. That reminds you of the current status of the computer you ordered a few weeks ago. You then recall the conversation with the salesperson. Then you get back to the emails and think about the email with the invitation to visit a foreign lab. You remember your last visit, the dinner you had with your friends and all the fun you had. This memory brings you back to the thought that you have to respond right away to that email. In sum, mind wandering dynamics seems to entail a process of free, but not necessarily random, thought movement. This dynamic of free movement is responsible for the heightened variability of thought content (Mills et al., 2018). Mills et al. (2018) coined the "default variability hypothesis" to refer to the process by which the dynamics of free movement between thoughts favors the encoding of separate memory episodes and the consolidation of episodic memories into semantic knowledge. It is precisely this variability that distinguishes mind wandering from ruminative thoughts (i.e., the persistence of sticky and recurrent thoughts). In fact, there is evidence that these ruminative thoughts are associated with task-related interference (Dias da Silva et al., 2018). The misclassification of rumination as mind wandering has been in large part responsible for the widespread misattribution of negative costs in terms of attention (Hu et al., 2012), executive functioning (McVay et al., 2013) and mood (Wilson et al., 2014) to mind wandering. In contrast, mind wandering defined as a process of mental improvisation has consistent benefits in terms of creativity (Baird et al., 2011), memory consolidation (Mills et al., 2018), and mental simulation (O'Callaghan et al., 2015).

Recently Marron et al. (2018) found that the degree of mental improvisation, as expressed in terms of free association fluency, flexibility, and semantic remoteness during a free association task, is related to an increase in activation of the DMN and a decrease in activation of core nodes from the executive network (e.g., Inferior Frontal Gyrus). Notably, these free association markers were positively correlated with creativity measures but not with intelligence scores. As in theater or music improvisation, our thoughts seem to have a mind of their own, moving freely but often recurring around a specific theme before departing into a new associative dynamic. Curiously, studies on music improvisation consistently report a deactivation in brain regions responsible for executive functioning (i.e., dorsolateral prefrontal cortex) and the concurrent activation of core nodes of the DMN (e.g., anterior cingulate; Beaty, 2015; Landau & Limb, 2017).

Mental Navigation

Mind wandering is also characterized by a process of mental navigation. While time travel is most often acknowledged in mind wandering, a mental navigation mode is better illustrated by the existence of a triple de-centration: time de-centration, space de-centration, and mind de-centration. Next, we will briefly address each of these mental navigation components.

Several studies have shown that mind wandering entails a time-travel process. Mind wandering has a remarkable temporal orientation (90%), allowing the individual to navigate between the past (~29%), present (~12%) and, above all, the future (~48%, Smallwood & Schooler, 2015). Notably, about half of the time, the mind wanders to some time in the future. This suggests that, along with an eventual consolidation of past memories, mind wandering frees the individual from the here and now, simulating the future and potentiating autobiographical planning (Stawarczyk et al., 2013).

This time travel is undissociated from the correlative process of space navigation—mentally moving from the "here and now" to "there and then". Similarly to what happens with episodic memory, the mental evocation of past or foreseen contexts is hippocampal dependent (Tulving, 2002). A recent study by McCormick et al. (2018) found that patients with hippocampal amnesia were no different than healthy controls in reporting high levels of mind wandering during quiet restful moments. However, their instances of mind wandering were found to be mostly dependent on semantic knowledge (i.e., closer to ruminative thoughts than mental improvisation), in contrast with the episodic content more typically found for healthy controls. In support of this space navigation process, healthy controls reported having mind wandering thoughts of an intense sensorial quality, particularly concerning the experience of visual scenes.

However, mind wandering is not an uninhabited scenario. That is, during mind wandering, time and space de-centration goes often together with mind navigation. This third type of mind de-centration is characterized by the ability to be able to tune in with others' experiences and move into their minds and imagine how they are thinking, feeling, or behaving. Although there are some cultural and individual differences, individuals often adopt (~50%) a third-person perspective when mind wandering; that is, they see the world from the viewpoint of an outside observer (Christian et al., 2013). Building on evidence from this third-person perspective along with findings indicating the enrolment of core DMN nodes responsible for social cognitive processes (Davey et al., 2016; Li et al., 2014; Mars et al., 2012; Poerio & Smallwood, 2016), we can assert along with Corballis (2015) that mind wandering may be central for developing a theory of mind (i.e., the ability to identify or attribute mental states in ourselves and others).

Mind Wandering Function: Priming the Psychosocial Mode

We will now be maintaining that the processes of perceptual decoupling and mental improvisation, with a triple—time, space, mind—de-centration, promote a reorientation of the mind from the current physical reality (i.e., intuitive/folk physics) to a predominantly psychosocial mode (i.e., intuitive/folk psychology). While the understanding of the physical reality predominantly requires systematic thinking, the comprehension of psychosocial phenomena relies mostly on reflective, creative, and empathic processes. As a result of daily dealing with physical and psychosocial phenomena, individuals develop a sort of intuitive physics (i.e., folk physics) and intuitive psychology (i.e., folk psychology). On the one hand, this intuitive physics translates the nature and degree of individual understanding of physical phenomena into an individual theory of the world. On the other hand, this intuitive psychology translates our personal understanding of the psychosocial reality into an individual theory of the mind (Baron-Cohen, 1997; Kamps et al., 2017).

As stated before, the DMN supports core socio-cognitive processes involved in developing an individual theory of the mind. The DMN, as a network supporting mind wandering, is also central in our orientation to the psychosocial domain. Curiously, the DMN is anti-correlated with the fronto-parietal (attention/executive) network predominantly involved in processing physical phenomena. This is illustrated in an interesting study by Jack et al. (2013). In their experiment, participants were presented with several problem-solving vignettes, some portraying tasks requiring reasoning about mental states and others requiring reasoning about causal/mechanical issues. The results indicate that not only the DMN was associated with the psychosocial domain and the fronto-parietal network with the physical domain but also that the activity of these regions was reciprocally inhibited.

This type of folk psychology (versus folk physics) orientation sustained by activating or deactivating the mind's default mode is also illustrated in Simon Baron-Cohen's *Systemizing–Empathizing Theory* (Greenberg et al., 2018). According to his view, people can be allocated to a dispositional continuum ranging from empathizing (i.e., drive to identify another person's emotions and thoughts and to respond to these with an appropriate emotion) to systemizing (i.e., drive to analyze, understand, predict, control, and construct rule-based systems).

Confirming the relationship between an intuitive psychology/DMN association, Takeuchi et al. (2014) demonstrate that empathizing is positively correlated with resting state functional connectivity between different DMN nodes, particularly, the medial prefrontal cortex, the dorsal anterior cingulate, the precuneus, and the left superior temporal sulcus. In contrast, systemizing positively correlates with resting state functional connectivity in an "external attention network" between the dorsolateral prefrontal cortex and the dorsal anterior cingulate cortex.

Indeed, the DMN is active during a range of tasks related to both mind wandering (Christoff et al., 2009; Kirschner et al., 2012; Mason et al., 2007; Scheibner et al., 2017) and theory of mind (Jack et al., 2013; Oliveira Silva et al., 2018; Takeuchi et al., 2014). However, DMN activations alone do not guarantee that both are equivalent. Moreover, correlations do not imply causation. Nevertheless, correlations do provide ground for future research for investigating the manner in which mind wandering states may support such a theory of the mind. As recently shown in a series of studies, it seems that we are by default in some sort of empathizing mode (Oliveira Silva et al., 2018), with DMN activity and connectivity being central to maintaining this state of mind (Esménio et al., 2019a, b). Although research is still underway, it may very well be the case that our default mind wandering state significantly contributes to prime this similarly default empathizing/psychosocial mode, helping individuals navigate the socio-emotional world around them (Poerio & Smallwood, 2016).

Concluding Remarks: A Time to Be *Mindwanderful*

During the last decades, the concept of mindfulness has witnessed a growing popularity (Tomlinson et al., 2018). Even though different definitions are available for mindfulness (Allen et al., 2012; Kabat-Zinn, 2003; Keng et al., 2011; Moore &

Malinowski, 2009), most of the researchers see it as a process of directing the attentional focus to the individual's current experience in the present moment while avoiding thought escape into the past/future. As such, a mindful mind seems to be the opposite of a wandering mind (Schooler et al., 2014). For example, Mrazek et al. (2012) demonstrated that people with high levels of mindfulness report fewer instances of mind wandering and perform better on an attention focus task (i.e., mindful breathing).

Despite some controversy regarding conceptual and methodological aspects in mindfulness research (Van Dam et al., 2018), there is evidence for the benefits of mindfulness in terms of orientating attention to the current physical reality (Posner et al., 2015). In contrast to orienting attention to a physical reality, mind wandering optimizes an orientation to the psychosocial domain. In addition to being aware of the present moment, mindfulness can also refer to the act of being aware of one's own internal thoughts and not just stimuli in the external environment (Ellamil et al., 2016). As such, it could also be that mind wandering and mindfulness represent two ends of the same construct. Therefore, it is necessary to find an ideal balance between attention to the external world and our internal thoughts, while also mindfully being aware of the wandering mind and the benefits that might come with it. Now the question remains: How can individuals take full advantage of the benefits of mind wandering in order to facilitate navigation in the psychosocial domain?

Several studies are currently underway, testing whether we can impact mind wandering by modulating specific neural correlates. For example, building on EEG markers of mind wandering instances, we recently launched a series of studies that explore the viability of different real-time EEG protocols (e.g., SMR⇑Theta⇓; Theta⇑SMR⇓) in improving mind wandering during an attention task (Gonçalves et al., 2018a, b). Other authors are using different strategies to neuromodulate processes associated with mind wandering by using transcranial direct current simulation (Axelrod et al., 2015; Axelrod et al., 2018; Boayue et al., 2020), or even real time MEG and fMRI (Garrison et al., 2013). Although these studies are in their beginning stages, as we evolve in the identification of reliable brain predictors of mind wandering, we hope to come up with more reliable methods for detecting and impacting mind wandering (Hosseini & Guo, 2019; Jin et al., 2019).

The ideal balance between mindfulness and mind wandering is still not known (Schooler et al., 2014). However, it seems that in order to facilitate both navigation across the physical and psychosocial domains, individuals may gain an advantage by adopting a *mindwanderfulness* position—a process of strategically switching between mindfulness and mind wandering, in order to respond adaptively to the demands of physical and psychosocial domains (Gonçalves, 2019; Hasenkamp, 2018).

References

Allen, M., Dietz, M., Blair, K. S., van Beek, M., Rees, G., Vestergaard-Poulsen, P., … Roepstorff, A. (2012). Cognitive-affective neural plasticity following active-controlled mindfulness intervention. *Journal of Neuroscience, 32*(44), 15601–15610. https://doi.org/10.1523/JNEUROSCI.2957-12.2012

Andrews-Hanna, J. R., Smallwood, J., & Spreng, R. N. (2014). The default network and self-generated thought: Component processes, dynamic control, and clinical relevance. *Annals of the New York Academy of Sciences, 1316*(1), 29–52. https://doi.org/10.1111/nyas.12360

Andrews-Hanna, J. R., Irving, Z. C., Fox, K. C. R., Spreng, R. N., & Christoff, K. (2018). The neuroscience of spontaneous thought: An evolving interdisciplinary field. In *The Oxford handbook of spontaneous thought: Mind-wandering, creativity, and dreaming*. https://doi.org/10.1093/oxfordhb/9780190464745.013.33

Axelrod, V., Rees, G., Lavidor, M., & Bar, M. (2015). Increasing propensity to mind- wander with transcranial direct current stimulation. *Proceedings of the National Academy of Sciences of the United States of America, 112*(11), 3314–3319. https://doi.org/10.1073/pnas.1421435112

Axelrod, V., Zhu, X., & Qiu, J. (2018). Transcranial stimulation of the frontal lobes increases propensity of mind-wandering without changing meta-awareness. *Scientific Reports, 8*(1), 1–14. https://doi.org/10.1038/s41598-018-34098-z

Baird, B., Smallwood, J., & Schooler, J. W. (2011). Back to the future: Autobiographical planning and the functionality of mind-wandering. *Consciousness and Cognition, 20*(4), 1604–1611. https://doi.org/10.1016/j.concog.2011.08.007

Baron-Cohen, S. (1997). Are children with autism superior at folk physics? *New Directions for Child Development, 1997*(75), 45–54. https://doi.org/10.1002/cd.23219977504

Beaty, R. E. (2015). The neuroscience of musical improvisation. *Neuroscience and Biobehavioral Reviews, 51*, 108–117. https://doi.org/10.1016/j.neubiorev.2015.01.004

Boayue, N. M., Csifcsák, G., Aslaksen, P., Turi, Z., Antal, A., Groot, J., … Mittner, M. (2020). Increasing propensity to mind-wander by transcranial direct current stimulation? A registered report. *European Journal of Neuroscience, 51*(3), 755–780. https://doi.org/10.1111/ejn.14347

Boksem, M. A. S., Meijman, T. F., & Lorist, M. M. (2006). Mental fatigue, motivation and action monitoring. *Biological Psychology, 72*(2), 123–132. https://doi.org/10.1016/j.biopsycho.2005.08.007

Bristow, D., Haynes, J. D., Sylvester, R., Frith, C. D., & Rees, G. (2005). Blinking suppresses the neural response to unchanging retinal stimulation. *Current Biology, 15*(14), 1296–1300. https://doi.org/10.1016/j.cub.2005.06.025

Christian, B. M., Miles, L. K., Parkinson, C., & Macrae, C. N. (2013). Visual perspective and the characteristics of mind wandering. *Frontiers in Psychology,* 4, 699. https://doi.org/10.3389/fpsyg.2013.00699

Christoff, K., Gordon, A. M., Smallwood, J., Smith, R., & Schooler, J. W. (2009). Experience sampling during fMRI reveals default network and executive system contributions to mind wandering. *Proceedings of the National Academy of Sciences of the United States of America, 106*(21), 8719–8724. https://doi.org/10.1073/pnas.0900234106

Christoff, K., Irving, Z. C., Fox, K. C. R., Spreng, R. N., & Andrews-Hanna, J. R. (2016). Mind-wandering as spontaneous thought: A dynamic framework. *Nature Reviews Neuroscience, 17*(11), 718–731. https://doi.org/10.1038/nrn.2016.113

Corballis, M. C. (2013). Mental time travel: A case for evolutionary continuity. *Trends in Cognitive Sciences, 17*(1), 5–6. https://doi.org/10.1016/j.tics.2012.10.009

Corballis, M. C. (2015). *The wandering mind: What the brain does when you're not looking*. University of Chicago Press.

Davey, C. G., Pujol, J., & Harrison, B. J. (2016). Mapping the self in the brain's default mode network. *NeuroImage, 132,* 390–397. https://doi.org/10.1016/j.neuroimage.2016.02.022

Dias da Silva, M. R., Rusz, D., & Postma-Nilsenová, M. (2018). Ruminative minds, wandering minds: Effects of rumination and mind wandering on lexical associations, pitch imitation and eye behaviour. *PLoS One, 13*(11), 1–20. https://doi.org/10.1371/journal.pone.0207578

Dias da Silva, M. R., Gonçalves, Ó. F., & Postma, M. (2020). Assessing the relationship between trait and state levels of mind wandering during a tracing task. In *Annual meeting of the Cognitive Science Society 2020: Developing a mind: Learning in humans, animals, and machines. Toronto, Canada*.

Dias da Silva, M., Gonçalves, Ó. F., & Postma, M. (2022). Revisiting consciousness: Distinguishing between states of conscious focused attention and mind wandering with EEG. *Consciousness & Cognition, 101*, 1–18. https://doi.org/10.1016/j.concog.2022.103332

Dixon, M.L., Girn, M., Christoff, K. (2017). Hierarchical Organization of Frontoparietal Control Networks Underlying Goal-Directed Behavior. In: Watanabe, M. (eds) The Prefrontal Cortex as an Executive, Emotional, and Social Brain. Springer, Tokyo. https://doi.org/10.1007/978-4-431-56508-6_7

Domhoff, G. W. (2018). Dreaming is an intensified form of mind-wandering, based in an augmented portion of the default network. In K. C. R. Fox & K. Christoff (Eds.), *The Oxford handbook of spontaneous thought: Mind-wandering, creativity, and dreaming* (pp. 355–370). https://doi.org/10.1093/oxfordhb/9780190464745.013.7

Ellamil, M., Fox, K. C. R., Dixon, M. L., Pritchard, S., Todd, R. M., Thompson, E., & Christoff, K. (2016). Dynamics of neural recruitment surrounding the spontaneous arising of thoughts in experienced mindfulness practitioners. *NeuroImage, 136*, 186–196. https://doi.org/10.1016/j.neuroimage.2016.04.034

Esménio, S., Soares, J. M., Oliveira-Silva, P., Gonçalves, Ó. F., Decety, J., & Coutinho, J. (2019a). Brain circuits involved in understanding our own and other's internal states in the context of romantic relationships. *Social Neuroscience, 14*(6), 729–738. https://doi.org/10.1080/17470919.2019.1586758

Esménio, S., Soares, J. M., Oliveira-Silva, P., Zeidman, P., Razi, A., Gonçalves, Ó. F., … Coutinho, J. (2019b). Using resting-state DMN effective connectivity to characterize the neurofunctional architecture of empathy. *Scientific Reports, 9*(1), 1–9. https://doi.org/10.1038/s41598-019-38801-6

Fox, M. D., Snyder, A. Z., Vincent, J. L., Corbetta, M., Van Essen, D. C., & Raichle, M. E. (2005). The human brain is intrinsically organized into dynamic, anticorrelated functional networks. *Proceedings of the National Academy of Sciences of the United States of America, 102*(27), 9673–9678. https://doi.org/10.1073/pnas.0504136102

Fox, K. C. R., Nijeboer, S., Solomonova, E., Domhoff, G. W., & Christoff, K. (2013). Dreaming as mind wandering: Evidence from functional neuroimaging and first-person content reports. *Frontiers in Human Neuroscience*, *7,* 1–18. https://doi.org/10.3389/fnhum.2013.00412

Garrison, K. A., Scheinost, D., Worhunsky, P. D., Elwafi, H. M., Thornhill, T. A., Thompson, E., … Brewer, J. A. (2013). Real-time fMRI links subjective experience with brain activity during focused attention. *NeuroImage, 81,* 110–118. https://doi.org/10.1016/j.neuroimage.2013.05.030

Gonçalves, Ó. F. (2019). *Cérebro Errante.* Pearson Clinical.

Gonçalves, Ó. F., Oliveira-Silva, P., de Souza-Queiroz, J., Amaro, E., Rêgo, G., Leite, J., … Boggio, P. S. (2017a). Is the relationship between mind wandering and attention culture-specific? *Psychology and Neuroscience, 10*(2), 132–143. https://doi.org/10.1037/pne0000083

Gonçalves, Ó. F., Rêgo, G., Oliveira-Silva, P., Leite, J., Carvalho, S., Fregni, F., … Boggio, P. S. (2017b). Mind wandering and the attention network system. *Acta Psychologica, 172*, 49–54. https://doi.org/10.1016/j.actpsy.2016.11.008

Gonçalves, Ó. F., Carvalho, S., Mendes, A. J., Leite, J., & Boggio, P. S. (2018a). Neuromodulating attention and mind-wandering processes with a single session real time EEG. *Applied Psychophysiology and Biofeedback, 43*(2), 143–151. https://doi.org/10.1007/s10484-018-9394-4

Gonçalves, Ó. F., Carvalho, S., Mendes, A. J., Lema, A., Leite, J., & Boggio, P. S. (2018b). Neuromodulating attention and mind-wandering processes with multi- session real-time electroencephalogram. *Porto Biomedical Journal, 3*(2), e17. https://doi.org/10.1016/j.pbj.0000000000000017

Gonçalves, Ó. F., da Silva, M. R. D., Carvalho, S., Coelho, P., Lema, A., Mendes, A. J., … Leite, J. (2020). Mind wandering: Tracking perceptual decoupling, mental improvisation, and mental navigation. *Psychology and Neuroscience, 13*(4), 493–502. https://doi.org/10.1037/pne0000237

Greenberg, D. M., Warrier, V., Allison, C., & Baron-Cohen, S. (2018). Testing the empathizing–systemizing theory of sex differences and the extreme male brain theory of autism in half a million people. *Proceedings of the National Academy of Sciences of the United States of America, 115*(48), 12152–12157. https://doi.org/10.1073/pnas.1811032115

Hasenkamp, W. (2018). Catching the wandering mind: Meditation as a window into spontaneous thought. In K. C. R. Fox & K. Christoff (Eds.), *The Oxford handbook of spontaneous thought: Mind-wandering, creativity, and dreaming*. https://doi.org/10.1093/oxfordhb/9780190464745.013.12

Hosseini, S., & Guo, X. (2019). Deep convolutional neural network for automated detection of mind wandering using EEG signals. In *ACM-BCB 2019 – Proceedings of the 10th ACM international conference on bioinformatics, computational biology and health informatics* (pp. 314–319). https://doi.org/10.1145/3307339.3342176

Hu, N., He, S., & Xu, B. (2012). Different efficiencies of attentional orienting in different wandering minds. *Consciousness and Cognition, 21*(1), 139–148. https://doi.org/10.1016/j.concog.2011.12.007

Jack, A. I., Dawson, A. J., Begany, K. L., Leckie, R. L., Barry, K. P., Ciccia, A. H., & Snyder, A. Z. (2013). FMRI reveals reciprocal inhibition between social and physical cognitive domains. *NeuroImage, 66,* 385–401. https://doi.org/10.1016/j.neuroimage.2012.10.061

Jin, C. Y., Borst, J. P., & van Vugt, M. K. (2019). Predicting task-general mind- wandering with EEG. *Cognitive, Affective, & Behavioral Neuroscience*, *19(*4), 1059–1073. https://doi.org/10.3758/s13415-019-00707-1

Kabat-Zinn, J. (2003). Mindfulness-based interventions in context: Past, present, and future. *Clinical Psychology: Science and Practice, 10*, 144–156. https://doi.org/10.1093/clipsy/bpg016

Kam, J. W. Y., & Handy, T. C. (2013). The neurocognitive consequences of the wandering mind: A mechanistic account of sensory-motor decoupling. *Frontiers in Psychology, 4*, 1–13. https://doi.org/10.3389/fpsyg.2013.00725

Kam, J. W. Y., & Handy, T. C. (2014). Differential recruitment of executive resources during mind wandering. *Consciousness and Cognition, 26*(1). https://doi.org/10.1016/j.concog.2014.03.002

Kamps, F. S., Julian, J. B., Battaglia, P., Landau, B., Kanwisher, N., & Dilks, D. D. (2017). Dissociating intuitive physics from intuitive psychology: Evidence from Williams syndrome, *168,* 146–153. *Cognition.* https://doi.org/10.1016/j.cognition.2017.06.027

Keng, S. L., Smoski, M. J., & Robins, C. J. (2011). Effects of mindfulness on psychological health: A review of empirical studies. *Clinical Psychology Review, 31*(6), 1041–1056. https://doi.org/10.1016/j.cpr.2011.04.006

Killingsworth, M. A., & Gilbert, D. T. (2010). A wandering mind is an unhappy mind. *Science, 330*(606), 932. https://doi.org/10.1126/science.1192439

Kirschner, A., Kam, J. W. Y., Handy, T. C., & Ward, L. M. (2012). Differential synchronization in default and task-specific networks of the human brain. *Frontiers in Human Neuroscience, 6,* 1–10. https://doi.org/10.3389/fnhum.2012.00139

Landau, A. T., & Limb, C. J. (2017). The neuroscience of improvisation. *Music Educators Journal, 103*(3), 27–33. https://doi.org/10.1177/0027432116687373

Li, W., Mai, X., & Liu, C. (2014). The default mode network and social understanding of others: What do brain connectivity studies tell us. *Frontiers in Human Neuroscience, 74,* 1–15. https://doi.org/10.3389/fnhum.2014.00074

Marron, T. R., Lerner, Y., Berant, E., Kinreich, S., Shapira-Lichter, I., Hendler, T., & Faust, M. (2018). Chain free association, creativity, and the default mode network. *Neuropsychologia, 118,* 40–58. https://doi.org/10.1016/j.neuropsychologia.2018.03.018

Mars, R. B., Neubert, F. X., Noonan, M. A. P., Sallet, J., Toni, I., & Rushworth, M. F. S. (2012). On the relationship between the "default mode network" and the "social brain". *Frontiers in Human Neuroscience, 6,* 1–9. https://doi.org/10.3389/fnhum.2012.00189

Mason, M. F., Norton, M. I., Van Horn, J. D., Wegner, D. M., Grafton, S. T., & Macrae, C. N. (2007). Wandering minds: The default network and stimulus- independent thought. *Science, 315*(5810), 393–395. https://doi.org/10.1126/science.1131295

McCormick, C., Rosenthal, C. R., Miller, T. D., & Maguire, E. A. (2018). Mind-wandering in people with hippocampal damage. *Journal of Neuroscience, 38*(11), 2745–2754. https://doi.org/10.1523/JNEUROSCI.1812-17.2018

McVay, J. C., Meier, M. E., Touron, D. R., & Kane, M. J. (2013). Aging ebbs the flow of thought: Adult age differences in mind wandering, executive control, and self-evaluation. *Acta Psychologica, 142*(1), 136–147. https://doi.org/10.1016/j.actpsy.2012.11.006

Mills, C., Herrera-Bennett, A., Faber, M., & Christoff, K. (2018). Why the mind wanders: How spontaneous thought's default variability may support episodic efficiency and semantic optimization. In K. C. R. Fox & K. Christoff (Eds.), *The Oxford handbook of spontaneous thought: Mind-wandering, creativity, and dreaming*. Oxford University Press.

Moore, A., & Malinowski, P. (2009). Meditation, mindfulness and cognitive flexibility. *Consciousness and Cognition, 18*(1), 176–186. https://doi.org/10.1016/j.concog.2008.12.008

Mrazek, M. D., Smallwood, J., & Schooler, J. W. (2012). Mindfulness and mind- wandering: Finding convergence through opposing constructs. *Emotion, 12*(3), 442–448. https://doi.org/10.1037/a0026678

Mutz, J., & Javadi, A.-H. (2017). Exploring the neural correlates of dream phenomenology and altered states of consciousness during sleep. *Neuroscience of Consciousness, 2017*(1), 1–12. https://doi.org/10.1093/nc/nix009

O'Callaghan, C., Shine, J. M., Lewis, S. J. G., Andrews-Hanna, J. R., & Irish, M. (2015). Shaped by our thoughts – A new task to assess spontaneous cognition and its associated neural correlates in the default network. *Brain and Cognition, 93,* 1–10. https://doi.org/10.1016/j.bandc.2014.11.001

Oliveira Silva, P., Maia, L., Coutinho, J., Frank, B., Soares, J. M., Sampaio, A., & Gonçalves, Ó. (2018). Empathy by default: Correlates in the brain at rest. *Psicothema, 30*(1), 97–103. https://doi.org/10.7334/psicothema2016.366

Poerio, G. L., & Smallwood, J. (2016). Daydreaming to navigate the social world: What we know, what we don't know, and why it matters. *Social and Personality Psychology Compass, 10*(11), 605–618. https://doi.org/10.1111/spc3.12288

Poerio, G. L., Sormaz, M., Wang, H. T., Margulies, D., Jefferies, E., & Smallwood, J. (2017). The role of the default mode network in component processes underlying the wandering mind. *Social Cognitive and Affective Neuroscience, 12*(7), 1047–1062. https://doi.org/10.1093/scan/nsx041

Posner, M. I., Rothbart, M. K., & Tang, Y. Y. (2015). Enhancing attention through training. *Current Opinion in Behavioral Sciences, 4,* 1–5. https://doi.org/10.1016/j.cobeha.2014.12.008

Raichle, M. E. (2010). Two views of brain function. *Trends in Cognitive Sciences, 14*, 180–190. https://doi.org/10.1016/j.tics.2010.01.008

Raichle, M. E., MacLeod, A. M., Snyder, A. Z., Powers, W. J., Gusnard, D. A., & Shulman, G. L. (2001). A default mode of brain function. *Proceedings of the National Academy of Sciences of the United States of America, 98*(2), 676–682. https://doi.org/10.1073/pnas.98.2.676

Regis, M. (2013). *Daydreams and the function of fantasy*. New York: Palgrave Macmillan. https://doi.org/10.1057/9781137300775

Sämann, P. G., Wehrle, R., Hoehn, D., Spoormaker, V. I., Peters, H., Tully, C., … Czisch, M. (2011). Development of the brain's default mode network from wakefulness to slow wave sleep. *Cerebral Cortex, 21*(9), 2082–2093. https://doi.org/10.1093/cercor/bhq295

Scheibner, H. J., Bogler, C., Gleich, T., Haynes, J. D., & Bermpohl, F. (2017). Internal and external attention and the default mode network. *NeuroImage, 148,* 381–389. https://doi.org/10.1016/j.neuroimage.2017.01.044

Schooler, J. W., Smallwood, J., Christoff, K., Handy, T. C., Reichle, E. D., & Sayette, M. A. (2011). Meta-awareness, perceptual decoupling and the wandering mind. *Trends in Cognitive Sciences, 15*, 319–326. https://doi.org/10.1016/j.tics.2011.05.006

Schooler, J. W., Mrazek, M. D., Franklin, M. S., Baird, B., Mooneyham, B. W., Zedelius, C., & Broadway, J. M. (2014). The middle way. Finding the balance between mindfulness and mind-wandering. In *Psychology of learning and motivation – Advances in research and theory, 60,* 1–33. https://doi.org/10.1016/B978-0-12-800090-8.00001-9

Schredl, M. (2019). Being someone or something else in the dream: Relationship to thin boundaries. *Imagination, Cognition and Personality, 40*(1), 43–51. https://doi.org/10.1177/0276236619896272

Seli, P., Kane, M. J., Smallwood, J., Schacter, D. L., Maillet, D., Schooler, J. W., & Smilek, D. (2018). Mind-wandering as a natural kind: A family- resemblances view. *Trends in Cognitive Sciences, 22*(6), 479–490. https://doi.org/10.1016/j.tics.2018.03.010

Smallwood, J., & Schooler, J. W. (2015). The science of mind wandering: Empirically navigating the stream of consciousness. *Annual Review of Psychology, 66*(1), 487–518. https://doi.org/10.1146/annurev-psych-010814-015331

Smilek, D., Carriere, J. S. A., & Cheyne, J. A. (2010). Out of mind, out of sight: Eye blinking as indicator and embodiment of mind wandering. *Psychological Science, 21*(6), 786–789. https://doi.org/10.1177/0956797610368063

Stawarczyk, D. (2018). Phenomenological properties of mind-wandering and daydreaming: A historical overview and functional correlates. In K. C. R. Fox & K. Christoff (Eds.), *The Oxford handbook of spontaneous thought: Mind-wandering, creativity, and dreaming*. https://doi.org/10.1093/oxfordhb/9780190464745.013.18

Stawarczyk, D., Majerus, S., Maj, M., Van der Linden, M., & D'Argembeau, A. (2011a). Mind-wandering: Phenomenology and function as assessed with a novel experience sampling method. *Acta Psychologica, 136*(3), 370–381. https://doi.org/10.1016/j.actpsy.2011.01.002

Stawarczyk, D., Majerus, S., Maquet, P., & D'Argembeau, A. (2011b). Neural correlates of ongoing conscious experience: Both task-unrelatedness and stimulus-independence are related to default network activity. *PLoS One, 62*(2), 1–14. https://doi.org/10.1371/journal.pone.0016997

Stawarczyk, D., Cassol, H., & D'Argembeau, A. (2013). Phenomenology of future- oriented mind-wandering episodes. *Frontiers in Psychology, 4,* 425. https://doi.org/10.3389/fpsyg.2013.00425

Suddendorf, T., & Corballis, M. C. (2007). The evolution of foresight: What is mental time travel, and is it unique to humans? *Behavioral and Brain Sciences, 30*(3), 299–313. https://doi.org/10.1017/S0140525X07001975

Takeuchi, H., Taki, Y., Nouchi, R., Sekiguchi, A., Hashizume, H., Sassa, Y., … Kawashima, R. (2014). Association between resting-state functional connectivity and empathizing/systemizing. *NeuroImage, 99,* 312–322. https://doi.org/10.1016/j.neuroimage.2014.05.031

Tomlinson, E. R., Yousaf, O., Vittersø, A. D., & Jones, L. (2018). Dispositional mindfulness and psychological health: A systematic review. *Mindfulness. 9*(1), 23–43. https://doi.org/10.1007/s12671-017-0762-6

Tulving, E. (2002). Episodic memory: From mind to brain. *Annual Review of Psychology. 53*(1), 1–25 https://doi.org/10.1146/annurev.psych.53.100901.135114

Van Dam, N. T., van Vugt, M. K., Vago, D. R., Schmalzl, L., Saron, C. D., Olendzki, A., … Meyer, D. E. (2018). Mind the hype: A critical evaluation and prescriptive agenda for research on mindfulness and meditation. *Perspectives on Psychological Science, 13*(1), 36–61. https://doi.org/10.1177/1745691617709589

Wilson, T. D., Reinhard, D. A., Westgate, E. C., Gilbert, D. T., Ellerbeck, N., Hahn, C., … Shaked, A. (2014). Just think: The challenges of the disengaged mind. *Science, 345*(6192), 75–77. https://doi.org/10.1126/science.1250830