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IN PRESS AT TRENDS IN COGNITIVE SCIENCES

Mind-wandering as a natural kind: A family-resemblances view

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Trends Box

- Recent research on mind-wandering has indicated that this experience is a complex phenomenon varying on numerous dimensions, which suggests that mind-wandering is best considered as a multidimensional construct held together by patterns of overlapping and non-overlapping features.

- To date, however, researchers have tended to treat mind-wandering as a unitary construct (e.g., encompassing only task-unrelated thought).

- We argue that this practice leads to a lack of appreciation of the specificity of particular findings and that it artificially constrains conceptual and theoretical understanding of the phenomenon.

- We therefore propose that researchers adopt a family-resemblances approach to mind-wandering, which involves treating mind-wandering as a heterogeneous construct, and clearly measuring/describing the specific aspects of the variety of mind-wandering under investigation.

Abstract

As empirical research on mind-wandering accelerates, we draw attention to an emerging trend in how mind-wandering is conceptualized. Previously articulated definitions of mind-wandering differ from each other in important ways, yet they also maintain overlapping characteristics. This conceptual structure suggests that mind-wandering is best considered from a family-resemblances perspective, which entails treating it as a graded, heterogeneous construct and clearly measuring and describing the specific aspect(s) of mind-wandering that researchers are investigating. We believe that adopting this family-resemblances approach will increase conceptual and methodological connections among related phenomena in the mind-wandering family and encourage a more nuanced and precise understanding of the many varieties of mind-wandering.

Keywords: mind-wandering; family resemblances; definition; heterogeneous; varieties

"Mind-wandering" encompasses a broad range of phenomena

Introspection indicates that our conscious experiences are not always tied to ongoing events or to tasks we are performing. Scientific investigation of this phenomenon, commonly referred to as "mind-wandering," has recently accelerated. Laboratory and daily-life studies of mind-wandering amply demonstrate the prevalence and importance of this aspect of human experience. Estimates suggest that we spend upwards of half our waking lives engaged in mind-wandering [1]. Moreover, this ubiquitous experience predicts a range of important functions and outcomes. On the one hand, mind-wandering has been associated with such beneficial processes as goal-directed thinking [2], planning [3], and creativity [4]. On the other hand, it correlates with such costly outcomes as attenuated processing of the environment [5, 6], driving accidents [7], disruptions to learning [8-10], affective dysfunction [11], and impaired performance in daily life [12]. A broader theme that has also emerged is that "mind-wandering" encompasses a range of experiences that vary in terms of content, intentionality, task-relatedness, and relationship to external stimuli (among other things). This heterogeneity suggests that, like other natural constructs (e.g., mindfulness [13], intelligence [14], creativity [15]), mind-wandering might be best considered from a **family-resemblances perspective** – that is, as a heterogeneous, fuzzy-boundaried construct that coheres amid patterns of overlapping and non-overlapping features.

In this article, we will first examine prominent definitions of mind-wandering, considering the benefits of viewing them as complementary—and necessarily incomplete—rather than competing. We will then outline a family-resemblances framework for mind-wandering research and consider its utility. Finally, we will explain how adopting this framework will facilitate development of more nuanced scientific accounts of mind-wandering and we provide empirical strategies for achieving this goal.

Different Definitions of Mind-Wandering Are Best Viewed as Complementary, Not Competing

To date, the most common definitions of mind-wandering include task-unrelated thought (TUT), unintentional thought, stimulus-independent thought (SIT), stimulus-independent and task-unrelated thought (SITUT), and meandering, unguided thought. Although investigations of these varieties of mind-wandering have been fruitful, challenges arise from such conceptual heterogeneity: Researchers have treated these perspectives on mind-wandering as theoretical competitors. Indeed, some published definitions of mind-wandering are exclusive of others (e.g., mind-wandering must reflect task-unrelated thought and not task-free thought [16] or mind-wandering must reflect unguided, and not guided, thoughts, even if such thoughts are unrelated to one's ongoing task [17]). Because each of these varieties of mind-wandering captures features shared by some, but not all, experiences that emerge when the mind wanders, we suggest that these different definitions complement, rather than compete with, one another. We ultimately argue that the field cannot viably assume a single definition of mind-wandering based on a circumscribed set of necessary and sufficient features.

Task-Unrelated Thought

TUT refers to thoughts that are unrelated to one's ongoing task [16]. The TUT definition of mind-wandering helpfully allows researchers to identify contexts requiring people to attend to certain tasks, as well as the consequences of attention failures. Moreover, studies examining TUT mimic the daily-life activities in which people engage, which helps researchers understand mind-wandering's contribution to everyday pursuits [e.g., 12, 18]. A disadvantage of defining mind-wandering exclusively as TUT, however, is that it discounts many experiences that most people recognize as mind-wandering. Introspectively, we know that our minds do not stop

wandering when we sit idly (e.g., while riding a bus). And, empirically, mind-wandering is frequently studied in contexts lacking any focal task to perform; indeed, much of our knowledge about the neural correlates of mind-wandering comes from resting-state studies that simply require participants to lie in a magnetic-resonance-imaging scanner [e.g., 19]. Thus, both intuition and scientific research demonstrate TUT's insufficiency as an exclusive definition of mind-wandering.

Unintentional Thought

Another common definition of mind-wandering is thought that occurs without intention [e.g., 16, 20, 21]. However, this excludes situations in which people sit dreamily, purposely allowing their thoughts to drift, or cases in which people deliberately neglect a task, or seek mental escape from unpleasant situations, in the service of entertaining TUT. Not only have researchers considered such scenarios to reflect mind-wandering [e.g., 22], but the assumption that participants' reports of "mind-wandering" uniformly lack intention has been questioned by daily-life findings that people often report engaging in "intentional mind-wandering" [e.g., 23, 24]. In the laboratory, as well, many TUTs that people report are, in fact, engaged intentionally [e.g., 25, 26, 27]. Thus, defining mind-wandering strictly in terms of unintentional thought seems too exclusive of experiences commonly recognized and self-reported as mind-wandering.

Stimulus-Independent Thought

SIT refers to thoughts that "arise from intrinsic changes that occur within an individual," as opposed to "stimulus-dependent thoughts," or, "extrinsic changes that are cued directly from perceptual events occurring in the external environment [i.e., stimulus-dependent thoughts]" [28, p. 490]. Although some researchers have proposed that mind-wandering must reflect stimulus-

independent thought [e.g., 1][1], stimulus independence also characterizes certain forms of *task-related*, goal-oriented cognition. Indeed, many tasks require information to be buffered over time in a stimulus-independent form. For example, while completing a working-memory task, participants consciously maintain information across stimulus events. Similarly, good task performance sometimes requires people to retrieve and generate information, as in creative-problem-solving activities.

Given that most researchers do not conceptualize mind-wandering as task-relevant cognition, and given that stimulus-independent thought can include task-relevant thought, the SIT definition seems overly inclusive, and thus conflicts with people's general understanding of mind-wandering. At the same time, defining mind-wandering as SIT can be overly restrictive. Consider, for example, the scenario in which you are eating dinner with your family and your thoughts drift to an argument you just had with your sibling, who is seated next to you. Such stimulus-associated thoughts would qualify as "mind-wandering" to many people. Yet, because these thoughts were triggered by (and continue to feature) an environmental stimulus, the SIT definition rejects them as mind-wandering.

Stimulus-Independent Task-Unrelated Thought

Defining mind-wandering as SITUT [e.g., 29] circumvents the previously discussed problem with SIT; namely, that task performance can require people to think about stimuli no longer in the environment, but these goal-directed, on-task thoughts are nevertheless classified as

[1] Although these authors defined mind-wandering as SIT, they operationalized it for participants as TUT, without ensuring that reported TUTs were stimulus-independent. This inconsistency between researchers' conceptualizations and operationalizations of mind-wandering has also appeared in studies wherein mind-wandering was conceptualized/defined as unintentional TUT, but operationalized simply as "TUT," and in studies where mind-wandering was conceptualized/defined as internally focused thought, but again operationalized only as "TUT." This is an issue to which we return, and hope to remedy, later in this article.

"mind-wandering." This is no longer problematic with a SITUT definition because, to qualify as mind-wandering, thoughts must be both stimulus-independent *and* task-unrelated. Nonetheless, SITUT is limited as a gold-standard definition of mind-wandering [e.g., 30] because it excludes thoughts commonly recognized as mind-wandering in a similar manner as do both the SIT definition (e.g., mentally replaying the argument with a sibling) and TUT definition (e.g., task-free mind-wandering on the bus).

Meandering, Unguided Thought

Researchers have recently proposed that, to qualify as mind-wandering, a thought must be meandering and unguided [e.g., 17]. Although investigations of this variety of mind-wandering have provided theoretical insights [31], as with the other definitions, this definition excludes thoughts that are commonly recognized as mind-wandering (e.g., perseverative TUTs, or purposeful thoughts about holiday activities). We therefore cannot endorse adopting unguided thought as an exclusive definition of mind-wandering.

Interim Conclusions

Specific and exclusive definitions of mind-wandering do not—and perhaps cannot—adequately capture the rich variety of this experience (and some definitions may incidentally include experiences that do not seem to reflect "mind-wandering"). Moreover, despite clear differences in conceptualizations of mind-wandering (e.g., TUT, SIT, unguided thought), researchers often adopt a broad-brush focus on "mind-wandering" when drawing conclusions, rather than constraining theoretical discussions to the specific variety of mind-wandering investigated. For instance, now-common claims in the literature are that "people spend up to 50% of their waking lives mind-wandering," and "mind-wandering predicts creativity." Importantly, however, the researchers who initially reported these findings examined only the

TUT variety of mind-wandering. Nevertheless, such broad claims are frequently made in separate studies and opinion pieces examining different varieties of mind-wandering, implying that these claims generalize [e.g., 32]. Researchers may thus be lumping together fundamentally different experiences into the same category, which could lead not only to conceptual confusion, but also to theoretical conflicts and inappropriate applications (for an example, see Box 1).

Box 1. Lumping varieties of mind-wandering together can cause theoretical complications

McVay and Kane (2010) proposed what later became an influential theoretical account of mind-wandering [20]. Their Executive Control Failures × Concerns account argued that mind-wandering occurs when a person fails to "defend primary-task performance against interference from … thoughts" [20, p.195]. One important implication of this account, then, is that mind-wandering reflects unintentional thoughts cued by context; indeed, deliberate, willful shifts of attention would hardly qualify as control failures (and might be best categorized as controlled processing). Thus, although the Executive Control Failures account helped guide the development and refinement of mind-wandering theory, it does not capture well certain varieties of thought that many theories and laypeople would classify as "mind-wandering." For example, allowing one's mind to wander while sitting by the lake, or deliberately planning a dinner date while sitting in calculus class, would not qualify as mind-wandering because such thoughts would not reflect control failures. Given that the Executive Control Failures account does not appertain to all varieties of mind-wandering, one may be tempted to simply reject it, particularly if one views mind-wandering as a unitary construct caused by a single mechanism. The family-resemblances account of mind-wandering, in contrast, allows for the possibility that the Executive Control Failures account does, in fact, provide a reasonable explanation of *certain varieties* of mind-wandering only (particularly those that are unintentional and task-unrelated). Thus, the family-resemblances view allows room for numerous mechanisms that underpin types of mind-wandering.

Potential Solutions to Mind-Wandering's Conceptual and Definitional Challenges

If no single definition of mind-wandering is universally adequate or acceptable, should the field simply abandon its use in favor of more nuanced, qualified terms, such as "*unintentional task-unrelated thought,*" or "*intentional stimulus-independent thought*"? This strategy would undoubtedly increase clarity, but "mind-wandering" is a useful umbrella term just as "cognition," and "creativity" are (and it hardly seems sensible to abandon the term "cognition" because definitions of visual cognition do not encompass those of numerical cognition). Moreover, adopting the term "mind-wandering," in 2006 [16] seems to have inspired an acceleration of research. Perhaps most important, introducing the term "mind-wandering" to the scientific literature encouraged cross-talk among researchers who were separately studying related phenomena (e.g., TUT and daydreaming). Thus, abandoning "mind-wandering" does not appear advisable.

Perhaps the field should instead propose a definition of mind-wandering with necessary and sufficient conditions, as belonging to a "classical view" of category membership? Many researchers (ourselves included) have tried this approach. Classical definitions of mind-wandering are appealing, but as we demonstrated above, no single definition can capture all the facets and subtleties of mind-wandering, and neither logic nor empiricism can select among them. The fact that different researchers have thoughtfully developed conflicting definitions of mind-wandering amply demonstrates the perils of pursuing a unitary but arbitrary conception.

The heterogeneity of mind-wandering experiences and definitions implies that the best way forward may be to adopt a new approach. We propose that the field acknowledge mind-

wandering to be a multidimensional and fuzzy construct encompassing a family of experiences with common and unique features[2].

A Family-Resemblances Approach to Mind-Wandering

> "Consider the proceedings that we call "games." I mean board-games, card-games, ball-games, Olympic-games, and so on. What is common to them all? —Don't say: "There must be something common, or they would not be called 'games'"—but look and see whether there is anything common to them all. —For if you look at them you will not see something that is common to them all, but similarities, relationships, and a whole series of them at that" [Wittgenstein, 33, pp. 31-32].

As Wittgenstein noted, some categories have necessary and sufficient defining features that apply to all category members (e.g., prime numbers), but most human-created categories are held together by overlapping subsets of similarities, or "family resemblances," rather than a common thread running through all members. Eleanor Rosch and colleagues similarly distinguished *digital categories*, for which membership is all-or-none, from *natural categories*, for which membership is analog. Natural categories are characterized as "networks of overlapping attributes" [34], and exemplars of natural categories vary in terms of their "graded membership" within their categorical family: Whereas highly prototypical members have

[2] It might be argued that because mind-wandering has been defined in numerous different ways, it is already being treated as a heterogeneous construct. For example, mind-wandering has been defined across studies as unintentional task-unrelated thought, intentional task-unrelated thought, stimulus-dependent thought (to name a few). The problem, however, is that these definitions have been treated as competing classical definitions of the construct, not complementary definitions of a heterogeneous construct. For example, definitions requiring that thoughts must be unintentional in order to be considered mind-wandering compete with definitions that consider intentional, task-unrelated thought to reflect mind-wandering. Thus, the field has operated not as if mind-wandering is heterogeneous, but rather, as if there are certain minimal values along one or more dimensions that are necessary to classically define the construct, and that, in the absence of such necessary and sufficient defining features, a thought does not qualify as mind-wandering. Put differently, there exist multiple, competing classical definitions of the construct, which can give rise to the illusion that mind-wandering is being treated as heterogeneous when in fact it has been treated as a singular, classically definable construct, with classical definitions that vary across studies.

attributes that overlap with the most other exemplars of the category, low-prototypical members have little overlap (see Figure 1, Key Figure, Panel a).

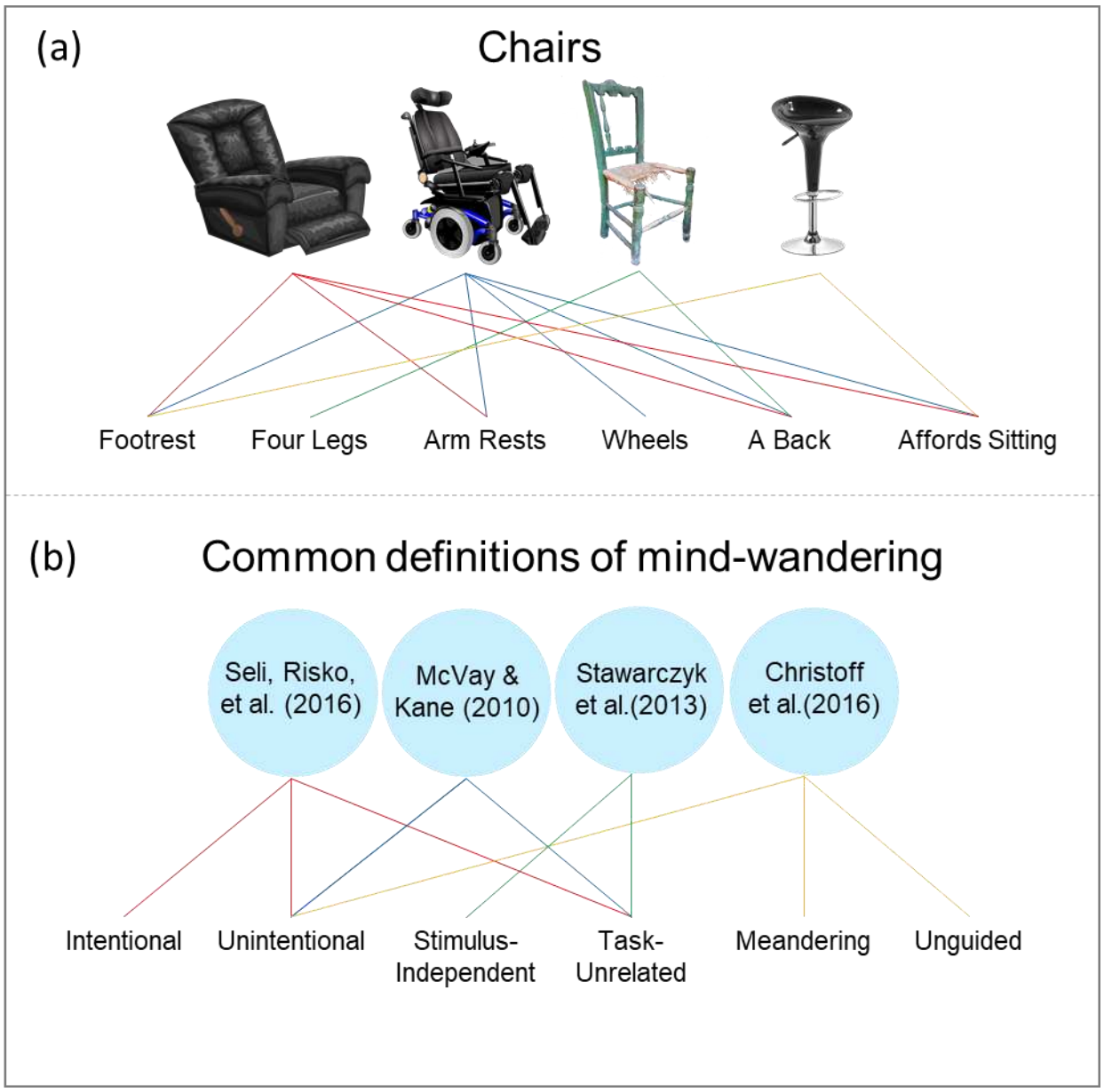

Figure 1 (Key Figure). Schematic for a family-resemblances view.
In panel (a) are four chairs that share one or more features with the each other. For example, the first, second, and fourth chairs all afford sitting (the third chair has a broken seat), and the first, second, and third chairs all have backs. However, no single feature runs through all members of the family of chairs. Hence, there is no universal feature that defines membership. Instead, the "family" of chairs is held together by overlapping features.

In panel (b) are examples of different definitions of mind-wandering from four articles [17, 20, 29, 54, respectively]. Across these articles, mind-wandering is defined with reference to specific aspects of conscious experiences, including intentionality, stimulus-dependence, task relatedness, and/or content stability. However, the family resemblances-view posits that, just as there is no single feature that defines the chair family, there are no specific features that a thought must have to be granted membership in the mind-wandering family. Instead, by the family-resemblance view, mind-wandering is a collection of related experiences that share some, but not all, features.

Prototypicality and Graded Membership Within the Mind-Wandering Family

A family-resemblances view characterizes mind-wandering as a natural category with graded membership (i.e., some exemplars are more prototypical than others; see Figure 1, Panel b). For instance, within the family of mind-wandering definitions presented in Figure 1, panel b, graded membership can be determined by identifying the number of shared features that each definition, or exemplar, shares with the others. The most frequently endorsed features of mind-wandering across these definitions include "unintentional" and "task-unrelated" thought, so thoughts characterized by these features would be considered more prototypical cases of mind-wandering than thoughts characterized by less frequently shared features (e.g., intentional, or unguided thought). To empirically (and more systematically) quantify graded membership in the mind-wandering category, researchers could examine all definitions of mind-wandering reported in the literature and determine the extent to which features associated with each (e.g., task-unrelatedness, intentionality, stimulus-dependence, and level of guidance) overlap with features associated with the other definitions.

Alternatively (or additionally), as in Rosch's seminal research on graded membership [34], researchers could ask people (experts, laypeople, or both) to report exemplars of mind-wandering and assess which features of these exemplars overlap with others. Across different samples, however, there may, arise some variation in graded membership. For instance, the "most prototypical" case of mind-wandering identified by researchers may appear as a slightly less prototypical case in another sample, say, of novelists (although with sufficiently large datasets, increased stability should be achieved). In any case, such variation in prototypicality motivates rather than impedes a family-resemblances approach, since this conceptualization treats mind-wandering as a heterogeneous construct whose members share features with some

but not other members (in the same way, we can reasonably disagree about whether tennis or solitaire are more prototypical games without threatening our understanding of the "game" category).

The Mind-Wandering Family: Inclusion and Exclusion

One unavoidable complication with natural categories is that their boundaries are not clearly demarcated. Indeed, absent a classical definition, there are no necessary and sufficient defining features with which to include or exclude exemplars from the category. For instance, whereas a four-legged object that affords sitting would be classified by most as a "chair," the point at which an object is granted or denied membership in the "chair" family is unclear. More prototypical "chairs" such as Adirondack and Windsor chairs elicit little dispute, but objects such as a tuffet, or even a large, flat rock, may generate disagreement. The rock shares at least one feature with prototypical chairs (it affords sitting), but few others. In the same way, for example, intentional, guided, stimulus-independent TUT might be considered analogous to the rock because it shares few features with common mind-wandering exemplars. And just as one cannot definitively state, "the rock is/is not a chair," one cannot definitively conclude whether intentional, guided, stimulus-independent TUT should be granted or denied membership in the mind-wandering family (for more on this topic, see Box 2). Nevertheless, this critical characteristic of natural constructs need not stifle investigations of mind-wandering. In fact, because the family-resemblances approach motivates more precise specification of the dimensions associated with the thoughts in question, we will be better able to investigate the causes, consequences, functions, and correlates of such thoughts. Moreover, by quantifying graded membership in the family, we can avoid erroneously equating all exemplars within the

family (i.e., we can identify exemplars that better capture the essence of mind-wandering via quantitative assessments of prototypicality).

Box 2. Characterizing graded membership in the mind-wandering family

According to our argument, neither logic nor data can determine the types of thoughts that should be included or excluded from the mind-wandering family. This may seem problematic (if not perturbing), and thus present itself as a strike against the family-resemblances approach. This inability to definitively include or exclude thoughts from the mind-wandering family, however, is not a consequence of the family-resemblances approach, per se. Rather, it is a problem that necessarily arises with natural constructs that are not classically defined. A classical definition is required for determining not only which constructs ought to be included in a given family, but also those to be excluded. Thus, if one commits to an approach to mind-wandering that avoids this inclusion-exclusion problem, one must also commit to a reasonable, tractable, classical definition of mind-wandering with unanimous agreement. As multiple definitions of mind-wandering already exist—some of which are mutually exclusive—this seems a fruitless endeavor: any disagreement would render the classical definition problematic, since it would exclude forms of thought that people recognize as mind-wandering. Thus, we suggest that the field cannot tenably reject the family-resemblances approach while also failing to generate an accepted classical definition.

We reiterate that accepting mind-wandering as a fuzzy-boundaried and heterogenous construct does not bring its scientific study to a halt. Rather, it should prove theoretically fruitful because, by quantifying graded membership, we can determine more and less prototypical instances of mind-wandering and more accurately investigate their features and functions. As long as researchers are careful to report the specific (whether more or less prototypical) variety of mind-wandering they are investigating—an obligation derived from the family-resemblances approach—we can effectively isolate different types of mind-wandering, along with their causes, consequences, and associates, rather than conflating these unique experiences and inappropriately generalizing our results across all exemplars of mind-wandering.

Evidence Supporting the Utility of a Family-Resemblances View of Mind-Wandering

Scientific benefits of adopting a family-resemblances view of mind-wandering are evident when different members of the mind-wandering family demonstrate distinct causes, consequences, or associates. Indeed, if different varieties of mind-wandering behave differently—and evidence suggests that they do—then ignoring their diversity may lead to underspecified or erroneous conclusions. Take, for instance, a study of mindfulness meditation's effects on rates of stimulus-dependent and stimulus-independent TUT [35]. Participants first completed a sustained-attention task intermittently interrupted by "thought probes" that asked whether any TUTs they experienced were stimulus-dependent or stimulus-independent (pretest). Participants then either engaged in mindfulness meditation or listened to an audiobook (control condition), after which they re-completed the sustained-attention task with thought probes (post-test). Whereas rates of stimulus-independent TUT remained unchanged across pre- and post-tests for meditation subjects, they significantly *increased* for controls; in contrast, whereas rates of stimulus-dependent TUT did not vary from pre- to post-test in the meditation condition, they significantly *decreased* in the control condition (for similar dissociations of stimulus-dependent and stimulus-independent TUTs, see [36-38]). This dissociation reinforces the utility—if not necessity—of the family-resemblances approach to mind-wandering research: If these varieties of mind-wandering had been treated as reflecting a single, unitary construct, their unique behaviors would have been undetectable, and the potential effects of meditation might be misinterpreted.

Another dissociation supporting a family-resemblances approach to mind-wandering comes from examining task-related versus task-unrelated mind-wandering during video lectures (here, task-related mind-wandering was operationalized as elaborations or reflections on lecture

material that did not correspond to the momentary video content [39]). Students who engaged in more task-related mind-wandering tended to recall more lecture-related details than did students who engaged in less, whereas students who reported higher rates of task-unrelated mind-wandering tended to recall less information about the lecture than did those who reported lower rates.

The utility of a family-resemblances view may be best illustrated by studies examining the correlates of mind-wandering experiences that are engaged with versus without intention. A large-scale neuroimaging study of trait variation in intentional and unintentional mind-wandering ([40]; see Figure 2, panel a) found distinct neural correlates for these two thought types. Indeed, analysis of the whole-brain thickness of grey matter indicated mind-wandering-related differences in the retrosplenial cortex and the lingual gyrus: Whereas higher rates of unintentional mind-wandering were associated with greater thickness in the retrosplenial cortex and lingual gyrus in the left hemisphere, higher rates of intentional mind-wandering were associated with less cortical thickness in these same areas in the right hemisphere. A similar dissociative pattern emerges in behavioral data (see Figure 2, panel b): Whereas trait levels of intentional mind-wandering correlate positively with people's tendency toward non-reactivity to internal experiences (a facet of mindfulness), trait levels of unintentional mind-wandering correlate negatively with it [41]. Likewise, separate work [25] shows that, whereas people experience more intentional mind-wandering during easy versus difficult tasks, they report more unintentional mind-wandering in difficult versus easy tasks (for similar dissociations, see [42-45]).

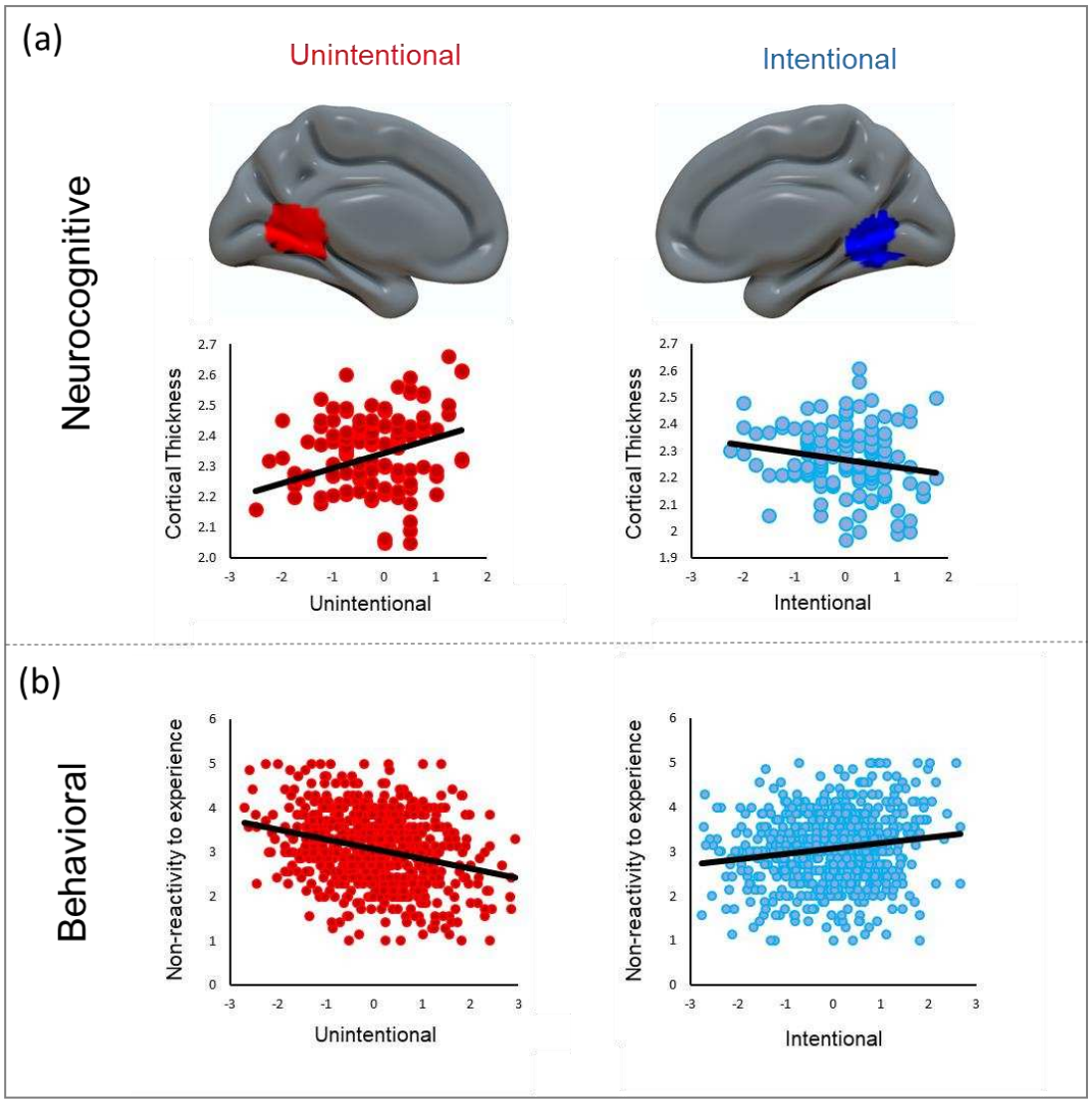

Figure 2. Distinct neurocognitive and behavioral correlates of unintentional and intentional mind-wandering. Panel (a) illustrates a dissociation between intentional and unintentional mind-wandering in correlations with thickness of the retrosplenial cortex/lingual gyrus [40]. Participants reporting higher rates of trait-level unintentional mind-wandering tended to show greater cortical thickness in the retrosplenial cortex/lingual gyrus in the left hemisphere than did participants reporting lower rates of unintentional mind-wandering. Conversely, participants reporting higher rates of trait-level intentional mind-wandering tended to show less cortical thickness in the retrosplenial cortex/lingual gyrus in the right hemisphere than did participants reporting lower rates of intentional mind-wandering.

Panel (b) displays a dissociation between intentional and unintentional mind-wandering in their relations to self-reported mindfulness (i.e., the non-reactivity to experience facet of the five-facet mindfulness questionnaire [55]). Whereas participants reporting higher rates of unintentional mind-wandering tended to report lower levels of mindfulness, those reporting higher rates of intentional mind-wandering tended to report higher levels of mindfulness.

These results, taken together, highlight the utility of a family-resemblances framework for mind-wandering research. The typical practice of treating mind-wandering as a unitary construct precludes important discoveries about the diversity of the mind-wandering family.

Implications of a Family-Resemblances Approach to the Study of Mind-Wandering

Acknowledging that mind-wandering is a heterogeneous concept and that a universally agreed-upon definition of mind-wandering—with necessary and sufficient conditions—is not forthcoming has implications for future scientific investigations. First, because family resemblances arise from common and distinct features, research may benefit from assessing multiple features of experience at the same time. This approach, which is common to daily-life investigations of mind-wandering [e.g., 46, 47, 48], but rare in laboratory studies (but see [26, 49, 50]), asks participants to answer consecutive probe questions about immediate thought content, allowing researchers to identify common and distinct elements of experience. Multivariate statistical techniques can then reduce respondents' data into a few dimensions that can be compared to other measures (such as neural function) to assess common versus distinct features or mechanisms. Limited but growing evidence suggests that stable features of experience across participant samples, and that, consistent with a family-resemblances account, these features differentially predict neurocognitive measures [50].

Second, a family-resemblances approach encourages the field to consider which dimensions of experience should be studied in the first place. One approach to this problem is to have participants provide open-ended reports about their experiences. These could then be categorized (by participants or independent raters) based on established or novel dimensions of interest. Although open-ended reports can present interpretive challenges (such as requiring verbalization of potentially non-verbalizable experiences, reporting deeply personal thoughts, or

"punishing" mind-wandering reports by making them more effortful than on-task reports), they have been successfully employed in some studies examining the temporal focus of mind-wandering [51, 52]. Collecting large corpuses of open-ended reports would allow text-mining techniques to reveal novel and potentially unknown dimensions of the mind-wandering state.

A family-resemblances approach might also increase the intellectual—if not methodological—connections among related phenomena that some might consider non-prototypical mind-wandering, such as spontaneous autobiographical semantic memories, earworms, depressive rumination, and so forth. The heterogeneous view of mind-wandering facilitates the realization that neighboring constructs may be directly relevant to each other, and so they should not be studied in isolation, or reside in separate scientific literatures.

Perhaps of most importance, a family-resemblances framework will encourage researchers to specify the mind-wandering feature(s) under study in their experiments, both to participants and readers. Methodological and conceptual clarity will simply require, in empirical manuscripts, something like the following sentence: "Here, we conceptualized mind-wandering as _____, and operationally defined it for our participants as _____." Critically, this approach allows researchers the freedom to study whatever features of mind-wandering they wish, while providing needed specificity about aspects of the experience being explored. Theorists will more easily compare results across studies, and researchers will carefully consider and motivate the specific type of mind-wandering they are studying, while ensuring that their conceptualizations of mind-wandering are not misaligned with their operational definitions, as in previous work [e.g., 1, 21, 53].

Concluding remarks

Mind-wandering encompasses diverse subjective experiences that vary in their defining properties, and in some cases, in their causes, consequences, and correlates. As such, we think that mind-wandering is best considered and researched within a family-resemblances framework, which entails recognizing mind-wandering as a heterogeneous construct and clarifying the dimensions that are under investigation. The family-resemblances framework (a) eliminates unproductive disagreement about "mind-wandering" definitions, (b) embraces all commonly recognized forms of mind-wandering as worthy of study (e.g., deliberate daydreaming), (c) adds precision to operational definitions of mind-wandering, and (d) allows the field to retain the broad term, "mind-wandering," which helpfully denotes the mind-wandering family and implies that distinct concepts within this family may be fundamentally similar to each other. Moreover, the family-resemblances perspective raises new questions regarding conceptual and methodological approaches to future research (See Outstanding Questions). By acknowledging the diversity of states and experiences that can be reasonably characterized as mind-wandering—while simultaneously specifying the dimensions that are relevant to any particular investigation—psychologists and neuroscientists can begin to unravel the many strands that contribute to this ubiquitous yet elusive category of mental life.

Outstanding Questions Box

- *How are different dimensions of mind-wandering associated/dissociated with each other?* Studies examining the overlap and differences among different varieties of mind-wandering could provide important insights. For instance, unintentional TUT and task-free rumination may have similar causes, in which case, methods of remediation for these two thought types may be similar. Moreover, whereas meandering, unguided thoughts may be particularly likely to lead to creative insights, perseverative, guided thoughts may not.

- *Do different external contexts (e.g., task difficulty, lab versus daily-life) or internal contexts (e.g., arousal, motivation) differentially evoke distinct varieties of mind-wandering?* Understanding the causes of different types of mind-wandering could be important in cases where people seek to reduce or increase the rate of occurrence of such thoughts. This could also inform theoretical accounts of mind-wandering. For instance, research has already suggested that manipulations of task difficulty can differentially affect rates of intentional and unintentional mind-wandering, and this has led some to propose separate mechanisms to explain the maintenance and occurrence of each thought type.

- *How many dimensions of mind-wandering can be reasonably measured during a single thought-probe?* Although we have argued that it will be important for researchers to concurrently assess numerous features of participants' thoughts, it is unclear how many features of thought a participant can accurately report on. One concern is that participants' memories for the features of their thoughts may be somewhat transient, and so assessments of multiple features of thought may be problematic. Although research has suggested that participants are able to accurately report on various aspects of their thoughts, it will be important to closely examine this issue in future work, and to determine a limit for the number of dimensions that can be reasonably indexed.

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References

1. Killingsworth, M.A. and Gilbert, D.T. (2010) A wandering mind is an unhappy mind. Science 330 (6006), 932.
2. Gorgolewski, K.J. 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 (5), e97176.
3. Baird, B. et al. (2011) Back to the future: autobiographical planning and the functionality of mind-wandering. Conscious Cogn 20 (4), 1604-11.
4. Baird, B. et al. (2012) Inspired by distraction: mind wandering facilitates creative incubation. Psychol Sci 23 (10), 1117-22.
5. Smallwood, J. et al. (2008) Going AWOL in the brain: mind wandering reduces cortical analysis of external events. J Cogn Neurosci 20 (3), 458-69.
6. Kam, J.W. and Handy, T.C. (2013) The neurocognitive consequences of the wandering mind: a mechanistic account of sensory-motor decoupling. Front Psychol 4, 725.
7. Yanko, M.R. and Spalek, T.M. (2014) Driving with the wandering mind: the effect that mind-wandering has on driving performance. Hum Factors 56 (2), 260-9.
8. Wammes, J.D. et al. (2016) Mind wandering during lectures II: Relation to academic performance. Scholarship of Teaching and Learning in Psychology 2 (1), 33-48.
9. Seli, P. et al. (2016) On the relation between motivation and retention in educational contexts: The role of intentional and unintentional mind wandering. Psychon Bull Rev 23 (4), 1280-7.
10. Farley, J. et al. (2013) Everyday attention and lecture retention: the effects of time, fidgeting, and mind wandering. Front Psychol 4, 619.
11. Smallwood, J. et al. (2003) Task unrelated thought whilst encoding information. Conscious Cogn 12 (3), 452-84.
12. McVay, J.C. et al. (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 (5), 857-63.
13. Lutz, A. et al. (2015) Investigating the phenomenological matrix of mindfulness-related practices from a neurocognitive perspective. Am Psychol 70 (7), 632-58.
14. Stanton, N. (1995) Human Cognitive Abilities: A Survey of Factor-Analytic Studies, by J. B. Carroll, Cambridge University Press, Cambridge (1993), pp. iv + 819, ISBN 0-521-38712-4. Ergonomics 38 (5), 1074.
15. Kaufman, J.C. and Beghetto, R.A. (2009) Beyond Big and Little: The Four C Model of Creativity. Review of General Psychology 13 (1), 1-12.
16. Smallwood, J. and Schooler, J.W. (2006) The restless mind. Psychol Bull 132 (6), 946-58.
17. Christoff, K. et al. (2016) Mind-wandering as spontaneous thought: a dynamic framework. Nat Rev Neurosci 17 (11), 718-731.
18. Kane, M.J. et al. (2017) For Whom the Mind Wanders, and When, Varies Across Laboratory and Daily-Life Settings. Psychol Sci 28 (9), 1271-1289.
19. Mason, M.F. et al. (2007) Wandering minds: the default network and stimulus-independent thought. Science 315 (5810), 393-5.
20. McVay, J.C. and Kane, M.J. (2010) Does mind wandering reflect executive function or executive failure? Comment on Smallwood and Schooler (2006) and Watkins (2008). Psychol Bull 136 (2), 188-97; discussion 198-207.

21. Bixler, R. and D'Mello, S. (2014) Toward Fully Automated Person-Independent Detection of Mind Wandering. In User Modeling, Adaptation, and Personalization, Umap 2014 (Dimitrova, V. et al. eds), pp. 37-48.
22. Grodsky, A. and Giambra, L. (1990) The consistency across vigilance and reading tasks of individual differences in the occurrence of task unrelated and task related images and words. Imagination, Cognition and Personality 10, 39-52.
23. Seli, P. et al. (2017) Cognitive aging and the distinction between intentional and unintentional mind wandering. Psychol Aging 32 (4), 315-324.
24. Seli, P. et al. (2016) Assessing the associations among trait and state levels of deliberate and spontaneous mind wandering. Conscious Cogn 41, 50-6.
25. Seli, P. et al. (2016) On the Necessity of Distinguishing Between Unintentional and Intentional Mind Wandering. Psychol Sci 27 (5), 685-91.
26. Seli, P. et al. (2017) What did you have in mind? Examining the content of intentional and unintentional types of mind wandering. Conscious Cogn 51, 149-156.
27. Forster, S. and Lavie, N. (2009) Harnessing the wandering mind: the role of perceptual load. Cognition 111 (3), 345-55.
28. Smallwood, J. and Schooler, J.W. (2015) The science of mind wandering: empirically navigating the stream of consciousness. Annu Rev Psychol 66, 487-518.
29. Stawarczyk, D. et al. (2013) Phenomenology of future-oriented mind-wandering episodes. Front Psychol 4, 425.
30. Stawarczyk, D. et al. (2011) Mind-wandering: phenomenology and function as assessed with a novel experience sampling method. Acta Psychol (Amst) 136 (3), 370-81.
31. Mills, C. et al. (2017) Is an off-task mind a freely-moving mind? Examining the relationship between different dimensions of thought. Conscious Cogn.
32. Immordino-Yang, M.H. et al. (2012) Rest Is Not Idleness: Implications of the Brain's Default Mode for Human Development and Education. Perspect Psychol Sci 7 (4), 352-64.
33. Wittgenstein, L. (1968) Philosophical investigations, 3rd edn., Basil Blackwell Ltd.
34. Rosch, E. and Mervis, C.B. (1975) Family resemblances: Studies in the internal structure of categories. Cognitive Psychology 7 (4), 573-605.
35. Xu, M. et al. (2017) Mindfulness and mind wandering: The protective effects of brief meditation in anxious individuals. Conscious Cogn 51, 157-165.
36. Maillet, D. and Schacter, D.L. (2016) When the mind wanders: Distinguishing stimulus-dependent from stimulus-independent thoughts during incidental encoding in young and older adults. Psychol Aging 31 (4), 370-9.
37. Maillet, D. et al. (2017) Mind-wandering and task stimuli: Stimulus-dependent thoughts influence performance on memory tasks and are more often past- versus future-oriented. Conscious Cogn 52, 55-67.
38. Plimpton, B. et al. (2015) Role of triggers and dysphoria in mind-wandering about past, present and future: A laboratory study. Conscious Cogn 33, 261-76.
39. Jing, H.G. et al. (2016) Interpolated testing influences focused attention and improves integration of information during a video-recorded lecture. J Exp Psychol Appl 22 (3), 305-18.
40. Golchert, J. et al. (2017) Individual variation in intentionality in the mind-wandering state is reflected in the integration of the default-mode, fronto-parietal, and limbic networks. Neuroimage 146, 226-235.
41. Seli, P. et al. (2015) Not all mind wandering is created equal: dissociating deliberate from spontaneous mind wandering. Psychol Res 79 (5), 750-8.

42. Phillips, N.E. et al. (2016) On the influence of re-reading on mind wandering. Q J Exp Psychol (Hove) 69 (12), 2338-2357.
43. Seli, P. et al. (2015) On the relation of mind wandering and ADHD symptomatology. Psychon Bull Rev 22 (3), 629-36.
44. Konishi, M. et al. (2017) When attention wanders: Pupillometric signatures of fluctuations in external attention. Cognition 168, 16-26.
45. Seli, P. et al. (2017) Intentionality and meta-awareness of mind wandering: Are they one and the same, or distinct dimensions? Psychon Bull Rev.
46. Kane, M.J. et al. (2007) For whom the mind wanders, and when: an experience-sampling study of working memory and executive control in daily life. Psychol Sci 18 (7), 614-21.
47. Klinger, E. (1978) Modes of normal conscious flow. In The Stream of Consciousness: Scientific Investigations into the Flow of Human Experience (Pope, K.S. and Singer, J.L. eds), Plenum.
48. Song, X. and Wang, X. (2012) Mind wandering in Chinese daily lives--an experience sampling study. PLoS One 7 (9), e44423.
49. Medea, B. et al. (2016) How do we decide what to do? Resting-state connectivity patterns and components of self-generated thought linked to the development of more concrete personal goals. Exp Brain Res.
50. Smallwood, J. et al. (2016) Representing Representation: Integration between the Temporal Lobe and the Posterior Cingulate Influences the Content and Form of Spontaneous Thought. PLoS One 11 (4), e0152272.
51. Smallwood, J. et al. (2009) When is your head at? An exploration of the factors associated with the temporal focus of the wandering mind. Consciousness & Cognition 18 (1), 118-125.
52. Rummel, J. et al. (2017) Dealing with prospective memory demands while performing an ongoing task: Shared processing, increased on-task focus, or both? J Exp Psychol Learn Mem Cogn 43 (7), 1047-1062.
53. Kopp, K. et al. (2015) Influencing the occurrence of mind wandering while reading. Conscious Cogn 34, 52-62.
54. Seli, P. et al. (2016) Mind-Wandering With and Without Intention. Trends Cogn Sci 20 (8), 605-17.
55. Baer, R.A. et al. (2006) Using self-report assessment methods to explore facets of mindfulness. Assessment 13 (1), 27-45.