The Science of Mind Wandering: Empirically Navigating the Stream of Consciousness

Jonathan Smallwood[1] and Jonathan W. Schooler[2]

[1]Department of Psychology, The University of York, Heslington, York YO10 5DD United Kingdom; email: jonny.smallwood@york.ac.uk

[2]Department of Psychological and Brain Sciences, University of California, Santa Barbara, California 93106

Annu. Rev. Psychol. 2015. 66:487–518

First published online as a Review in Advance on September 29, 2014

The *Annual Review of Psychology* is online at psych.annualreviews.org

This article's doi: 10.1146/annurev-psych-010814-015331

Keywords

mind wandering, self-generated thought, perceptual decoupling, meta-awareness, mental time travel, default mode network

Abstract

Conscious experience is fluid; it rarely remains on one topic for an extended period without deviation. Its dynamic nature is illustrated by the experience of mind wandering, in which attention switches from a current task to unrelated thoughts and feelings. Studies exploring the phenomenology of mind wandering highlight the importance of its content and relation to meta-cognition in determining its functional outcomes. Examination of the information-processing demands of the mind-wandering state suggests that it involves perceptual decoupling to escape the constraints of the moment, its content arises from episodic and affective processes, and its regulation relies on executive control. Mind wandering also involves a complex balance of costs and benefits: Its association with various kinds of error underlines its cost, whereas its relationship to creativity and future planning suggest its potential value. Although essential to the stream of consciousness, various strategies may minimize the downsides of mind wandering while maintaining its productive aspects.

Contents

INTRODUCTION

Experience is not always tethered to the here and now; instead, it ebbs and flows between mental contents from both intrinsic and extrinsic sources. Although there is a long tradition of research on how attention shifts between external sources (e.g., Desimone & Duncan 1995, Posner & Petersen 1990, Treisman & Gelade 1980), science has only recently taken aim at understanding how the mind shifts between external events and internal thoughts and feelings unrelated to the goings on around it. Following the seminal work of Singer, Klinger, and Antrobus on daydreaming in the late 1960s and early 1970s (Antrobus et al. 1966, Klinger 1966), a handful of researchers explored the psychological processes underpinning the mind's capacity to stray from external events and to generate thoughts with no referent in the environment (Giambra 1989, Teasdale et al. 1995). However, only in the past decade has widespread scientific attention been given to the topic of mind wandering (Smallwood & Schooler 2006).

Mind wandering: a shift in the contents of thought away from an ongoing task and/or from events in the external environment to self-generated thoughts and feelings

A confluence of factors have contributed to the suitability of mind wandering as a focus of research (Callard et al. 2013, Forster 2013, Gilbert et al. 2007, Gruberger et al. 2011, Kane & McVay 2012, Killeen 2013, Marchetti et al. 2012, Mooneyham & Schooler 2013, Schooler et al. 2011, Smallwood 2013a, Smallwood & Schooler 2006). Unquestionably, this issue has been the beneficiary of a change in the scientific zeitgeist regarding the appropriateness of the study of consciousness. The field of psychology was slow to shed the skepticism toward internal experience that it inherited from the behaviorist era (Callard et al. 2012, Cohen & Schooler 1997). However,

as scientific consideration of consciousness became more accepted, so too did the investigation of mind wandering. Closely allied with this shift were methodological advances in the study of consciousness. As we discuss below, the stream of consciousness is being increasingly illuminated by the strategy of triangulation, whereby self-report, behavioral measures, and neurocognitive measures are used together to make inferences about underlying mental states (Schooler & Schreiber 2004, Varela & Thompson 2003).

Research on mind wandering undoubtedly has also been advanced by research in cognitive neuroscience, and in particular the development of functional magnetic resonance imaging (fMRI) (Ogawa et al. 1990). The spatial resolution offered by fMRI has meant that it has swiftly become a primary tool for investigating the inner workings of the mind, a technique that is at its most advantageous when focused on private experiences such as mind wandering. Moreover, in the early years of this century a network of brain regions focused on the medial surface of the cortex and known as the default mode network was discovered (Greicius et al. 2003, Raichle et al. 2001). This network is active when participants engage in the sort of thinking that occurs during mind wandering, such as thoughts about the future, of themselves, or of other people (Andrews-Hanna et al. 2014), and it was swiftly linked to the mind-wandering state (Mason et al. 2007; McKiernan et al. 2003, 2006). The discovery of this network and its experiential correlates provided a viable starting point from which to understand the brain basis of mind wandering.

Finally, it has become apparent that neurocognitive processes that are not constrained by external input are ubiquitous aspects of the human condition. Unconstrained neural processing, such as that which occurs during the resting state, is common to all known brain networks, which raises important questions on how to interpret task-free activity (Buckner & Vincent 2007, Smith et al. 2009). Moreover, studies indicate that people spend somewhere between 25% and 50% of their waking hours engaged in thoughts unrelated to the here and now (Kane et al. 2007, Killingsworth & Gilbert 2010). Unconstrained mental processes are the norm rather than the exception for our species, and mind wandering provides a clear paradigm in which to understand their psychological features.

Happily, the gap is closing between the regularity with which people mind wander and the frequency with which scientists study it. The past decade has witnessed an explosion of developments in understanding how, when, and why the mind wanders. This review describes the methods that have been established to understand mind wandering, examines its phenomenology and the neurocognitive processes that it entails, and considers the costs and benefits that this experience can bring. Before considering these issues in detail, the conceptual and empirical challenges that understanding the wandering mind entails are described.

Triangulation: a procedure for inferring internal mental processes based on a combination of self-reports and physiological and behavioral measures

Default mode network: a network of brain regions involving the medial surface of the cortex that is engaged by the sort of thinking that occurs during mind wandering (e.g., the future, the self, other people) and is active during periods of mind wandering

Self-generated thought: the capacity for a person to generate mental contents that are not derived directly from immediate perceptual input

TERMINOLOGY, MEASUREMENT, AND CONCEPTUAL ISSUES

Terminology

When the mind wanders, attention drifts from its current train of thought (often an external task) to mental content generated by the individual rather than cued by the environment. Often the thoughts that occur during mind-wandering experiences are described as task unrelated (Giambra 1989) or stimulus independent (Antrobus et al. 1966), terms that capture the independence of the experiences from perception and ongoing actions. Other terms, such as autobiographical thought or mind pops (Kvavilashvili & Mandler 2004), capture the generative process that provides the content of the experience itself. One term that captures the generative aspects of these experiences as well as their independence from perception is self-generated thought (Smallwood 2013a,b). The

SELF-GENERATED THOUGHT

Self-generation describes how an experience arises rather than its relation to intention. The term self-generated thought emphasizes that the contents of experience arise from intrinsic changes that occur within an individual rather than extrinsic changes that are cued directly from perceptual events occurring in the external environment. These experiences can occur intentionally, such as when we consider the solution to a work-related problem on the journey to work, or they can also occur unintentionally, such as when our mind wanders while reading.

Self-generated thought can be task related as well as task unrelated. In cognitive science, the term task is often confounded with external action. However, many tasks do not depend upon current perceptual input or lead to immediate behavior. Tasks such as deciding where to go for brunch on the weekend, or what journal to send a scientific manuscript to, can be performed reasonably well using imagination alone. These are examples of task-related self-generated thought. Self-generated thought can also be task unrelated when its occurrence coincides with the performance of an alternative task, such as during vigilance or while driving an automobile or reading. These are examples of task-unrelated self-generated thought.

The independence of self-generated thought from the term task relatedness is important because it allows for mind-wandering episodes to contain both strategic/deliberate and spontaneous/unintentional elements, a distinction that may be important in its experiential qualities (see section on Phenomenology) and in distinguishing the positive and negative elements of mind wandering (see section on Costs and Benefits). **Figure 1** illustrates the ways in which self-generated thought and task-related thought are independent constructs.

Self-generated thoughts are distinct from external distraction. When occurring during an unrelated task, self-generated thought is a well-documented cause of error. However, studies have shown that these errors can be distinct from those based on external distraction. For example, the individuals whose minds wander the most exhibit the least neural processing of distractors (Barron et al. 2011) (although see Forster & Lavie 2014) and are the least impacted by orienting cues (Hu et al. 2012); distracter events are processed most strongly when people are on task (Esterman et al. 2014). Similarly, studies of individual differences suggest cognitive control makes partially distinct contributions to internal and external distraction (Stawarczyk et al. 2014, Unsworth & McMillan 2014). One reason why task-unrelated self-generated thought and external distraction are distinct is that the former depends on the process of perceptual decoupling whereas the latter does not (see Component Processes section). **Figure 1** illustrates how self-generation of thought is distinct from external distraction.

conceptual basis of self-generated thought and its distinction from both task-unrelated thought and external distraction are described in **Figure 1** (see also sidebar Self-Generated Thought).

Measurement

Experience sampling (ES): a methodology for assessing ongoing thoughts in which participants are periodically asked to report what they are currently thinking about

Investigations of mind wandering use the technique of experience sampling (ES) (Kahneman et al. 2004) to capture moments when we are conscious of intrinsic or extrinsic input (see sidebar Experience Sampling: A Tool for Measuring the Wandering Mind). Despite researchers' interests in the wandering that leads our thoughts to stray from the moment, the experimental measurement usually corresponds to the contents of conscious experience at particular moments in time. Although it is safe to assume that dynamic changes must have led to the current mental state, the ES approach does not enable researchers to watch in real time as conscious states evolve from one mental state to the next. This is one reason why an important avenue in research on mind wandering is the pursuit of indirect measures of the experience.

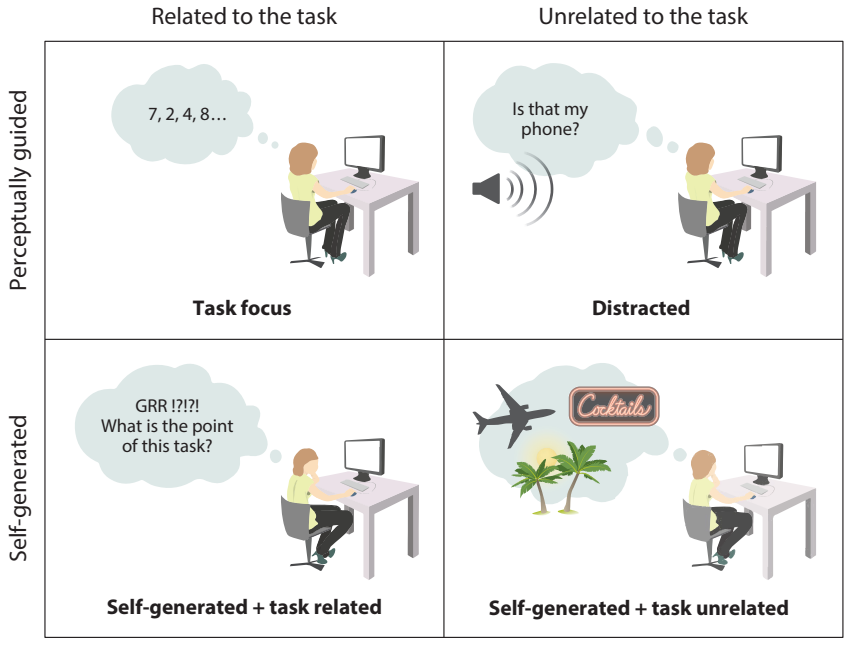


Figure 1

A schematic of the relationship between the focus of cognition (task-related) and self-generated thought. The term self-generated thought is not specific to states of mind wandering; instead, it refers to processes involved in producing mental contents that are not primarily driven by the external environment. For example, in the top left panel the participant is fully focused on the task such that the contents of thought are only those that arise from sensory input. However, in the bottom left panel the thoughts of the participant are related to the task but are also self-generated because the task stimulus in of itself does not necessitate the thought. This would be an example of task-related self-generated thought. Self-generated thought is not always a property of thoughts that are unrelated to the task in hand. For example, in the top right panel the participant is distracted by a noise in the environment and so becomes temporarily disengaged from the task she is performing. However, this external distraction arises due to perceptual input, not through the self-generation of mental contents. Finally, in the bottom right panel the participant has disengaged attention from the task in hand and has begun to self-generate thoughts regarding her upcoming beach holiday.

Conceptual Issues

It is standard to investigate the basis of cognitive functions through the experimental manipulation of the process in question. Usually an imperative stimulus is presented to participants and their response (behavioral, neural, or psychological) is recorded. By varying the nature of the stimulus or the task that participants perform and observing any changes that occur, inferences can be drawn on the nature of the underlying mental processes (Donders 1969). Mind-wandering episodes depend to a large extent on processes that are spontaneous rather than those induced directly by the experimenter (Smallwood 2013a), and these changes have few directly observable consequences. The experimental investigation of mind wandering, therefore, poses a number of specific challenges that must be overcome in order to measure and assess mind wandering in a scientific manner.

One challenge arises because researchers lack the ability to directly cause the mind to wander. Instead, the spontaneous occurrence of mind wandering means that the causal path that links the experience to ongoing processes and outcomes is opaque. For example, evidence suggests that poor

EXPERIENCE SAMPLING: A TOOL FOR MEASURING THE WANDERING MIND

Experience sampling (ES) refers to the collection of self-reports regarding a participant's ongoing experience (Kahneman et al. 2004). There are a number of different methods of ES.

1. Probe-caught method. The most common ES method is to acquire data using a sampling regime known as the probe-caught method (Smallwood & Schooler 2006). Participants are intermittently interrupted and probed regarding the contents of their experience. These occur in a random or quasi-random manner, although studies have used sampling regimes based on changes in performance (such as reading times; Franklin et al. 2011). One important issue is the duration between online ES probes, with studies showing greater reports of off-task thought with larger gaps between probes (Seli et al. 2013, Smallwood et al. 2002).
2. Self-caught method. Participants are asked to spontaneously provide ES reports, such as reporting when they catch their mind wandering (Smallwood & Schooler 2006). In combination with the probe-caught method, this may allow the estimation of the capacity of participants to reflect upon their conscious experience (Schooler et al. 2011).
3. Retrospective method. ES data are gathered at the end of a task via questionnaires, preserving the natural time course of the task (Barron et al. 2011, Smallwood et al. 2012). This can be important for certain covert measures (such as resting state fMRI). One limitation in the retrospective measure is that it can be confounded with individual differences unless multiple measurements are recorded within the same individual (e.g., Gorgolewski et al. 2014).
4. Open-ended method. ES data can also be gathered by asking participants to describe in their own words what they experienced during a task (Baird et al. 2011). This method has the advantage of not imposing categories that constrain participants' reports.

Triangulation between different techniques will be important to allow an account of mind wandering that is not tied to a specific method. For example, probe-caught (Franklin et al. 2013a, Kam et al. 2011, Smallwood et al. 2011a) and retrospective methods (Barron et al. 2011, Smallwood et al. 2012) reveal similar changes in pupil dilation and EEG, which suggests that certain results will be conserved across ES methodologies.

executive control leads to greater mind wandering during demanding tasks (McVay & Kane 2009, 2011). However, mind wandering in the context of executive control tasks has a negative influence on performance (Mrazek et al. 2012a). It is thus unclear whether low executive control causes greater mind wandering, or greater mind wandering during span tasks causes lower estimations of control.

The covert nature of mind wandering creates a second challenge to its investigation. Unlike perceptual guided thought that can be assessed directly through its contributions to action, self-generated experiences are fundamentally internal, with few external manifestations. Current understanding of the mind-wandering state depends on the experimenter's capacity to sample experience in an effective and nonbiased manner (see Experience Sampling sidebar for a description of the different ES approaches that can be used to study mind wandering).

A third challenge arises because assessment of mind wandering typically depends on self-report. A reliance on introspection means that studies of mind wandering need to be corroborated by external measures to ensure that the results are not simply a consequence of the limitations of self-report (Schooler & Schreiber 2004) or the concern that they may indirectly change the quality of the experience (Smallwood & Schooler 2006).

Therefore, at least three conceptual issues arise in the investigation of mind wandering: (*a*) the lack of direct experimental control, (*b*) the covert nature of self-generated thoughts, and (*c*) the validity and potential reactivity of introspective evidence. Over the past decade, advances

in the field of mind wandering have facilitated progress on these issues, and **Figure 2** provides a schematic account of how these different techniques might be employed in a laboratory study.

Lack of direct experimental control. Although mind wandering cannot be induced as precisely as can external task performance, various manipulations can influence its occurrence. For example, mind wandering is closely linked to unhappiness (Smallwood et al. 2007b), and the experimental induction of negative affect can increase the occurrence of mind wandering (V. Engert, J. Smallwood & T. Singer, manuscript under review; Smallwood et al. 2009a; Smallwood & O'Connor 2011; Vinski & Watter 2013) (see top left panel in **Figure 2**). Other work has found that states of craving, or intoxication through alcohol, increase mind wandering (Sayette et al. 2010, 2012). Finally, studies have documented that engaging in meditative practice can help to reduce the mind's tendency to wander (Morrison et al. 2013, Mrazek et al. 2013a).

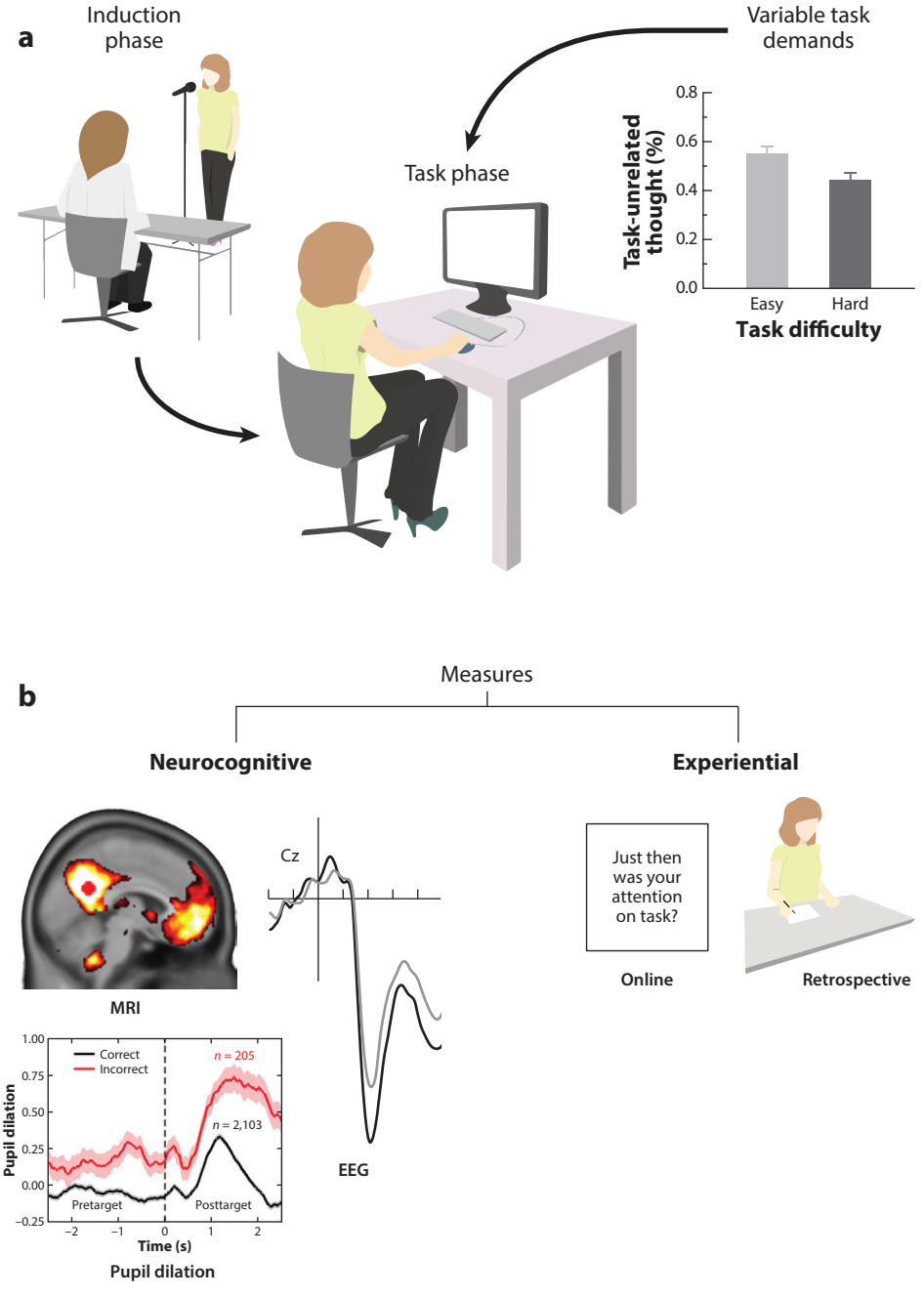
It is also possible to manipulate mind wandering by varying the demands of an ongoing task with respect to controlled processing (Mason et al. 2007, Teasdale et al. 1995), perceptual input (Forster & Lavie 2009, Levinson et al. 2012), or motivation (Antrobus et al. 1966, Smallwood et al. 2007b). One common approach is to vary between a choice reaction time task and a working memory task (e.g., Smallwood et al. 2009b). In these two paradigms, perceptual input is constant; however, the working memory task requires participants to continually encode and maintain this stimulus, whereas this is not necessary in the choice reaction time task. As a result, task-unrelated thought is more common in the choice reaction time task (for an example, see top right panel in **Figure 2**).

Thus, although mind wandering cannot be directly induced, by altering a person's psychological state or varying the complexity of an ongoing task it is possible to gain some degree of experimental control over the experience. These manipulations are critical in understanding the nature of the wandering mind because they provide boundary conditions that inform our understanding of the functions of the state.

The covert nature of the mind-wandering state. To measure mind wandering, researchers employ ES to document when and under what conditions the experience occurred. These approaches are invaluable in illuminating the content of the experiences themselves; however, because they are subjective they are also difficult to verify objectively. One solution is to combine subjective and objective indices of cognitive function in order to identify the variance common to both, a process referred to as triangulation (Schooler & Schreiber 2004).

Studies have found that variability is characteristic of the mind-wandering state in terms of both response times (Carriere et al. 2008; Cheyne et al. 2006, 2011; McVay & Kane 2009) and physical posture (Carriere et al. 2013, Seli et al. 2014). Mind wandering is also associated with divergent eye movements (Foulsham et al. 2013, Reichle et al. 2010), greater pupil dilation (Franklin et al. 2013a; Smallwood et al. 2011b, 2012), more frequent eye blinks (Smilek et al. 2010), and changes in electroencephalography (EEG) readings (Baird et al. 2014, Barron et al. 2011, Kam et al. 2011, Smallwood et al. 2008a) and in the blood-oxygen-level dependent (BOLD) signal as recorded during fMRI (Allen et al. 2013, Christoff et al. 2009, Stawarczyk et al. 2011a). At the neural level, multivoxel pattern analysis has been able to predict subjective reports of the content of thought at rest on the basis of task-based examples of the same types of thought (Tusche et al. 2014). These covert markers validate the subjective measures and allow different cognitive and neural accounts of the mind-wandering experience to be tested. They also raise the possibility that indirect markers for mind wandering could ultimately be used to detect its occurrence without interrupting study participants.

The influence of measurement on the mind-wandering state. Although ES is an invaluable tool for studying mind wandering, it also carries the risk that introspection changes the nature of the state that is being assessed (Schooler 2002a). Online ES alerts the participant to the key dependent measure of the experiment, and by periodically disrupting the ongoing task disrupts the natural dynamics of both task performance and of the experience itself. Finally, because introspection has



the potential to change the psychological meaning of an event, ES could alter the quality of the experience itself.

One solution is to acquire self-report data after participants have completed an experimental session. Although this measure necessarily depends on memory, it allows the collection of data without artificial disruptions and is useful because by preserving the integrity of time-course data, it allows temporal properties in objective measures to be related to ES data. Retrospective indicators of self-generated thought have been related to the dynamic changes that occur in the time-series data derived from pupillometry (Smallwood et al. 2012), EEG (Barron et al. 2011), and the BOLD signal during the resting state (Gorgolewski et al. 2014).

Meta-awareness: the mental state that arises when attention is directed toward explicitly noting the current contents of consciousness, e.g., realizing that one's mind is wandering

PHENOMENOLOGY

Research over the past 15 years has made progress in understanding the phenomenological aspects of mind wandering. Studies have explored the form and content of the self-generated thoughts that occur during mind wandering and have found that they are often an eclectic mixture of thoughts regarding the future and memories from the past, usually with personal relevance. Research has also focused on the relationship between mind wandering and meta-awareness (Schooler 2002a); i.e., an individual's explicit awareness of the current contents of thought. This work has shown that individuals routinely fail to notice that their minds have wandered, and a lack of meta-awareness is often associated with more pronounced indicators of the state.

The Content of Self-Generated Thought

Introspective evidence suggests that the different forms that the mind-wandering experience can take are limited primarily by the scope of an individual's imagination. Despite the eclectic mixture of mental contents that occupy our minds when they wander, research exploring the content of

Figure 2

A schematic diagram describing the different methodologies used to study mind wandering in the laboratory. Panel *a* illustrates the techniques that researchers can employ to gain experimental control. One way that mind wandering can be manipulated is through the induction of psychological states that alter the occurrence of mind wandering or the mental content that is self-generated during the experience. This is depicted in the top left of the figure, which illustrates the induction of social stress via a public speaking exercise. Following the induction of a psychological state conducive to mind wandering, participants can engage in a laboratory task (often computer based). The complexity of the demands of the task that participants perform can also be modulated to change the amount of time that participants engaged in task-unrelated thoughts (*top right*). Both the induction of psychological states and the manipulation of task demands allow the identification of causal pathways and delineate boundary conditions. Panel *b* depicts a number of different techniques that can be used to measure the mind-wandering state. Subjective measurements of the participants' experience can be acquired online as they perform the task using experience sampling. It is also possible to measure the experience retrospectively at the end of the experiment via a questionnaire. Objective measurements of ongoing neurocognitive function can also be acquired during the task phase. These include the blood-oxygen-level dependent (BOLD) signal, which is measured using functional magnetic resonance imaging (fMRI), electroencephalography (EEG), or pupillometry. These indirect measures provide detailed information on the cortical processing that is taking place during mind wandering and thus are invaluable in testing and refining current accounts of the information processes that take place during mind wandering. Abbreviations: Cz, central midline electrode; *n*, number of samples. Data on variable task demands taken from Smallwood et al. (2013a); pupil dilation, Smallwood et al. (2011a); fMRI, Smallwood et al. (2013a); EEG, Kam et al. (2011).

the experience has demonstrated a number of general principles upon which this complexity can be understood.

Mindfulness: a mental state entailing a primary focus on the circumstances of the present

Inspired by work on mental time travel (Tulving 2002), research has shown that mind wandering about the past and future has distinct psychological correlates. Studies have documented a bias toward thinking about the future in both the laboratory and in daily life across a range of countries including China (Song & Wang 2012), Japan (Iijima & Tanno 2012), the United States (Baird et al. 2011, Smallwood et al. 2011b), the United Kingdom (Smallwood et al. 2009b), Germany (Ruby et al. 2013b), and Belgium (Stawarczyk et al. 2011a). This prospective bias may be moderated by task demands because participants tend to decrease the amount of future thinking as task demands increase (e.g., Smallwood et al. 2009b). The left panels of **Figure 3** illustrate two examples of the prospective bias as it is seen in the laboratory.

Past-related thought also has a distinct psychological profile. Unhappiness is a correlate of mind wandering in general (Killingsworth & Gilbert 2010; Smallwood et al. 2004, 2007b) and is particularly pronounced for episodes focused on the past. A retrospective bias to mind wandering is associated with low mood in the laboratory (Ruby et al. 2013a, Smallwood & O'Connor 2011, Stawarczyk et al. 2013) and in daily life (Poerio et al. 2013).

Other work has identified a range of phenomenological features that characterize mind wandering. For example, self-generated experiences with perseverative features tend to be associated with psychopathological states such as anxiety and depression (Ottaviani & Couyoumdjian 2013, Ottaviani et al. 2013), whereas interesting mind-wandering experiences are a concomitant of positive mood (Franklin et al. 2013b). Finally, studies have examined the different forms of thoughts including imagery and words, the specificity of the experience, and the relevance of the thought to the individual (Delamillieure et al. 2010, Gorgolewski et al. 2014).

A more principled approach for dealing with the wide variety of experiences that occur during mind wandering is to explore the patterns of covariance that are present within ES data. To achieve this aim, multiple dimensions of ES data are collected at the same time and are decomposed using statistical techniques such as chain-p principal component analysis (PCA) to reveal the latent structure of thought. Ruby and colleagues applied PCA to ES data to confirm that past- and future-related self-generated thoughts are unique statistical categories of thought (Ruby et al. 2013a,b). These statistically derived components were predictive of independent measures such as ongoing performance and individual differences in psychological function. **Figure 3*a,b*** illustrates the structure of thoughts identified by PCA; it is noteworthy that the factors are reasonably consistent across two independent data sets. Similar decomposition of ES data has been employed on a retrospective measure of self-generated thought, and these factors have been shown to vary with neurocognitive changes occurring in the brain at rest (Gorgolewski et al. 2014).

Hierarchical clustering has also been used to provide information on the dimensional structure of thought. This technique has shown that valence, specificity, and self-relevance account for substantial variance in the content of mind-wandering episodes (Andrews-Hanna et al. 2013). These dimensions explained significant variance in independent measures such as rumination and mindfulness.

Altogether, research suggests that the content of self-generated thoughts that arise during mind wandering has a rich structure reflecting variables such as temporal focus, affective state, and interest. Moreover, the form and content of the self-generated experiences that occur during mind wandering can influence the associated functional outcomes of the state. This is known as the content regulation hypothesis (Andrews-Hanna et al. 2014, Smallwood & Andrews-Hanna 2013) (see sidebar Understanding the Costs of the Wandering Mind).

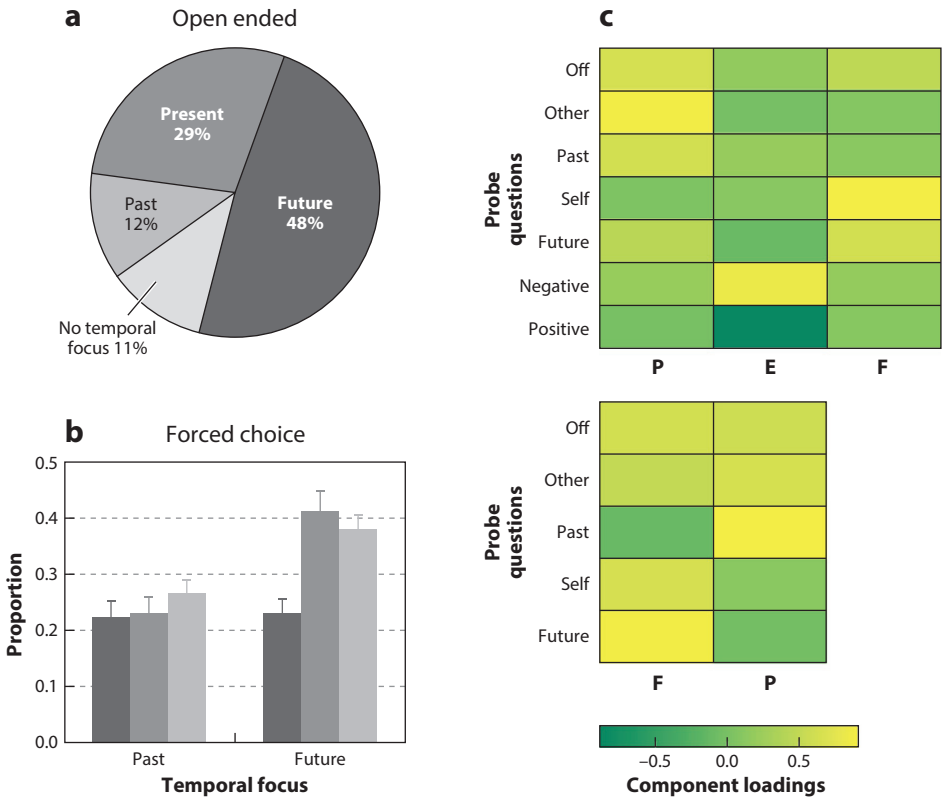


Figure 3

The sociotemporal content of the self-generated thoughts that occur during mind wandering. Studies have shown that a large proportion of mind wandering is spent engaged in self-generated thought that is related to the concerns of the individuals and the people close to them, and it is often directed to times other than the present. Both (*a*) open-ended experience sampling (ES) and (*b*) forced-choice reports indicate that there is a prospective bias to the thoughts that participants experience during mind wandering. (*b*) Prospective bias is reduced by engaging in a task that requires working memory (dark gray) relative to either a choice reaction time task (medium gray) or passive viewing (light gray). More sophisticated approaches to the content of self-generated thought have explored the internal structure of experience sampling data using statistical procedures such as principal component analysis (Ruby et al. 2013a,b). This structure is represented in (*c*) the heat maps in which a positive weighting of the different elements of experience are reflected in warm yellow, and a negative weighting is described in the cooler green. This approach has shown that self-generated thought consists of different categories of experience that can be discriminated on the basis of whether they are focused on the future (F) or the past (P). A third component is associated with the emotional valence of the experiences (E). Data in (*a*) taken from Baird et al. (2011); (*b*), Smallwood et al. (2009a); (*c*), Ruby et al. (2013a,b).

Relation to Awareness

One important feature of mind wandering is the moment at which we recognize that the current content of thought is discrepant from the ostensible task that the individual is (or was) performing (Schooler 2002a). This aspect of the experience can be compelling, for example when we notice our mind has wandered while we are reading, engaged in conversation, or watching television (Schooler et al. 2004). On at least certain occasions, therefore, mind wandering reflects a failure

UNDERSTANDING THE COSTS OF THE WANDERING MIND: THE CONTEXT AND CONTENT REGULATION HYPOTHESES

Although mind wandering is both a cause of error in external tasks (such as reading or automobile driving) and has close links to negative affect, it is also a correlate of creativity and delay of gratification. In addition, it is a correlate of both greater and lesser executive control. The variable manner in which mind wandering relates to assorted psychological constructs illustrates how accounts of its functional outcomes must accommodate rather complex patterns of data.

Context regulation hypothesis. Two clear patterns emerge from the work on mind wandering across the past decade. First, mind wandering is more likely under conditions that do not demand external attention. Second, mind wandering is a cause of poor performance in demanding tasks such as reading. Together, these lines of evidence suggest that optimal cognition would limit task-unrelated self-generated thoughts to situations that do not demand continuous attention. This is known as the context regulation hypothesis.

Content regulation hypothesis. A second consequence of mind wandering is its documented relationship to negative affect, with studies suggesting that negatively toned mind wandering may be implicated in premature aging (Epel et al. 2013). However, studies have found that the most deleterious consequences occur when the mind wanders to the past rather than to other topics. Furthermore, aspects of the content of mind wandering (such as interest) are also linked to positive mood (Franklin et al. 2013b). Together, these results suggest that the relationship between the functional outcomes, at least with respect to mood, depends on the content of the episodes. This is known as the content regulation hypothesis and suggests that the costs of such mind-wandering experiences can only be properly understood by taking into account the content of the experiences (see Phenomenology section).

to maintain continuous awareness on the links between the contents of conscious thought and our current goals.

Two approaches have been used to investigate meta-awareness of mind wandering. One asks participants to indicate whether they had been aware that their minds had drifted and has shown that the consequences of mind wandering are more pronounced when the episode is described as lacking awareness. Unaware mind-wandering episodes are associated with greater behavioral cost, such as especially rapid and careless task performance (Smallwood et al. 2007a,b). One study measured mind wandering while participants read a detective novel (Smallwood et al. 2008c). An analysis indicated that participants who mind wandered without awareness (termed zoning out) at critical periods in the task were less likely to solve the crime than were those who mind wandered but were aware of this fact (termed tuning out) (see **Figure 4*a***). Neuroimaging studies have shown that neural systems that play a role in self-generated experiences are more engaged during mind-wandering episodes of which the participant lacks awareness (Christoff et al. 2009). Finally, unaware mind wandering has also been associated with higher levels of depression (Deng et al. 2012), increases in mind wandering following stereotype threat (Mrazek et al. 2011), greater disruptions of everyday tasks (McVay et al. 2009), and increases in the risk of an accident while driving a car (Cowley 2013).

A second approach examines how effectively participants can notice that their mind has wandered. Participants are asked to indicate with a manual response when they notice that their minds have wandered from the task being performed. These self-caught mind-wandering reports are thought to represent mind-wandering episodes that reached meta-awareness. By comparing self-caught mind wandering with mind-wandering episodes caught by probes, it is possible to draw inferences about the role of meta-awareness in various situations (Schooler et al. 2011).

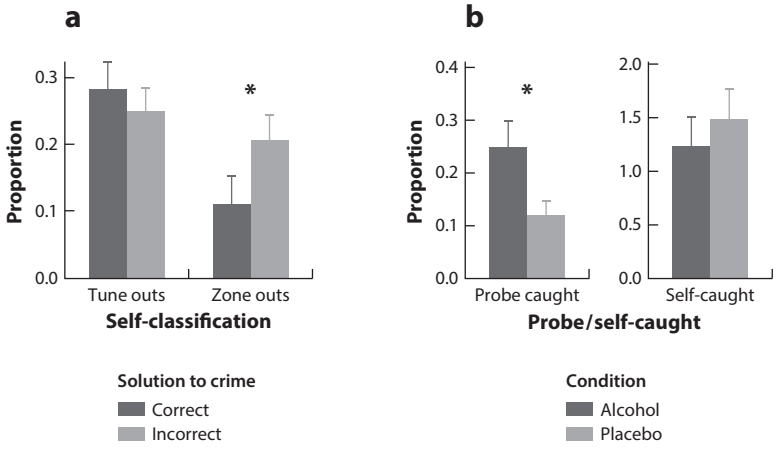


Figure 4

The role of meta-awareness in the mind-wandering state. A compelling aspect of the experience of mind wandering is the recognition that one's thoughts have wandered from the task in hand. This dissociation between mind wandering and knowing that one is mind wandering is described as an absence of meta-awareness and is important in determining the association between mind wandering and ongoing task performance; it is also essential in influencing individuals by manipulations that are conducive to mind wandering. One method to assess meta-awareness of mind wandering is to ask participants to classify if they were aware of the focus of their attention. This self-classification approach (*a*) has shown that the occurrence of episodes of mind wandering classified as lacking awareness—known as zone outs—are more detrimental to a participant's capacity to solve the crime in a detective novel than are episodes in which the participant was aware of mind wandering (known as tune outs). A second method (*b*) is to ask participants to self-report every time that they notice that their mind has wandered and to intermittently probe them to assess their current state of consciousness. This probe/self-caught method has shown that manipulations in participants, such as the consumption of alcohol, markedly increase the likelihood of mind wandering without producing a commensurate increase in the probability that they will notice that their minds have wandered. Asterisks indicate $p < 0.05$. Data in (*a*) taken from Smallwood et al. (2008a); (*b*), Sayette et al. (2010).

For example, whereas probe-caught mind wandering is predictive of reading comprehension, self-caught episodes are often less so (Schooler et al. 2004).

Studies have shown that manipulations that reduce meta-awareness increase the probability of mind wandering and decrease the probability of it being noticed. For example, Sayette et al. (2009) found that although alcohol intoxication doubled the likelihood of probe-caught mind-wandering episodes, participants were still numerically less likely to self-catch mind-wandering episodes when intoxicated relative to when sober (see **Figure 4*b***). Inducing cigarette craving produced similar disparate effects on self- and probe-caught mind-wandering rates (Sayette et al. 2010). Self-caught episodes also have a unique relationship to the eye movements that occur during reading (Reichle et al. 2010). Finally, an investigation of people's capacity to notice thought intrusions regarding a prior romantic partner whom they were trying not to think about revealed that people were routinely caught thinking about the partner before they noticed it themselves. Moreover, the desire to still be with a partner was associated with an increased likelihood of thinking about the partner (as revealed by more frequent probe-caught episodes) and a decreased probability of spontaneously noticing such thoughts (as revealed by less frequent self-caught episodes) (Baird et al. 2013a).

Probe-caught/self-caught paradigm: comparing spontaneous with cued reporting of a mental state (e.g., mind wandering) in order to estimate its association with meta-awareness

Overall, studies have revealed that (*a*) participants often fail to notice that their minds have wandered, (*b*) various factors can have distinct effects on the likelihood of mind wandering versus

noticing that one is mind wandering, and (*c*) aware versus unaware mental diversions can have distinct characteristics with respect to both their impact and content. Although these findings are consistent with the hypothesis that meta-awareness may play a functional role in modulating the impact of mind wandering, additional research is needed to ascertain the role meta-awareness has in controlling the mind-wandering state (see sidebar Open Questions Regarding the Phenomenology of Mind Wandering).

Component process account: the hypothesis that complex mental states such as thinking about the future depend on the combination of multiple subprocesses

Perceptual decoupling/coupling: the capacity for the mind to flexibly disengage/engage attentional processes from sensory input

THE COMPONENT PROCESS VIEW

One problem that arises when attempting to understand the thoughts that occur during mind wandering is that the rich diversity of potential experiences has to be accounted for by a smaller subset of underlying processes. This section considers evidence from psychology and neuroscience with the aim of describing the different underlying processes that in combination produce the complex varieties of experiences that occur during mind wandering as well as the experiences that make up other aspects of daily life. This is known as the component process account of mental states (Smallwood 2013a,b) and assumes that different types of thoughts and feelings arise through the flexible combination of a smaller number of underlying processes.

The self-generated thoughts that occur during mind wandering demonstrate that complex higher-order cognition can arise despite being unrelated to the events in the external environment or any task being performed. A component process account would need to explain at least three important aspects of this phenomenon: (*a*) how higher cognition can become disengaged from external processing, (*b*) how people self-generate task-unrelated mental content, and (*c*) how this disengagement and self-generation are coordinated and/or regulated by the individual.

Recent neurocognitive studies have shed light on all three issues. First, studies have demonstrated that the amplitude of responses evoked by external events is reduced during periods of mind wandering. This finding provides basic support for the principle of perceptual decoupling, which suggests that during periods of self-generated thought, attention is disengaged from perception. Second, studies suggest that emotional and episodic processes are involved in the self-generation of mental content during mind wandering. Third, studies have found evidence that executive control processes are important in the coordination of the mind-wandering state itself. Evidence

OPEN QUESTIONS REGARDING THE PHENOMENOLOGY OF MIND WANDERING

1. What is the relationship between meta-cognitive awareness and the control of mind wandering?
It is possible that the experience of catching one's mind wandering is the result of a monitoring process that allows the individual to intermittently take stock of the contents of consciousness and direct it back to the desired goal. It is also possible that the process of catching is a consequence of the mind-wandering episode coming to an end for other reasons, and because the experience has loosened its grip on consciousness, the individual gains the opportunity to self-report the experience.
2. What is the relationship between different types of content and different qualities of thought?
It is possible that important linkages exist between the mental contents of the experience and subjective qualities such as awareness. For example, studies have found that ruminating on the past during mind wandering is linked to negative mood (Smallwood & O'Connor 2011) and that dysphoric thought is also characterized by a lack of awareness (Deng et al. 2012). These findings could explain why participants have difficulty in refraining from rumination: A lack of awareness of thoughts regarding the past would prevent individuals from disengaging from these cognitions (see also Baird et al. 2013a).

OPEN QUESTIONS REGARDING THE COMPONENT PROCESS ACCOUNT

1. What role does perceptual decoupling play in self-generated thought?

One possibility is that perceptual decoupling is necessary for a coherent internal train of thought to emerge (Kam & Handy 2013; Smallwood 2013a,b). In this view, perceptual decoupling reflects the flexible reorganization of processes to facilitate a conscious focus on self-generated information. In the same way that attention allows one modality of sensory information to receive preferential processing compared to an irrelevant modality (Posner & Petersen 1990), perceptual decoupling may facilitate self-generated thought by inhibiting the processing of information unrelated to the train of thought, which in this case can be events taking place in the external environment.

A second possibility is that perceptual decoupling is not a process that is specifically dedicated to insulating the inner stream of thought but rather is a consequence of limited attentional resources (Franklin et al. 2013c). According to this alternative view, the process of perceptual decoupling reflects the fact that attention has ceased to be paid to external information, but it does not play a functional role in maintaining the ongoing internal train of thought.

2. What role does executive control play in the mind-wandering state?

At present there is no consensus on the precise relationship between mind wandering and executive control, despite the identification of a clear link between them (McVay & Kane 2010, Smallwood 2010). The executive failure account (McVay & Kane 2010) does not explain the positive correlation between working memory capacity and task-unrelated self-generated thoughts in nondemanding conditions (Levinson et al. 2012, Rummel & Boywitt 2014), interpretations of causality with respect to mind wandering (Mrazek et al. 2012a), or the difference between external distraction and self-generated thought (Barron et al. 2011, Esterman et al. 2014, He et al. 2013, Stawarczyk et al. 2014, Unsworth & McMillan 2014). Similarly, the executive control hypothesis (Smallwood & Schooler 2006) does not explain why high working memory reduces mind wandering in demanding tasks (McVay & Kane 2009, 2010; Unsworth & McMillan 2013). Because neither the executive failure nor the executive control hypothesis can explain the available data, a compromise may be found in the idea that the role of executive control in the mind-wandering state varies as a function of the relative demands of the external task. This is known as the context regulation hypothesis (see Costs and Benefits section).

for each of these component processes forms the focus of this section of the review (see also sidebar Open Questions Regarding the Component Process Account).

How Higher Cognition Becomes Disengaged from External Processing

Perceptual coupling and decoupling. When attention is directed to an external goal, it can facilitate action by increasing the processing of relevant sensory input (Posner & Petersen 1990). By contrast, when the mind wanders to self-generated information, it becomes disengaged from events in the external world. This attentional shift is known as perceptual decoupling and is hypothesized to have two consequences. First, it corresponds to a reorganization of cognition to focus on intrinsic rather than extrinsic inputs. Second, it is associated with reduced attention to the external input. Perceptual decoupling is therefore one reason why transient self-generated states can persist and hence lead to errors on demanding external tasks (Kam & Handy 2013, Smallwood 2013a) (see section on Costs and Benefits). **Figure 5** highlights several key results demonstrating the decoupling of attention from perception during mind wandering.

Evidence for perceptual decoupling comes from studies that examine the temporal relationship between self-generated thought and the cortical processing of external information. One way that

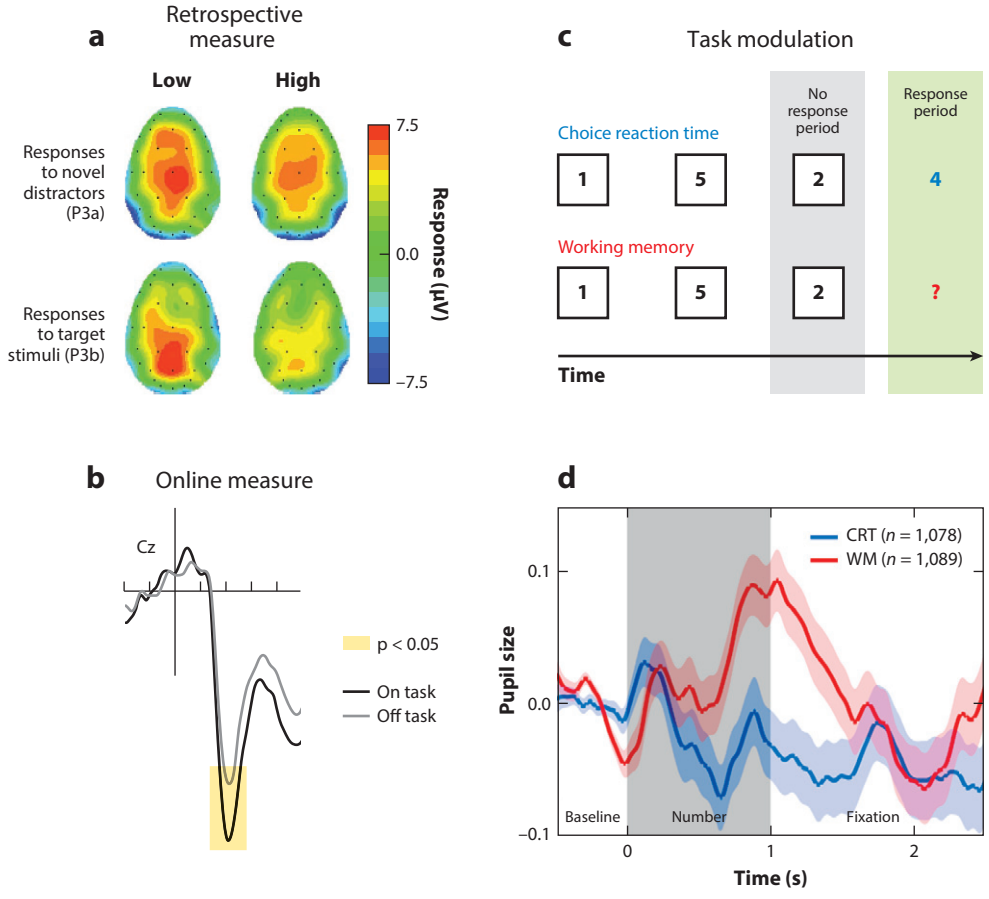


Figure 5

Evidence of the decoupling of attention from perception during the mind-wandering state. A well-documented aspect of the mind-wandering state is the disengagement of attention from events taking place in the here and now. This process is known as perceptual decoupling and can be measured by examining the amplitude of evoked response in neurocognitive measures that index processing of events in a task. For example, the amplitude of a positive event-related potential in the electroencephalogram, known as the P3, is reduced (*a*) for participants who engage in the most task-unrelated thought as assessed by a retrospective measure and (*b*) during periods when participants are off task as measured using experience sampling. It is also possible to manipulate the occurrence of task-unrelated thought and show that this is associated with a reduction in the evoked responses related to external input. For example, participants were engaged in a choice reaction time task that required no external attention during the no-response period and a working memory task that required continuous attention during this period (*c*). Evidence indicates that during periods when no behavioral response is required, the pupil signal shows greater evoked response during the working memory task (depicted in red) than during the choice reaction time task (depicted in blue). Consistent with the decoupling hypothesis, the transient occurrences of mind wandering as well as the conditions that promote it are characterized by reduced evoked responses to external events. Abbreviations: CRT, choice reaction time; Cz, central midline electrode; *n*, number of samples; WM, working memory. Data in (*a*) taken from Barron et al. (2011); (*b*), Kam et al. (2011); (*c*), Smallwood (2011b).

the cortical processing of external information can be characterized is by quantifying the evoked response that occurs because of a stimulus such as the amplitude of event-related potentials (ERPs) that are derived from EEG. An ERP known as the P3 occurs approximately 300 milliseconds after task-relevant events are processed and indexes task-related attention (Polich 1986). At the trait level, studies have shown that the P3 is reduced for individuals who experienced high levels of

task-unrelated thinking during a task (Barron et al. 2011). The P3 is also smaller during states of task-unrelated thought (Kam et al. 2014, Macdonald et al. 2011, Smallwood et al. 2008a). A reduction in the amplitude of the ERP is not limited to the P3; it also occurs for components that indicate sensory processing of auditory, visual, and tactile domains, suggesting that changes in early perceptual processes occur during mind wandering (Kam et al. 2011, 2014). **Figure 5*a*,*b*** illustrates reductions in the P3 component from two representative studies. It is important to note that the studies yielded similar results yet differed on the method of ES they employed, illustrating that the reduced P3 during high-incidence periods of mind wandering is observed across different measures of the experience.

How People Self-Generate Mental Content Unrelated to Their Environment

Episodic thought. Self-reports of the content of mind-wandering episodes suggest that they are frequently focused on events that occur at distinct time periods either in the past or future (see section on Phenomenology). This mental time travel is thought to depend on episodic memory processes to generate the mental content (Tulving 2002). This raises the possibility that the self-generated mental content associated with mind wandering is partly the product of the episodic memory system.

Neuroimaging provides basic support for this episodic memory hypothesis. A large-scale network focused on the medial prefrontal cortex and the posterior cingulate cortex, known as the default mode network (DMN), is identified by its coordinated activity at rest (Greicius et al. 2003). A number of parallels between the literature on the DMN and mind wandering suggest that both have similar properties. Just as the mind-wandering state is conceived of as a process that is in opposition to external perception, at rest the core elements of the DMN are anticorrelated with brain regions engaged by external sensory processes, such as regions of the occipital cortex (Vincent et al. 2006). Furthermore, the degree of the anticorrelation between these regions and the medical prefrontal cortex is enhanced for participants who mind wander more during reading (Smallwood et al. 2013a). Likewise, for individuals who engage in specific self-generated thoughts at rest, regions of the occipital cortex exhibit reduced levels of activity (Gorgolewski et al. 2014).

More specifically, the DMN has been shown to be involved in the kind of thoughts that people experience during mind wandering. When individuals are tasked with imagining another place or time (Addis et al. 2012), or thinking about themselves (Kelley et al. 2002, Macrae et al. 2004, Mitchell et al. 2006), regions in the DMN increase their activity. The left panel of **Figure 6** presents the results of a meta-analysis using the automated meta-analysis tool Neurosynth (Yarkoni et al. 2011) to identify the keywords that were most associated with different subsystems of the DMN (Andrews-Hanna et al. 2014). It can be seen that the terms semantic and episodic are both prominent and that other terms (such as self, social, past, and future) correspond to the contents of thoughts that commonly occur during the mind-wandering state (see section on Phenomenology). More direct evidence of the involvement of the DMN in mind wandering comes from studies that examine its neural correlates. Studies using ES have documented that the DMN exhibits elevated activity during periods of task-unrelated self-generated thought (Allen et al. 2013, Christoff et al. 2009, Mason et al. 2007, Stawarczyk et al. 2011b). **Figure 6** (right panel) presents evidence for activity in the DMN during periods of self-generated-thought as indexed using online ES.

Emotion. Studies have shown that dysphoria is associated with greater mind wandering (Smallwood et al. 2005, 2007b), and a large-scale ES study found that when people mind

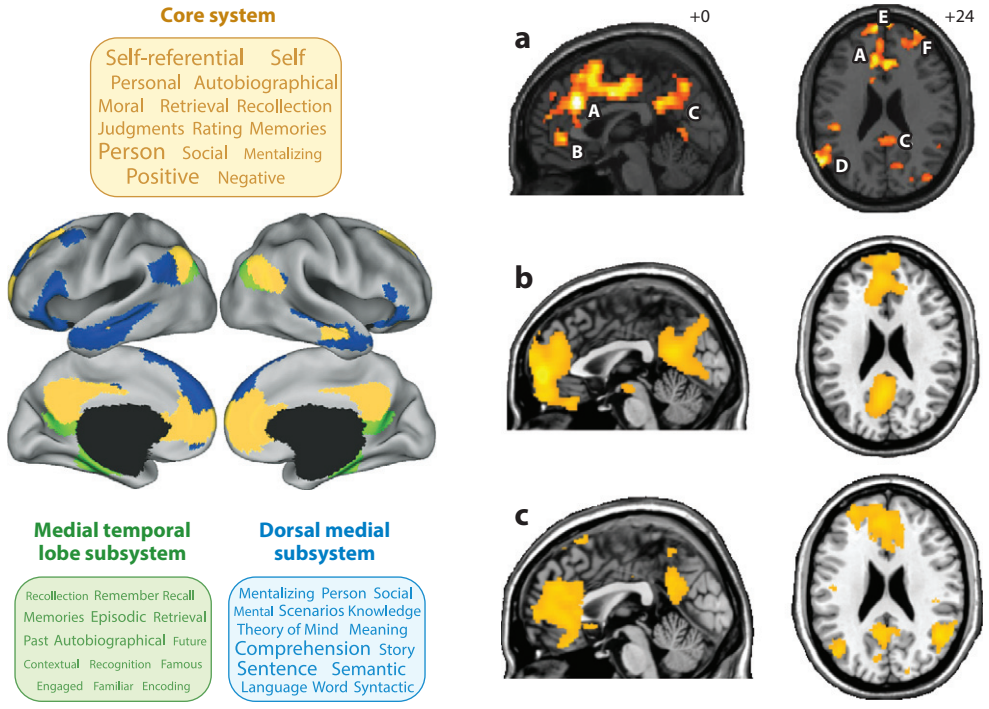


Figure 6

Evidence for the default mode network (DMN) as the substrate of the self-generated thought. The DMN is a large-scale brain network defined by the temporal correlation between activity in two core regions on the medial surface of the cortex, known as the posterior cingulate and medial prefrontal cortex. These regions form the core of the DMN (*yellow*) and interact with subnetworks including the medial temporal lobe subsystem (*green*) and the dorsal medial subsystem (*blue*). Meta-analyses using Neurosynth have shown that the core of this system tends to be engaged in self-referential processes, the medial temporal subsystem is engaged by episodic processes, and the dorsal medial subsystem is engaged by social processes. Together, these forms of thought are similar to the content of the self-generated thoughts that often occur during mind wandering, providing important evidence for the involvement of these regions in the mental content that occurs during mind wandering. Studies using experience sampling in conjunction with functional magnetic resonance imaging have shown that these regions show heightened activity during periods of task-unrelated thought (*a–c*). These brain images show that regions of the core aspects of the DMN exhibited greater activity during periods of task-unrelated thought. Regions: A, dorsal anterior cingulate cortex; B, ventral-medial medial pre-frontal cortex; C, posterior cingulate cortex; D, right temporal-parietal junction; E, dorsal medial prefrontal cortex; F, left rostral-lateral prefrontal cortex. Data in (*a*) taken from Christoff et al. (2009): cluster-forming threshold $p < 0.005$, cluster size $= 20$; (*b*), Stawarkzyck et al. (2011b): cluster-forming threshold $p < 0.005$, cluster size $= 20$; (*c*), Allen et al. (2013): cluster-forming threshold $p < 0.05$, cluster size $= 20$.

wander their mood is generally low (Killingsworth & Gilbert 2010). More recent work has documented that this relationship is mediated by the content of the mind-wandering experience, with higher levels of unhappiness associated with the past (Poerio et al. 2013, Ruby et al. 2013a, Smallwood & O'Connor 2011, Stawarczyk et al. 2013). Studies have also found that the consequence of self-generated thought on subsequent affect depends on its temporal content: Future thinking tends to reduce subsequent negative mood (Ruby et al. 2013a) and reduces cortisol levels following social stress (V. Engert, J. Smallwood & T. Singer, manuscript under review). Unpleasant thoughts during rest are also associated with greater activity in a region of dorsomedial prefrontal cortex. Together, these results suggest that affective processes are an important influence on the self-generated thought that occurs during mind wandering.

How Disengagement and Self-Generation are Coordinated and/or Regulated

Executive control. Individuals with good cognitive control limit their task-unrelated thoughts when external task demands are high (Kane & McVay 2012). Negative correlations between off-task thought and executive control abilities have been observed during complex span tasks, sustained attention tasks, and reading (McVay & Kane 2009, 2011; Mrazek et al. 2012a; Unsworth & McMillan 2013). By contrast, individuals with good cognitive control tend to produce more off-task thoughts when the environment is nondemanding (Levinson et al. 2012), and this effect has also been observed outside of the laboratory (Kane et al. 2007). Together, these data suggest that expertise in attentional control manifests as variations in the allocation of attention to internal and external sources depending on the demands of the environment. This is known as the context regulation hypothesis (see sidebar Understanding the Costs of the Wandering Mind: The Context and Content Regulation Hypotheses).

Meta-cognition. In addition to executive control, meta-cognitive processes may also contribute to the regulation of mind wandering (Fox & Christoff 2014, Schooler 2002b, Schooler et al. 2011). Allen and colleagues (2013) showed that participants who tended to vary in their attention between on-task and off-task states (as indexed by variability) tended to show better meta-cognitive awareness of task performance. Likewise, resting state fMRI has shown that the DMN is important in meta-cognition for information from memory (Baird et al. 2013b). Finally, Mrazek and colleagues (2013b) have shown that improving awareness of mind wandering via meditation reduced the occurrence of the experience.

Open Questions

One important question is what influences the motivation for mind wandering. Eric Klinger and colleagues demonstrated that a critical reason for mind wandering is that people are committed to goals that extend beyond the here and now, referred to as current concerns (Klinger 1967, 1973, 1984, 2013). This view hypothesizes that conscious thought is attracted to the most salient information and explains why our mind frequently turns inward under conditions in which the external environment is relatively uninteresting. Consistent with this hypothesis, studies have shown that financial motivation to perform the task reduces mind wandering (Mrazek et al. 2012a).

COSTS AND BENEFITS OF THE MIND-WANDERING STATE

Although the necessity of external attention to guide behavior is self-evident, the value of mind wandering is less clear. Indeed, more than a decade of research has revealed the broad range of situations under which the tendency to mind wander has a negative influence on task performance. By contrast, studies suggest that the tendency to mind wander is common across different cultures, and the relatively high frequency of the experience suggests that it is a normal rather than pathological aspect of the human condition. This section considers evidence of the costs and benefits of mind wandering with a view to emphasizing that the context in which the experience occurs and the content of the experience itself can determine the functional consequences of this state (see sidebar Understanding the Costs of the Wandering Mind). It then considers the potential benefits of the mind-wandering state.

Mind Wandering and Ongoing Performance

Mind wandering has been linked to poor outcomes in a wide range of tasks, such as those common in education. For example, mind wandering impairs comprehension during reading (Dixon &

Bortolussi 2013; Feng et al. 2013; Franklin et al. 2011; Jackson & Balota 2012; McVay & Kane 2011; Schooler et al. 2004; Smallwood et al. 2008c, 2013a; Unsworth & McMillan 2013) and during lectures (Farley et al. 2013, Szpunar et al. 2013a).

Although mind wandering tends to be generally associated with poor performance, it is generally less disruptive in tasks in which monitoring and encoding immediate input is less important (Ruby et al. 2013b) or when performance is automated (Teasdale et al. 1995). These contextual variations in the relationship between mind wandering and ongoing performance highlight that the costs of the experience can be better understood by taking into account the context in which it occurs (Andrews-Hanna et al. 2014, Smallwood & Andrews-Hanna 2013) (see sidebar Understanding the Costs of the Wandering Mind).

One implication of the context regulation hypothesis is that cognitive functioning may be maximized if mind wandering is limited to nondemanding circumstances rather than avoided entirely. Support for this view comes from a variety of sources, including studies that examine the relationship between mind wandering and control and those investigating its relationship to the capacity to delay gratification. When tasks make consistent demands on external attention, individuals with good executive control tend to limit the occurrence of task-unrelated self-generated thought (McVay & Kane 2009, 2011; Mrazek et al. 2012a; Unsworth & McMillan 2013). By contrast, when tasks make fewer demands, executive control tends to maximize the occurrence of task-unrelated thought both inside (Levinson et al. 2012, Rummel & Boywitt 2014) and outside of the laboratory (Kane et al. 2007). This facilitation is especially true of mind-wandering episodes in which the content is related to the future (Baird et al. 2011). Consistent with the context regulation hypothesis, future thinking is not associated with higher working memory when external task demands are especially strong. These results suggest that effective executive control can suppress self-generated thought when external demands are high; however, when demands of the task are low, executive control will take advantage of the person's excess resources and indulge in mind wandering.

A particularly troubling aspect of mind wandering is its relation to poor performance on demanding tasks that require general intellectual functioning. Mrazek and colleagues (2012a) found that mind wandering was associated with disrupted performance on a range of tasks involving executive control. Critically, it was demonstrated that the tendency of individuals to mind wander while taking working memory and intelligence tests was predictive of their prior SAT performance. Structural equation modeling based on these measures derived two latent variables: one corresponding to mind wandering during the working memory and intelligence measures and the other to general aptitude on these measures as well as the SAT. At the latent variable level, mind wandering predicted 49% of the variance in general aptitude. Consistent with the context regulation hypothesis, the ability to avoid mind wandering while engaging in a demanding task is a primary component of general intellectual ability, at least as measured by aptitude tests.

Further support for the context regulation hypothesis comes from studies that explore how mind wandering is related to an individual's capacity to delay gratification: the ability to disregard smaller immediate rewards in favor of greater rewards in the future (Mischel & Gilligan 1964). Superior delayed gratification is known to be predictive of positive attributes such as greater intelligence (Shamosh & Gray 2008). Studies have shown that individuals who make patient temporal economic decisions tend to report more self-generated thought primarily when external demands are low (Bernhardt et al. 2014, Smallwood et al. 2013b). The linkage between delayed gratification and the capacity to regulate the occurrence of mind wandering may reflect a capacity to titrate experiential demands in a strategic fashion in line with external conditions. Work exploring the link between attention-deficit/hyperactivity disorder (ADHD), which is characterized by impulsivity and mind wandering, suggests that ADHD-prone individuals fail to accurately trade off the value of their thoughts with respect to the demands of the external task (Franklin et al. 2014).

The Benefits of a Wandering Mind

In addition to exploring the costs of mind wandering, researchers have begun investigating and speculating about its potential benefits (for recent reviews, see Mooneyham & Schooler 2013, Schooler et al. 2014, Smallwood & Andrews-Hanna 2013).

Prospection. The self-generated thoughts that occur during mind wandering are often focused on the future, which would facilitate the benefits that prospection can bring to daily life (Baumeister & Masicampo 2010, Baumeister et al. 2011). The benefit of future planning during mind wandering may depend on the processes of mental contrasting (Oettingen & Schwörer 2013), whereby individuals consider both the potential obstacles to their goal and the benefits that will be accrued if those obstacles are overcome.

Creativity. A second beneficial outcome from mind wandering is the capacity to generate novel, creative thoughts. A fundamental similarity exists between the creative experience and the self-generated thoughts that arise during mind wandering: Both are illustrative of experiences people generate that are discrepant from the current or dominant psychological interpretations of the task environment. Consistent with this broad similarity, Baird and colleagues (2012) found a relationship between the tendency of individuals to mind wander and their performance on the unusual uses test, a measure of divergent thinking (Guilford et al. 1959). Moreover, circumstances conducive to mind wandering (i.e., engaging in a nondemanding task) resulted in a greater incubation benefit relative to those that required either continual external attention or periods of idle rest (Baird et al. 2012). In a related study, a positive relationship was found between mind wandering and the tendency to generate solution steps in a social problem–solving task (Ruby et al. 2013b). Thus, a second outcome of mind wandering could be the self-generation of pathways to problem solutions, perhaps because both outcomes depend on a capacity to generate mental contents that are divergent from current reality (for further discussion, see Mind Wandering in Daily Life section).

Meaning. Another potential value of mind wandering may be to enable people to place their experience in a meaningful context. Finding meaning in one's personal experiences can foster well-being (Janoff-Bulman 1992) and enhance health outcomes (Taylor et al. 2000). Research indicates that engaging in mental time travel, particularly thinking about specific remembered or anticipated events, can enhance self-reported meaning in life (A. Waytz, H.E. Hershfield & D.I. Tamir, manuscript under review). Given that mind wandering routinely entails thinking about past or future events, it may provide an important context for integrating experienced and anticipated events into a meaningful life narrative.

Mental breaks. Mind wandering may also be useful by providing mental breaks to relieve boredom from monotonous activities. For example, Baird et al. (2010) found that the reduction in mood associated with engaging in a boring task was attenuated for those individuals who regularly mind wander. This has recently been replicated by Ruby and colleagues (2013a), who showed that self-generated thought focused on the future could help remediate an unpleasant mood. The mental breaks associated with mind wandering may also enable dishabituation. Specifically, engaging in mind wandering may provide breaks that serve as the equivalent of spaced learning in memory paradigms or that attenuate the inhibition that builds up in semantic satiation (Mooneyham & Schooler 2013).

Parallels to night dreaming. Ultimately, it is plausible that mind wandering will be found to serve a functional role that rivals that of dreaming. Indeed, parallels exist between mind

wandering and dreaming (Fox et al. 2013): Both require that attention is decoupled from perceptual input and is accompanied by self-generated thought (e.g., dreams), both involve dampened executive and meta-cognitive processing, and both have been linked to benefits in creative incubation (Cai et al. 2009). Moreover, a substantial proportion of both dreams (Armitage et al. 1995) and mind-wandering episodes (Killingsworth & Gilbert 2010, Ruby et al. 2013a) focus on negative content. In both cases, it is plausible that this negative content is useful by encouraging the simulation of, and thereby preparedness for, potential threats (Revonsuo 2000). In the case of mind wandering, given that the thoughts that occur during mind wandering are explicitly directed to the future, this hypothesis may be more pertinent to daily than nocturnal self-generated thought.

MIND WANDERING IN DAILY LIFE

One of the most significant aspects of mind wandering is its relevance to everyday experience. Many everyday activities may be vulnerable to the effects of mind wandering. The experience is costly in educational contexts because it can profoundly undermine reading comprehension (Schooler et al. 2004), attending to lectures (Szpunar et al. 2013a), and even test taking (Mrazek et al. 2012a). Drivers are also especially vulnerable to mind wandering. Mind wandering increases the velocities and response times of drivers to sudden events while reducing the amount of headway distance that they maintain (Yanko & Spalek 2013). Epidemiological investigations of victims of car accidents provide further evidence of the likely contribution that mind wandering has in driving accidents. Galera and colleagues (2012) queried accident victims in emergency rooms regarding their circumstances immediately before the crash. Although a variety of factors discriminated the responsible from the nonresponsible driver (including alcohol consumption, external distraction, negative affect, psychotropic drug use, and sleep deprivation), being deeply absorbed in mind wandering was the single best predictor of accident responsibility.

Even specialists are susceptible to mind wandering. Aviation is one domain in which mind wandering appears to be pervasive. Casner & Schooler (2013) used ES with professional pilots in a full-motion 747-400 flight simulator certified for airline training and testing. In support of the context regulation hypothesis, pilots were especially likely to report mind wandering when engaging in flight segments that were going smoothly relative to segments in which they were having some difficulty. A follow-up study revealed that when pilots took the role of copilot, mind wandering occurred nearly as twice as often as when they were in the role of the pilot. Moreover, copilots no longer evidenced the capacity to rein in mind wandering when performance was challenged. Together, these findings suggest that even highly trained experts can mind wander in their domain of expertise, and although they may often manage to limit mind wandering to times that are minimally disruptive, they occasionally fail to do this. An important area for future research is to explore the many other domains in which mind wandering may impair performance.

Most of the research on everyday mind wandering focuses on the many situations in which mind wandering has detrimental consequences. Nevertheless, one recent study suggests an important real-world context in which mind wandering may be helpful. S. Gable, E. Hopper, M.D. Mrazek & J.W. Schooler (unpublished manuscript) examined the situations surrounding the generation of creative ideas by professional writers and physicists. Every evening for two weeks, participants responded to a questionnaire that asked them to indicate if they had any creative ideas that day, and if so, to indicate the situation and the estimated quality of the idea. Over 40% of the participants' creative ideas occurred when they were engaged in a non-work-related activity and/or thinking about something unrelated to the topic. Moreover, although creative ideas that occurred during mind wandering were not rated overall as more creative, they were more likely to be characterized as involving an "Aha!" experience and contributing to overcoming an impasse.

These preliminary findings bear out many anecdotal reports that important creative ideas occur during mind wandering.

TECHNIQUES FOR MINIMIZING THE DISRUPTING EFFECTS OF MIND WANDERING

The many situations in which mind wandering can be disruptive naturally raise the question of what strategies can be used to minimize its negative consequences.

Mindfulness Training

Practices that encourage individuals to be mindful of the present are currently the most empirically validated technique for minimizing the disruptive effects of mind wandering. For example, Mrazek et al. (2013a) compared the impact of a two-week mindfulness-training program to an active control (nutrition training). They found that mindfulness training significantly reduced mind wandering on both reading and working memory measures, which partially mediated concomitant improvements on both tasks. Mindfulness programs have reduced mind wandering and enhanced people's performance on several other tasks, including vigilance tasks (Jha et al. 2010). Even a simple 10-minute mindful breathing exercise can reduce absentminded errors on a simple vigilance task (Mrazek et al. 2012b).

Meta-Awareness

Several lines of research are consistent with the hypothesis that regularly "checking in" on the contents of one's mind may help to curtail episodes of mind wandering. Franklin et al. (2014) found that the association between ADHD symptoms and mind-wandering-related disruptions in everyday life was partially mediated by the degree to which individuals routinely noticed their mind wandering. The beneficial effects of mindfulness training noted above may in part stem from the fact that this practice encourages people to routinely take notice of the contents of their thoughts. Although more research is clearly needed, encouraging people to regularly take stock of whether or not they are mind wandering may help to curtail its disruptive effects.

Task Engagement

Unquestionably, participating in activities that encourage engagement in the task is one of the most effective ways to avoid mind wandering. For example, Szpunar et al. (2013b) found that interpolating periodic memory tests into an online lecture material markedly reduced mind wandering, which in turn led to improved retention of the lecture material. Other techniques that have increased individuals' engagement with the material and thereby reduced mind wandering include offering motivational incentives (Antrobus et al. 1966, Mrazek et al. 2012b), increasing the intrinsic interest (Grodsky & Giambra 1990, Unsworth & McMillan 2013), and engaging in elaborative processing (Moss et al. 2013).

CONCLUDING REMARKS

After many years of reticence, scientists are no longer wary of empirically exploring the stream of consciousness. Through the investigation of mind wandering, great progress has been made in charting the meandering between sensory experience and self-generated thoughts uncoupled

from perception. A careful consideration of the evidence discussed in this review, particularly the benefits and costs of mind wandering, raises the question of how to understand the role and functions of mind wandering in our daily lives. Email, smartphones, Facebook, and other vehicles for social networking allow us to interact with individuals who are a great geographical distance from us and illustrate the emphasis that we place on social interactions, even those that do not take place in the here and now. Given that self-generated thoughts are often of a social nature (Mar et al. 2012; Ruby et al. 2013a,b), our species' habit of mind wandering likely illustrates a more basic example of the same phenomenon: Even when deprived of our technology, we are still inclined to escape from the constraints of the moment to consider other times, places, and people.

The frequency with which our minds wander thus illustrates our desire for freedom from immediacy—a general property of cognitive systems that reflects activity that is unrelated to current environmental input (Shadlen & Kiani 2011). Intrinsic processes that are the hallmark of freedom from immediacy are a general property of the brain (Smith et al. 2009) and are considered influential in volitional choice and action (Haggard 2008, Schurger et al. 2012). The costs and benefits that arise from mind wandering can be understood as reflecting the ways in which we balance our desire for freedom from immediacy with the demands of attending to the moment (Smallwood 2013b). Regulating mind wandering to positive nonruminative thoughts may bring happiness, and limiting the time we devote to mentally planning a vacation during lectures or meetings may improve vocational outcomes. Because freedom from immediacy is an adaptive feature of cognition, its association with mind wandering provides an important perspective on how to conceive of the value of the experience. Just as the use of smartphones is valuable to society yet can cause automobile accidents (Nemme & White 2010), the rich imaginative mental life that mind wandering affords is valuable when it is used correctly but counterproductive when it is not.

SUMMARY POINTS

1. A confluence of factors has contributed to a major upsurge in mind wandering research, including increased refinements in its measurement, appreciation of its frequency, and understanding of its neurocognitive underpinnings.
2. The investigation of mind wandering requires overcoming challenges resulting from the lack of direct experimental control, the covert nature of mind wandering, and the reliance on self-report.
3. The content of mind-wandering episodes can vary with respect to temporal focus, affective state, and interest, which in turn can influence the associated functional outcomes of the state (the content regulation hypothesis).
4. Participants often fail to notice that their minds have wandered. Aware versus unaware mind-wandering episodes differ in the situations in which they are most likely to arise as well as in their respective impact on performance and brain activity.
5. During mind wandering, attention is often disengaged from external input, a process known as perceptual decoupling.
6. Emotional, episodic, and executive processes can be involved in the self-generation of mental content during mind wandering.
7. Effective attentional control enhances the ability of individuals to avoid mind wandering at inopportune times (the context regulation hypothesis).

8. The extensive costs of mind wandering include disrupting memory, comprehension, intellectual functioning, and a host of real-world activities.
9. Although its benefits are less extensively studied, mind wandering may have some important functions including contributing to future planning and creativity.
10. There are a number of promising approaches for minimizing the negative effects of mind wandering.

FUTURE ISSUES

Additional work is needed in the following areas:

1. Identifying reliable behavioral and physiological measures that can indicate the onset and offset of mind wandering without having to rely on individuals' self-reports.
2. Determining whether meta-awareness of mind wandering is causally involved in the termination of mind-wandering episodes or is merely a consequence of mind wandering ending for other reasons.
3. Characterizing the environmental conditions and internal concerns that tend to initiate mind wandering.
4. Elucidating the manner in which the contents of mind wandering may mediate its impact on performance.
5. Assessing the functional benefits of mind wandering.
6. Developing techniques for minimizing mind wandering at inopportune times.
7. Understanding individual differences in mind wandering, including its relationship to both negative characteristics (e.g., assorted mental disorders) and positive traits (e.g., creativity).
8. Appraising the impact that mind wandering has in many real-world activities that demand vigilance (e.g., medicine, transportation, security).
9. Examining the similarities and differences between self-generated thoughts that occur when individuals are simultaneously engaged in another task (i.e., mind wandering) or not otherwise occupied (i.e., resting state).
10. Delineating the situations in which mind wandering compromises well-being versus those in which it is affectively neutral or even uplifting.

DISCLOSURE STATEMENT

The authors are not aware of any affiliations, memberships, funding, or financial holdings that might be perceived as affecting the objectivity of this review.

ACKNOWLEDGMENTS

Thanks to Masaki Hagino for providing the artwork; to Florence Ruby, Mahiko Konishi, and Helga Smallwood for their help in the preparation of this manuscript; and to Micah Allen, Jessica

Andrews-Hanna, Arnaud D'Argembeau, and David Stawarczyk for providing their data. The writing of this review was supported by grant R305A110277 from the US Office of Education to both authors and grant 24329 from the John Templeton Foundation to the second author.

LITERATURE CITED

Addis DR, Knapp K, Roberts RP, Schacter DL. 2012. Routes to the past: neural substrates of direct and generative autobiographical memory retrieval. *NeuroImage* 59:2908–22

Allen M, Smallwood J, Christensen J, Gramm D, Rasmussen B, et al. 2013. The balanced mind: the variability of task-unrelated thoughts predicts error monitoring. *Front. Hum. Neurosci.* 7:743

Andrews-Hanna JR, Kaiser RH, Turner AE, Reineberg AE, Godinez D, et al. 2013. A penny for your thoughts: dimensions of self-generated thought content and relationships with individual differences in emotional wellbeing. *Front. Psychol.* 4:900

Andrews-Hanna JR, Smallwood J, Spreng RN. 2014. The default network and self-generated thought: component processes, dynamic control, and clinical relevance. *Ann. N. Y. Acad. Sci.* 1316:29–52

Antrobus JS, Singer JL, Greenberg S. 1966. Studies in the stream of consciousness: experimental enhancement and suppression of spontaneous cognitive processes. *Percept. Motor Skills* 23:399–417

Armitage R, Rochlen A, Fitch T, Trivedi M, Rush AJ. 1995. Dream recall and major depression: a preliminary report. *Dreaming* 5:189–98

Baird B, Smallwood J, Fishman DJ, Mrazek MD, Schooler JW. 2013a. Unnoticed intrusions: dissociations of meta-consciousness in thought suppression. *Conscious. Cogn.* 22:1003–12

Baird B, Smallwood J, Gorgolewski K, Margulies DS. 2013b. Medial and lateral networks in anterior prefrontal cortex support meta cognitive ability for memory and perception. *J. Neurosci.* 33:16657–65

Baird B, Smallwood J, Lutz A, Schooler JW. 2014. The decoupled mind: Mind-wandering disrupts cortical phase-locking to perceptual events. *J. Cogn. Neurosci.* 26:2596–607

Baird B, Smallwood J, Mrazek MD, Kam JW, Franklin MS, Schooler JW. 2012. Inspired by distraction: Mind wandering facilitates creative incubation. *Psychol. Sci.* 23:1117–22

Baird B, Smallwood J, Schooler JW. 2010. *I can shake that feeling: Positive mind-wandering prevents the deterioration of mood.* Poster presented at Toward a Science of Consciousness conf., Tucson, AZ

Baird B, Smallwood J, Schooler JW. 2011. Back to the future: autobiographical planning and the functionality of mind-wandering. *Conscious. Cogn.* 20:1604–11

Barron E, Riby LM, Greer J, Smallwood J. 2011. Absorbed in thought: the effect of mind wandering on the processing of relevant and irrelevant events. *Psychol. Sci.* 22:596–601

Baumeister RF, Masicampo EJ. 2010. Conscious thought is for facilitating social and cultural interactions: how mental simulations serve the animal-culture interface. *Psychol. Rev.* 117:945–71

Baumeister RF, Masicampo EJ, Vohs KD. 2011. Do conscious thoughts cause behavior? *Annu. Rev. Psychol.* 62:331–61

Bernhardt BC, Smallwood J, Tusche A, Ruby FJ, Engen HG, et al. 2014. Medial prefrontal and anterior cingulate cortical thickness predicts shared individual differences in self-generated thought and temporal discounting. *NeuroImage* 90:290–97

Buckner RL, Vincent JL. 2007. Unrest at rest: default activity and spontaneous network correlations. *NeuroImage* 37:1091–96

Cai DJ, Mednick SA, Harrison EM, Kanady JC, Mednick SC. 2009. REM, not incubation, improves creativity by priming associative networks. *Proc. Natl. Acad. Sci. USA* 106:10130–34

Callard F, Smallwood J, Golchert J, Margulies DS. 2013. The era of the wandering mind? Twenty-first century research on self-generated mental activity. *Front. Psychol.* 4:891

Callard F, Smallwood J, Margulies DS. 2012. Default positions: how neuroscience's historical legacy has hampered investigation of the resting mind. *Front. Psychol.* 3:321

Carriere JS, Cheyne JA, Smilek D. 2008. Everyday attention lapses and memory failures: the affective consequences of mindlessness. *Conscious. Cogn.* 17:835–47

Carriere JS, Seli P, Smilek D. 2013. Wandering in both mind and body: individual differences in mind wandering and inattention predict fidgeting. *Can. J. Exp. Psychol.* 67:19–31

Provided evidence that mind wandering enhances the creative benefits of an incubation interval.

Demonstrated that the capacity to regulate the occurrence of mind wandering to a nondemanding task depends on the cortical gray matter in a region of the anterior cingulate, providing the first evidence of a biological substrate accounting for an individual's capacity to control experience.

Casner SM, Schooler JW. 2013. Thoughts in flight automation use and pilots' task-related and task-unrelated thought. *Hum. Factors* 56:433–42

Cheyne JA, Carriere JS, Smilek D. 2006. Absent-mindedness: lapses of conscious awareness and everyday cognitive failures. *Conscious. Cogn.* 15:578–92

Cheyne JA, Carriere JS, Solman GJ, Smilek D. 2011. Challenge and error: critical events and attention-related errors. *Cognition* 121:437–46

Christoff K, Gordon AM, Smallwood J, Smith R, Schooler JW. 2009. Experience sampling during fMRI reveals default network and executive system contributions to mind wandering. *Proc. Natl. Acad. Sci. USA* 106:8719–24

Provided direct evidence that both the default mode network and the executive system are engaged during periods of mind wandering.

Cohen JD, Schooler JW. 1997. *Scientific Approaches to Consciousness*. New York: Psychol. Press

Cowley JA. 2013. Types of off-task thinking and performance decrements during simulated automobile driving. *Proc. Hum. Factors Ergon. Soc. Annu. Meet.*, 57:1214–18. Thousand Oaks, CA: Sage

Delamillieure P, Doucet G, Mazoyer B, Turbelin MR, Delcroix N, et al. 2010. The resting state questionnaire: an introspective questionnaire for evaluation of inner experience during the conscious resting state. *Brain Res. Bull.* 81:565–73

Deng Y-Q, Li S, Tang Y-Y. 2012. The relationship between wandering mind, depression and mindfulness. *Mindfulness* 5:124–28

Desimone R, Duncan J. 1995. Neural mechanisms of selective visual attention. *Annu. Rev. Neurosci.* 18:193–222

Dixon P, Bortolussi M. 2013. Construction, integration, and mind wandering in reading. *Can. J. Exp. Psychol.* 67:1–10

Donders FC. 1969. On the speed of mental processes. *Acta Psychol.* (*Amst.*) 30:412–31

Epel ES, Puterman E, Lin J, Blackburn E, Lazaro A, Mendes WB. 2013. Wandering minds and aging cells. *Clin. Psychol. Sci.* 1:75–83

Esterman M, Rosenberg MD, Noonan SK. 2014. Intrinsic fluctuations in sustained attention and distractor processing. *J. Neurosci.* 34:1724–30

Farley J, Risko EF, Kingstone A. 2013. Everyday attention and lecture retention: the effects of time, fidgeting, and mind wandering. *Front. Psychol.* 4:619

Feng S, D'Mello S, Graesser AC. 2013. Mind wandering while reading easy and difficult texts. *Psychon. Bull. Rev.* 20:586–92

Forster S. 2013. Distraction and mind-wandering under load. *Front. Psychol.* 4:283

Forster S, Lavie N. 2009. Harnessing the wandering mind: the role of perceptual load. *Cognition* 111:345–55

Forster S, Lavie N. 2014. Distracted by your mind? Individual differences in distractibility predict mind wandering. *J. Exp. Psychol.: Learn. Mem. Cogn.* 40:251–60

Foulsham T, Farley J, Kingstone A. 2013. Mind wandering in sentence reading: decoupling the link between mind and eye. *Can. J. Exp. Psychol.* 67:51–59

Fox KCR, Christoff K. 2014. Metacognitive facilitation of spontaneous thought processes: when metacognition helps the wandering mind find its way. In *The Cognitive Neuroscience of Metacognition*, ed. SM Fleming, CD Frith, pp. 293–319. Berlin: Springer-Verlag

Fox KCR, Nijeboer S, Solomonova E, Domhoff GW, Christoff K. 2013. Dreaming as mind wandering: evidence from functional neuroimaging and first-person content reports. *Front. Hum. Neurosci.* 7:412

Franklin MS, Broadway JM, Mrazek MD, Smallwood J, Schooler JW. 2013a. Window to the wandering mind: pupillometry of spontaneous thought while reading. *Q. J. Exp. Psychol.* (*Hove*) 66:2289–94

Franklin MS, Mrazek MD, Anderson CL, Smallwood J, Kingstone A, Schooler JW. 2013b. The silver lining of a mind in the clouds: interesting musings are associated with positive mood while mind-wandering. *Front. Psychol.* 4:583

Franklin MS, Mrazek MD, Broadway JM, Schooler JW. 2013c. Disentangling decoupling: comment on Smallwood 2013. *Psychol. Bull.* 139:536–41

Franklin MS, Mrazek MD, Anderson CL, Smallwood J, Kingstone A, Schooler JW. 2014. Tracking distraction: the relationship between mind-wandering, meta-awareness, and ADHD symptomatology. *J. Atten. Disord.* In press

Franklin MS, Smallwood J, Schooler JW. 2011. Catching the mind in flight: using behavioral indices to detect mindless reading in real time. *Psychon. Bull. Rev.* 18:992–97

Galera C, Orriols L, M'Bailara K, Laborey M, Contrand B, et al. 2012. Mind wandering and driving: responsibility case-control study. *BMJ* 345:e8105

Giambra LM. 1989. Task-unrelated-thought frequency as a function of age: a laboratory study. *Psychol. Aging* 4:136–43

Gilbert SJ, Dumontheil I, Simons JS, Frith CD, Burgess PW. 2007. Comment on "Wandering minds: the default network and stimulus-independent thought." *Science* 317:43

Gorgolewski KJ, Lurie D, Urchs S, Kipping JA, Craddock RC, et al. 2014. A correspondence between individual differences in the brain's intrinsic functional architecture and the content and form of self-generated thoughts. *PLOS ONE* 9:e97176

Greicius MD, Krasnow B, Reiss AL, Menon V. 2003. Functional connectivity in the resting brain: a network analysis of the default mode hypothesis. *Proc. Natl. Acad. Sci. USA* 100:253–58

Grodsky A, Giambra LM. 1990. The consistency across vigilance and reading tasks of individual differences in the occurrence of task-unrelated and task-related images and thoughts. *Imagination Cogn. Personal.* 10:39–52

Gruberger M, Ben-Simon E, Levkovitz Y, Zangen A, Hendler T. 2011. Towards a neuroscience of mind-wandering. *Front. Hum. Neurosci.* 5:56

Guilford JP, Fruchter B, Kelley HP. 1959. Development and applications of tests of intellectual and special aptitudes. *Rev. Educ. Res.* 29:26–41

Haggard P. 2008. Human volition: towards a neuroscience of will. *Nat. Rev. Neurosci.* 9:934–46

He Q, Xue G, Chen C, Lu ZL, Dong Q. 2013. Decoding the neuroanatomical basis of reading ability: a multivoxel morphometric study. *J. Neurosci.* 33:12835–43

Hu NT, He S, Xu BH. 2012. Different efficiencies of attentional orienting in different wandering minds. *Conscious. Cogn.* 21:139–48

Iijima Y, Tanno Y. 2012. [The effect of cognitive load on the temporal focus of mind wandering.] *Shinrigaku Kenkyu* 83:232–36

Jackson JD, Balota DA. 2012. Mind-wandering in younger and older adults: converging evidence from the sustained attention to response task and reading for comprehension. *Psychol. Aging* 27:106–19

Janoff-Bulman R. 1992. *Shattered Assumptions: Towards a New Psychology of Trauma*. New York: Free Press

Jha AP, Stanley EA, Kiyonaga A, Wong L, Gelfand L. 2010. Examining the protective effects of mindfulness training on working memory capacity and affective experience. *Emotion* 10:54–64

Kahneman D, Krueger AB, Schkade DA, Schwarz N, Stone AA. 2004. A survey method for characterizing daily life experience: the day reconstruction method. *Science* 306:1776–80

Kam JW, Dao E, Farley J, Fitzpatrick K, Smallwood J, et al. 2011. Slow fluctuations in attentional control of sensory cortex. *J. Cogn. Neurosci.* 23:460–70

Kam JW, Handy TC. 2013. The neurocognitive consequences of the wandering mind: a mechanistic account of sensory-motor decoupling. *Front. Psychol.* 4:725

Kam JW, Xu J, Handy TC. 2014. I don't feel your pain (as much): the desensitizing effect of mind wandering on the perception of others' discomfort. *Cogn. Affect. Behav. Neurosci.* 14:286–96

Kane MJ, Brown LH, McVay JC, Silvia PJ, Myin-Germeys I, Kwapil TR. 2007. For whom the mind wanders, and when: an experience-sampling study of working memory and executive control in daily life. *Psychol. Sci.* 18:614–21

Kane MJ, McVay JC. 2012. What mind wandering reveals about executive-control abilities and failures. *Curr. Dir. Psychol. Sci.* 21:348–54

Kelley WM, Macrae CN, Wyland CL, Caglar S, Inati S, Heatherton TF. 2002. Finding the self? An event-related fMRI study. *J. Cogn. Neurosci.* 14:785–94

Killeen PR. 2013. Absent without leave; a neuroenergetic theory of mind wandering. *Front. Psychol.* 4:373

Killingsworth MA, Gilbert DT. 2010. A wandering mind is an unhappy mind. *Science* 330:932

Klinger E. 1966. Fantasy need achievement as a motivational construct. *Psychol. Bull.* 66:291–308

Klinger E. 1967. Modeling effects on achievement imagery. *J. Personal. Soc. Psychol.* 7:49–62

Klinger E. 1973. Models, context, and achievement fantasy: parametric studies and theoretical propositions. *J. Personal. Assess.* 37:25–47

Klinger E. 1984. A consciousness-sampling analysis of test anxiety and performance. *J. Personal. Soc. Psychol.* 47:1376–90

A large experience sampling study indicating the ubiquitous nature of mind wandering in daily life and its implications for unhappiness.

Klinger E. 2013. Goal commitments and the content of thoughts and dreams: basic principles. *Front. Psychol.* 4:415

Kvavilashvili L, Mandler G. 2004. Out of one's mind: a study of involuntary semantic memories. *Cogn. Psychol.* 48:47–94

Levinson DB, Smallwood J, Davidson RJ. 2012. The persistence of thought: evidence for a role of working memory in the maintenance of task-unrelated thinking. *Psychol. Sci.* 23:375–80

Macdonald JS, Mathan S, Yeung N. 2011. Trial-by-trial variations in subjective attentional state are reflected in ongoing prestimulus EEG alpha oscillations. *Front. Psychol.* 2:82

Macrae CN, Moran JM, Heatherton TF, Banfield JF, Kelley WM. 2004. Medial prefrontal activity predicts memory for self. *Cereb. Cortex* 14:647–54

Mar RA, Mason MF, Litvack A. 2012. How daydreaming relates to life satisfaction, loneliness, and social support: the importance of gender and daydream content. *Conscious. Cogn.* 21:401–7

Marchetti I, Koster EH, Sonuga-Barke EJ, De Raedt R. 2012. The default mode network and recurrent depression: a neurobiological model of cognitive risk factors. *Neuropsychol. Rev.* 22:229–51

Mason MF, Norton MI, Van Horn JD, Wegner DM, Grafton ST, Macrae CN. 2007. Wandering minds: the default network and stimulus-independent thought. *Science* 315:393–95

McKiernan KA, D'Angelo BR, Kaufman JN, Binder JR. 2006. Interrupting the "stream of consciousness": an fMRI investigation. *NeuroImage* 29:1185–91

McKiernan KA, Kaufman JN, Kucera-Thompson J, Binder JR. 2003. A parametric manipulation of factors affecting task-induced deactivation in functional neuroimaging. *J. Cogn. Neurosci.* 15:394–408

McVay JC, Kane MJ. 2009. Conducting the train of thought: working memory capacity, goal neglect, and mind wandering in an executive-control task. *J. Exp. Psychol.: Learn. Mem. Cogn.* 35:196–204

McVay JC, Kane MJ. 2010. Does mind wandering reflect executive function or executive failure? Comment on Smallwood and Schooler 2006 and Watkins 2008. *Psychol. Bull.* 136:188–97; discussion 198–207

McVay JC, Kane MJ. 2011. Why does working memory capacity predict variation in reading comprehension? On the influence of mind wandering and executive attention. *J. Exp. Psychol.: Gen.* 141:302–20

McVay JC, Kane MJ, Kwapil TR. 2009. Tracking the train of thought from the laboratory into everyday life: an experience-sampling study of mind wandering across controlled and ecological contexts. *Psychon. Bull. Rev.* 16:857–63

Mischel W, Gilligan C. 1964. Delay of gratification, motivation for the prohibited gratification, and responses to temptation. *J. Abnorm. Psychol.* 69:411–17

Mitchell JP, Macrae CN, Banaji MR. 2006. Dissociable medial prefrontal contributions to judgments of similar and dissimilar others. *Neuron* 50:655–63

Mooneyham BW, Schooler JW. 2013. The costs and benefits of mind-wandering: a review. *Can. J. Exp. Psychol.* 67:11–18

Morrison AB, Goolsarran M, Rogers SL, Jha AP. 2013. Taming a wandering attention: short-form mindfulness training in student cohorts. *Front. Hum. Neurosci.* 7:897

Moss J, Schunn CD, Schneider W, McNamara DS. 2013. The nature of mind wandering during reading varies with the cognitive control demands of the reading strategy. *Brain Res.* 1539:48–60

Mrazek MD, Chin JM, Schmader T, Hartson KA, Smallwood J, Schooler JW. 2011. Threatened to distraction: mind-wandering as a consequence of stereotype threat. *J. Exp. Soc. Psychol.* 47:1243–48

Mrazek MD, Franklin MS, Phillips DT, Baird B, Schooler JW. 2013a. Mindfulness training improves working memory capacity and GRE performance while reducing mind wandering. *Psychol. Sci.* 24:776–81

Mrazek MD, Phillips DT, Franklin MS, Broadway JM, Schooler JW. 2013b. Young and restless: validation of the Mind-Wandering Questionnaire (MWQ) reveals disruptive impact of mind-wandering for youth. *Front. Psychol.* 4:560

Mrazek MD, Smallwood J, Franklin MS, Chin JM, Baird B, Schooler JW. 2012a. The role of mind-wandering in measurements of general aptitude. *J. Exp. Psychol.: Gen.* 141:788–98

Mrazek MD, Smallwood J, Schooler JW. 2012b. Mindfulness and mind-wandering: finding convergence through opposing constructs. *Emotion* 12:442–48

Nemme HE, White KM. 2010. Texting while driving: psychosocial influences on young people's texting intentions and behaviour. *Accid. Anal. Prev.* 42:1257–65

Introduced the idea that the default mode network supports the thoughts that occur during mind wandering.

Provided evidence that working memory can reduce the occurrence of mind wandering in a demanding task.

Demonstrated that the association between mind wandering and task performance generalizes across measures of intellectual functioning.

Oettingen G, Schwörer B. 2013. Mind wandering via mental contrasting as a tool for behavior change. *Front. Psychol.* 4:562

Ogawa S, Lee T, Kay A, Tank D. 1990. Brain magnetic resonance imaging with contrast dependent on blood oxygenation. *Proc. Natl. Acad. Sci. USA* 87:9868–72

Ottaviani C, Couyoumdjian A. 2013. Pros and cons of a wandering mind: a prospective study. *Front. Psychol.* 4:524

Ottaviani C, Shapiro D, Couyoumdjian A. 2013. Flexibility as the key for somatic health: from mind wandering to perseverative cognition. *Biol. Psychol.* 94:38–43

Poerio GL, Totterdell P, Miles E. 2013. Mind-wandering and negative mood: Does one thing really lead to another? *Conscious. Cogn.* 22:1412–21

Polich J. 1986. Attention, probability, and task demands as determinants of P300 latency from auditory stimuli. *Electroencephalogr. Clin. Neurophysiol.* 63:251–59

Posner MI, Petersen SE. 1990. The attention system of the human brain. *Annu. Rev. Neurosci.* 13:25–42

Raichle ME, MacLeod AM, Snyder AZ, Powers WJ, Gusnard DA, Shulman GL. 2001. A default mode of brain function. *Proc. Natl. Acad. Sci. USA* 98:676–82

Reichle ED, Reineberg AE, Schooler JW. 2010. Eye movements during mindless reading. *Psychol. Sci.* 21:1300–10

Revonsuo A. 2000. The reinterpretation of dreams: an evolutionary hypothesis of the function of dreaming. *Behav. Brain Sci.* 23:877–901

Ruby FJM, Smallwood J, Engen H, Singer T. 2013a. How self-generated thought shapes mood. *PLOS ONE* 8:e77554

Ruby FJM, Smallwood J, Sackur J, Singer T. 2013b. Is self-generated thought a means of social problem solving? *Front. Psychol.* 4:962

Rummel J, Boywitt CD. 2014. Controlling the stream of thought: Working memory capacity predicts adjustment of mind-wandering to situational demands. *Psychon. Bull. Rev.* 21:1309–15

Sayette MA, Dimoff JD, Levine JM, Moreland RL, Votruba-Drzal E. 2012. The effects of alcohol and dosage-set on risk-seeking behavior in groups and individuals. *Psychol. Addict. Behav.* 26:194–200

Sayette MA, Reichle ED, Schooler JW. 2009. Lost in the sauce: the effects of alcohol on mind-wandering. *Psychol. Sci.* 20:747–52

Sayette MA, Schooler JW, Reichle ED. 2010. Out for a smoke: the impact of cigarette craving on zoning out during reading. *Psychol. Sci.* 21:26–30

Schooler JW. 2002a. Re-representing consciousness: dissociations between experience and meta-consciousness. *Trends Cogn. Sci.* 6:339–44

Schooler JW. 2002b. Verbalization produces a transfer inappropriate processing shift. *Appl. Cogn. Psychol.* 16:989–97

Schooler JW, Mrazek MD, Franklin MS, Baird B, Mooneyham BW, et al. 2014. The middle way: finding the balance between mindfulness and mind-wandering. In *The Psychology of Learning and Motivation*, Vol. 60, ed. BH Ross, pp. 1–33. Burlington, MA: Academic

Schooler JW, Reichle ED, Halpern DV. 2004. Zoning out while reading: evidence for dissociations between experience and metaconsciousness. In *Thinking and Seeing: Visual Metacognition in Adults and Children*, ed. DT Levin, pp. 203–26. Cambridge, MA: MIT Press

Schooler JW, Schreiber CA. 2004. Experience, meta-consciousness, and the paradox of introspection. *J. Conscious. Stud.* 11:17–39

Schooler JW, Smallwood J, Christoff K, Handy TC, Reichle ED, Sayette MA. 2011. Meta-awareness, perceptual decoupling and the wandering mind. *Trends Cogn. Sci.* 15:319–26

Schurger A, Sitt JD, Dehaene S. 2012. An accumulator model for spontaneous neural activity prior to self-initiated movement. *Proc. Natl. Acad. Sci. USA* 109:E2904–13

Seli P, Carriere JS, Thomson DR, Cheyne JA, Martens KA, Smilek D. 2014. Restless mind, restless body. *J. Exp. Psychol.: Learn. Mem. Cogn.* 40:660–68

Seli P, Carriere JS, Levene M, Smilek D. 2013. How few and far between? Examining the effects of probe rate on self-reported mind wandering. *Front. Psychol.* 4:430

Shadlen MN, Kiani R. 2011. Consciousness as a decision to engage. In *Characterizing Consciousness: From Cognition to the Clinic?*, ed. S Dehaene, Y Christen, pp. 27–46. Berlin: Springer-Verlag

Demonstrated that different forms of mind wandering have different implications for mood, illustrating how the content of mind wandering influences its functional outcomes.

Demonstrated that alcohol simultaneously increases mind wandering while reducing individuals' meta-awareness of it.

Shamosh NA, Gray JR. 2008. Delay discounting and intelligence: a meta-analysis. *Intelligence* 36:289–305
Smallwood J. 2010. Why the global availability of mind wandering necessitates resource competition: reply to McVay and Kane 2010. *Psychol. Bull.* 136:202–7
Smallwood J. 2013a. Distinguishing how from why the mind wanders: a process-occurrence framework for self generated thought. *Psychol. Bull.* 139:519–35
Smallwood J. 2013b. Searching for the elements of thought: reply to Franklin, Mrazek, Broadway, and Schooler 2013. *Psychol. Bull.* 139:542–47
Smallwood J, Andrews-Hanna J. 2013. Not all minds that wander are lost: the importance of a balanced perspective on the mind-wandering state. *Front. Psychol.* 4:441
Smallwood J, Beach E, Schooler JW, Handy TC. 2008a. Going AWOL in the brain: Mind wandering reduces cortical analysis of external events. *J. Cogn. Neurosci.* 20:458–69
Smallwood J, Brown KS, Baird B, Mrazek MD, Franklin MS, Schooler JW. 2012. Insulation for daydreams: a role for tonic norepinephrine in the facilitation of internally guided thought. *PLOS ONE* 7:e33706
Smallwood J, Brown K, Baird B, Schooler JW. 2011a. Cooperation between the default mode network and the frontal-parietal network in the production of an internal train of thought. *Brain Res.* 1428:60–70
Smallwood J, Brown KS, Tipper C, Giesbrecht B, Franklin MS, et al. 2011b. Pupillometric evidence for the decoupling of attention from perceptual input during offline thought. *PLOS ONE* 6:e18298
Smallwood J, Davies JB, Heim D, Finnigan F, Sudberry M, et al. 2004. Subjective experience and the attentional lapse: task engagement and disengagement during sustained attention. *Conscious. Cogn.* 13:657–90
Smallwood J, Fitzgerald A, Miles LK, Phillips LH. 2009a. Shifting moods, wandering minds: Negative moods lead the mind to wander. *Emotion* 9:271–76
Smallwood J, Gorgolewski KJ, Golchert J, Ruby FJ, Engen H, et al. 2013a. The default modes of reading: modulation of posterior cingulate and medial prefrontal cortex connectivity associated with comprehension and task focus while reading. *Front. Hum. Neurosci.* 7:734
Smallwood J, McSpadden M, Luus B, Schooler J. 2008b. Segmenting the stream of consciousness: the psychological correlates of temporal structures in the time series data of a continuous performance task. *Brain Cogn.* 66:50–6
Smallwood J, McSpadden M, Schooler JW. 2007a. The lights are on but no one's home: meta-awareness and the decoupling of attention when the mind wanders. *Psychon. Bull. Rev.* 14:527–33
Smallwood J, McSpadden M, Schooler JW. 2008c. When attention matters: the curious incident of the wandering mind. *Mem. Cogn.* 36:1144–50
Smallwood J, Nind L, O'Connor RC. 2009b. When is your head at? An exploration of the factors associated with the temporal focus of the wandering mind. *Conscious. Cogn.* 18:118–25
Smallwood J, O'Connor RC. 2011. Imprisoned by the past: Unhappy moods lead to a retrospective bias to mind wandering. *Cogn. Emot.* 25:481–90
Smallwood J, O'Connor RC, Heim D. 2005. Rumination, dysphoria, and subjective experience. *Imagination Cogn. Personal.* 24:355–67
Smallwood J, O'Connor RC, Sudbery MV, Obonsawin M. 2007b. Mind-wandering and dysphoria. *Cogn. Emot.* 21:816–42
Smallwood J, Obonsawin M, Reid H. 2002. The effects of block duration and task demands on the experience of task unrelated thought. *Imagination Cogn. Personal.* 22:13–31
Smallwood J, Ruby FJ, Singer T. 2013b. Letting go of the present: Mind-wandering is associated with reduced delay discounting. *Conscious. Cogn.* 22:1–7
Smallwood J, Schooler JW. 2006. The restless mind. *Psychol. Bull.* 132:946–58
Smilek D, Carriere JS, Cheyne JA. 2010. Out of mind, out of sight eye blinking as indicator and embodiment of mind wandering. *Psychol. Sci.* 21:786–89
Smith SM, Fox PT, Miller KL, Glahn DC, Fox PM, et al. 2009. Correspondence of the brain's functional architecture during activation and rest. *Proc. Natl. Acad. Sci. USA* 106:13040–45
Song X, Wang X. 2012. Mind wandering in Chinese daily lives—an experience sampling study. *PLOS ONE* 7:e44423
Stawarczyk D, Majerus S, Catale C, D'Argembeau A. 2014. Relationships between mind-wandering and attentional control abilities in young adults and adolescents. *Acta Psychol. (Amst.)* 148:25–36

Provided early support for the decoupling hypothesis by demonstrating that during periods of self-generated thought the cortical response to external events was attenuated.

Provides a review of mind wandering that helped bring the topic into the spotlight of mainstream science.

Stawarczyk D, Majerus S, D'Argembeau A. 2013. Concern-induced negative affect is associated with the occurrence and content of mind-wandering. *Conscious. Cogn.* 22:442–48

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 Psychol.* (*Amst.*) 136:370–81

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* 6:e16997

Szpunar KK, Khan NY, Schacter DL. 2013a. Interpolated memory tests reduce mind wandering and improve learning of online lectures. *Proc. Natl. Acad. Sci. USA* 110:6313–17

Szpunar KK, Moulton ST, Schacter DL. 2013b. Mind wandering and education: from the classroom to online learning. *Front. Psychol.* 4:495

Taylor SE, Kemeny ME, Reed GM, Bower JE, Gruenewald TL. 2000. Psychological resources, positive illusions, and health. *Am. Psychol.* 55:99–109

Teasdale JD, Dritschel BH, Taylor MJ, Proctor L, Lloyd CA, et al. 1995. Stimulus-independent thought depends on central executive resources. *Mem. Cogn.* 23:551–59

Treisman AM, Gelade G. 1980. A feature-integration theory of attention. *Cogn. Psychol.* 12:97–136

Tulving E. 2002. Episodic memory: from mind to brain. *Annu. Rev. Psychol.* 53:1–25

Tusche A, Smallwood J, Bernhardt BC, Singer T. 2014. Classifying the wandering mind: revealing the affective content of thoughts during task-free rest periods. *NeuroImage* 97:107–16

Unsworth N, McMillan BD. 2013. Mind wandering and reading comprehension: examining the roles of working memory capacity, interest, motivation, and topic experience. *J. Exp. Psychol.: Learn. Mem. Cogn.* 39:832–42

Unsworth N, McMillan BD. 2014. Similarities and differences between mind-wandering and external distraction: a latent variable analysis of lapses of attention and their relation to cognitive abilities. *Acta Psychol.* (*Amst.*) 150:14–25

Varela F, Thompson E. 2003. Neural synchrony and the unity of mind: a neurophenomenological perspective. In *The Unity of Consciousness: Binding, Integration, and Dissociation*, ed. A Cleeremans, pp. 266–87. New York: Oxford Univ. Press

Vincent JL, Snyder AZ, Fox MD, Shannon BJ, Andrews JR, et al. 2006. Coherent spontaneous activity identifies a hippocampal-parietal memory network. *J. Neurophysiol.* 96:3517–31

Vinski MT, Watter S. 2013. Being a grump only makes things worse: a transactional account of acute stress on mind wandering. *Front. Psychol.* 4:730

Yanko MR, Spalek TM. 2013. Driving with the wandering mind: the effect that mind-wandering has on driving performance. *Hum. Factors* 56:260–69

Yarkoni T, Poldrack RA, Nichols TE, Van Essen DC, Wager TD. 2011. Large-scale automated synthesis of human functional neuroimaging data. *Nat. Methods* 8:665–70

Annual Review of Psychology

Volume 66, 2015

Contents

Indexes

Errata

An online log of corrections to *Annual Review of Psychology* articles may be found at http://www.annualreviews.org/errata/psych