Investigating the Phenomenological Matrix of Mindfulness-Related Practices From a Neurocognitive Perspective

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There has been a great increase in literature concerned with the effects of a variety of mental training regimes that generally fall within what might be called contemplative practices, and a majority of these studies have focused on mindfulness. Mindfulness meditation practices can be conceptualized as a set of attention-based, regulatory, and self-inquiry training regimes cultivated for various ends, including wellbeing and psychological health. This article examines the construct of mindfulness in psychological research and reviews recent, nonclinical work in this area. Instead of proposing a single definition of mindfulness, we interpret it as a continuum of practices involving states and processes that can be mapped into a multidimensional phenomenological matrix which itself can be expressed in a neurocognitive framework. This phenomenological matrix of mindfulness is presented as a heuristic to guide formulation of next-generation research hypotheses from both cognitive/behavioral and neuroscientific perspectives. In relation to this framework, we review selected findings on mindfulness cultivated through practices in traditional and research settings, and we conclude by identifying significant gaps in the literature and outline new directions for research.

Keywords: mindfulness meditation, meta-awareness, dereification, decentering, attention regulation

There has been a great increase in literature concerned with the effects of a variety of mental training regimes that generally fall within what might be called contemplative practices, and a majority of these studies have focused on mindfulness. Mindfulness meditation practices are conceptualized here as a set of attention-based, regulatory, and self-inquiry training regimes cultivated for various ends, including wellbeing and psychological health.

Mindfulness as an Explanandum

Overview of the Landscape of Research

Research on mindfulness spans a broad swath of approaches and research agendas. Some investigators attempt to uncover fundamental mechanisms of action, while others are concerned with the acquisition of new skills and evaluating their efficacy in clinical and nonclinical populations. This diversity is important for advancing our understanding, but it also creates multiple domains of tension among various subdisciplines that is fertile ground for misunderstanding. Some of these subdisciplines include cognitive neuroscience, developmental psychology, positive psychology, clinical and health psychology, psychiatry, preventive medicine, and education. In the humanities and allied fields, relevant subdisciplines include religious stud-

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ies, philosophy (especially philosophy of mind), anthropology and sociology. Here, we will approach mindfulness practices and training from the perspectives of psychology and cognitive neuroscience tempered by concerns from within the humanities. These are the points of view comprising the nascent field of contemplative science (see Davidson & Kaszniack, 2015, in this special issue).

Toward a Family Resemblance Approach

Before presenting a phenomenological and neurocognitive framework for investigating the effects of mindfulness practices, we first offer a critical overview of the various uses of the term *mindfulness* in academic psychology. Although attempts to generate an operational definition of mindfulness have been published and oft cited (e.g., Bishop et al., 2004), a consensus definition of mindfulness is lacking, and the myriad definitions in the literature can be seen as generating more confusion than clarity. This confusion not only reflects the relative novelty of contemplative science as an empirical field of research, but it also stems from complex issues related to the appropriation of practices and theoretical accounts from traditional contemplative sources, especially various Buddhist traditions (see Williams & Kabat-Zinn, 2011, for a compendium of papers considering this confusion in detail, and Harrington & Dunne, 2015, in this special issue). The use of Buddhist sources adds complexity and potential confusion, as Buddhist traditions have themselves disagreed on the nature of mindfulness and debated the topic for centuries (Dunne, 2015).

While the confusion over "mindfulness" arises from the breadth of contexts in which the term is used, this breadth itself stands in tension with a drive toward formulating a single, universally applicable definition. A further source of confusion, perhaps supported by the nascent nature of this field, has been the need to frame mindfulness-based interventions in ways that are maximally compatible with clinical medicine and psychology, such that these practices are seen through the lens of current scientific thinking and are articulated in ways that can be readily communicated to potential patients, healthcare providers, and researchers. Although clearly crucial to basic and clinical research, this restricted perspective increases the risk of misrepresenting (or missing altogether) the active ingredients underlying the potentially transformative effects of these practices whose techniques emerge in a context broader than clinical medicine, psychology or neuroscience.

We respond to the aforementioned issues by providing a heuristic tool that enables different styles and levels of training in mindfulness to be mapped into a multidimensional phenomenological space that can be used to generate hypotheses for empirical research. By phenomenological space, we mean the characterization of categorical features of the field of experience, as it is lived and verbally articulated in the first person (e.g., Husserl, 2008). This approach eschews any attempt to produce a single definition of mindfulness, and because it is based on the phenomenology of the practices, it is compatible with multiple explanatory and analytical schemas from divergent subdisciplines, including contemplative theories (e.g., in the *Abhidharma* or *Mahāmudrā*; see details in Gethin, 1998, and Dunne, 2015), or clinical frameworks (e.g., mindfulness-based stress reduction [MBSR]), or neuroscientific models (e.g., Hölzel et al., 2011; Vago & Silbersweig, 2012). In light of the confusion noted above, we will first discuss common (if conflicting) uses of the term *mindfulness*. Next, the model and its various dimensions will be presented. The remainder of this paper will then explore some tractable features of this heuristic model through the lens of psychology, and cognitive and affective neuroscience, including a selective review of mechanistic studies of mindfulness practices.

The Meanings of Mindfulness

In experimental and clinical psychology, the construct of mindfulness is generally used with three meanings that refer to (a) a mental trait, (b) a soteriological or spiritual path conceived in therapeutic and health-promotion terms, and (c) a single cognitive process commonly trained across multiple human activities. We will argue that, for the purposes of this analysis, mindfulness is best reconceived through a family resemblance approach whereby it can be presented as a variety of cognitive processes embedded in a complex postural, aspirational, and motivational context that contribute to states that resemble one another along well-defined phenomenological dimensions.

Mindfulness as a trait. Over the last several years, mindfulness has been operationalized as a stable, mental trait that can be measured by a variety of dispositional scales (e.g., the Five Facet Mindfulness Questionnaire, Baer, Smith, Hopkins, Krietemeyer, & Toney, 2006; Baer et al., 2008; or the Mindfulness Attention Awareness

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Scale, Brown & Ryan, 2003). This trait is thought to be measurable in subjects trained in mindfulness practices and also in untrained subjects. Some researchers have used these scales to characterize clinical groups (e.g., Leigh, Bowen, & Marlatt, 2005) or to identify in untrained subjects, the neural correlates of dispositional mindfulness (e.g., Creswell, Way, Eisenberger, & Lieberman, 2007). The capacity of a dispositional mindfulness scale to reflect the processes underlying mindfulness-related practices is still poorly understood, and it is likely problematic (see Grossman, 2011 and Van Dam, Hobkirk, Danoff-Burg, & Earleywine, 2012). In particular, the assumption of mindfulness as a stable trait does not account for the capacity to cultivate mindfulness as a skill, a capacity that is already indicated by some empirical findings (see Chambers, Gullone, & Allen, 2009; Hölzel et al., 2011; Lutz, Slagter, Dunne, & Davidson, 2008; Tang, Hölzel, & Posner, 2015, for reviews). This points to the general problem that the interpretation of questionnaire items may vary with exposure to the rhetoric of mindfulness practices. Grossman, in his 2008 commentary has addressed some of these issues (Grossman, 2008; see also Grossman & Van Dam, 2011). Similarly, expert Buddhist meditators did not differ from a control group on state mindfulness in a recent report (Antonova, Chadwick, & Kumari, 2015).

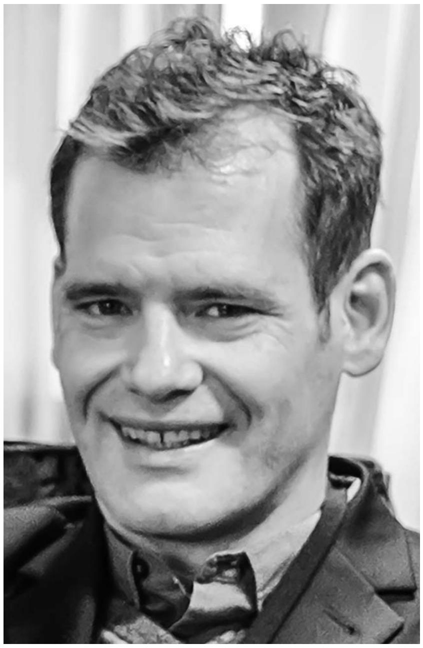
As such, we argue that the use of such scales does not advance understanding of the phenomenological changes individuals experience via mindfulness training. Nor does research solely involving changes over time or group-wise differences in trait mindfulness instruments advance understanding of the mechanisms of action by which mindfulness training produces changes in practitioners. That is, learning that participants' scores increase after training does not illuminate with any specificity which (if any) clinical vulnerabilities, or cognitive, affective, and social processes might be altered via training.

Beyond these general issues, we see three other areas in which "mindfulness" instruments are problematic. First, they lack sufficient divergent validity. That is, very little is known about if and how mindfulness, validated using confirmatory factor analysis (see Baer et al., 2008), may differ from other constructs. Recent studies have reported a high degree of correspondence between mindfulness scores and stress (Goldberg, Del Re, Hoyt, & Davis, 2014; Stanley, Schaldach, Kiyonaga, & Jha, 2011), personality factors (Siegling & Petrides, 2014), as well as other composite psychological factors such as quality of life and "adaptive functioning" (Goldberg, Del Re, Hoyt, & Davis, 2014; Sahdra et al., 2011).

Second, the sensitivity of mindfulness instruments to other forms of training is not known. While many studies examine if mindfulness scores change with mindfulness training, very few have investigated if and how the magnitude of change compares to changes that emerge from participating in other forms of training that do not involve mindfulness. For example, participants in a tango class exhibited comparable improvement in mindfulness scores when compared to participants in a mindfulness intervention (Pinniger, Brown, Thorsteinsson, & McKinley, 2012).

And third, mindfulness instruments suffer from response shifts and biases. Scores on mindfulness instruments may suffer from shifting baseline or response shifts, as is illustrated by, for example, Leigh and colleagues' (2005) finding that binge drinkers' mindfulness scores were greater than those of participants in a mindfulness retreat. In addition, results may be biased by issues surrounding social desirability, consistency effects, or superficial language familiarity between program content and instruments (see Sauer et al., 2013). For example, the wording of many mindfulness questionnaires overlaps with the jargon of mindfulness-based interventions (including terms such as *present-centered* and *nonjudgmental*) such that participation in an intervention may prime response biases in these measures (Van Dam, Hobkirk, Danoff-Burg, & Earleywine, 2012). These findings suggest that the interpretations of the items on a dispositional mindfulness scale can differ across groups in a way that clouds the very notion of dispositional mindfulness.

The confusing and even contradictory nature of these findings can be overcome by decomposing the rather monolithic notion of trait or dispositional mindfulness into more complex and dynamic processes describable through the model presented in the section "A Phenomenological Matrix of Mindfulness Practices." Our model is compatible with a notion of state mindfulness in that it represents a space of possible states where the duration of any given state is undefined. The link with a "state" of mindfulness of some duration must be understood as captured by the variance around some location in the model measured for some (arbitrary) period of time. Fully characterizing such states of mindfulness will require an integrated and careful description employing first-, second-, and third-person methods, including physiological measures by which to



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probe an individual's phenomenology in an online fashion along the dimensions we propose (see Varela, 1996; Petitmengin, Baulac, & Navarro, 2006, for methods). Instead of conceptualizing mindfulness as a unique and fixed state or trait, our view is that mindfulness training produces a family of identifiable phenomenological states in participants, which can shift. We propose that these states emerge due to the interaction of the processes subsumed within each dimension of the model.

In terms of traits, we do not reject the possibility that individuals reliably differ in their typical location on the dimensions of the model. The dimensions of the model, in fact, lend themselves to experimental assessments that can provide a robust way to characterize intrinsic individual differences as well as the impact of mindfulness-related practices.

Mindfulness as a soteriological path or way of life. In its second and broadest sense, mindfulness refers to a soteriological or spiritual path for cultivating wellbeing and alleviating suffering. This usage points to the Buddhist roots of mindfulness practices and the very broad and disparate use of the term in Buddhist contexts. The term most typically translated as "mindfulness" is *smṛti* (Sanskrit) or *sati* (Pāli), and, in both its technical and more common uses, this term has a semantic range that overlaps significantly with the English term *memory*. In its more technical uses, *smṛti* or mindfulness points to a fundamental capacity to retain an object in cognition, somewhat akin to working memory (Jha, Stanley, & Baime, 2010; Dreyfus, 2011). But as Rupert Gethin (2011) has pointed out, in its broadest sense, mindfulness also implies keeping in mind the larger context within which Buddhist practice occurs, including the motivations and goals for practice, and the ethical and aesthetic values that inform a practitioner's worldview. In short, in its broadest Buddhist sense, the term *mindfulness* often involves a Buddhist practitioner's commitment to a way of life and a stance toward experience that extends beyond any particular set of meditation techniques.

When brought into clinical and other secular contexts, the Buddhist notion of contemplative practice as therapy (see, e.g., *Sunakkhatta Sutta* in Ñāṇamoli & Bodhi, 2009) facilitates cultural translation, and it allows Buddhist techniques to be recontextualized within the personal goals and views of participants in modern-day mindfulness programs, often in ways that diverge noticeably from traditional Buddhist frameworks. At the same time, the notion of mindfulness as a way of life that extends beyond any particular technique has also played an important role in the development of mindfulness-based therapies (Kabat-Zinn, 1982; Teasdale et al., 2000). Jon Kabat-Zinn has noted (Williams & Kabat-Zinn, 2011) that mindfulness can be used as an "umbrella term" for a collection of practices and personal values that enable one to live mindfully. In MBSR (Kabat-Zinn, 1982), these practices include breath awareness meditation, body scan, walking meditation, yoga, didactic communication with an instructor, psychosocial support by group members, and attentive listening to inspirational texts (such as poetry). In keeping with this broad array of techniques, in MBSR the operational definition of mindfulness purposely remains somewhat broad. The intention in such an intervention is to avoid reducing mindfulness to any particular set of manualized techniques so as to allow participants to conceive of it in the larger sense of a stance toward experience or even as a way of life. This broad approach, both in terms of a conception of mindfulness and the use of multiple potentially therapeutic techniques including meditation, has been demonstrated to be clinically efficacious (see Dimidjian & Segal, 2015 in this special issue). However, we think that this way of using the term mindfulness may be too broad to guide empirical studies that specifically target underlying mechanisms of mindfulness practices. To achieve the latter, we propose a descriptive framework to help investigate the specific effects of these practices. In parallel with concerns regarding broad, but clinically useful, conceptions of mindfulness, we also suggest that it is not possible to state a single conception of the ethical and motivational stance or worldview presented to contextualize these techniques.

Mindfulness as a cognitive process. In a third sense, the term *mindfulness* describes core cognitive processes that are cultivated across various practices in mindfulness-based programs such as MBSR. This more technical use of the term parallels Buddhist usages, where the terms *smṛti* or *sati* are reinterpreted not just in the literal sense of "memory" noted earlier, but instead as a technical term for a cognitive capacity that can be cultivated in meditation (e.g., Gunaratana, 2002; Namgyal, Kunsang, & Rinpoche, 2004). The technical interpretation of mindfulness within Buddhism has engendered considerable debate among Buddhist theorists (Dreyfus, 2011; Dunne, 2011; Gethin, 2011; Olendzki, 2011; Teasdale & Chaskalson, 2011a, 2011b), but contemporary accounts from within

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psychology converge around some key themes. Along these lines, in 1994, Jon Kabat-Zinn proposed that mindfulness be operationally defined as “paying attention in a particular way: on purpose, in the present moment, and non-judgmentally” (Kabat-Zinn, 1994, see Kabat-Zinn, 2011, for a retrospective elaboration and informative interpretation of this phrase). This definition or its variants is reflected in much subsequent work such that in the psychological literature it is now generally accepted that, whatever else may be involved, mindfulness is necessarily present centered and nonjudgmental (see, e.g., Bishop et al., 2004; Chambers et al., 2009; Hölzel et al., 2011; Teasdale, Segal, & Williams, 1995). However, for the purposes of developing specific hypotheses about the effects and mechanisms of mindfulness, these two features are somewhat problematic. One problem is simply that these features are compatible with a wide range of practice styles. For example, although the style of awareness to be cultivated may be present centered, this does not indicate whether present-centered awareness is focused on a chosen sense-object (such as the sensations created by the breath at the nostrils), a mentally presented object (such as the visualization of a colored disk), or without any explicit chosen object (as in “choiceless awareness”). These three options characterize different styles of mindfulness practice, and these differences in practice style would impact empirical inquiry into mindfulness training owing, in part, to the training consequences of attention to these quite different targets.

Likewise, the term *nonjudgmental* can apply to various styles of mindfulness whose differences are also crucial to empirical inquiry. A nonjudgmental stance toward experience is generally construed to be nonreactive, where a reactive response is a thought or chain of thoughts that reflect a habitual and affectively charged pattern of response, often related to a particular self-related schema or narrative (e.g., Teasdale et al., 2002). The notion of being nonreactive is sometimes elicited by referring to such a stance as open or accepting (e.g., Hayes, 2004). If the term *judgmental* applies only to thoughts that are reactive in this way, then a nonjudgmental stance toward experience is compatible with styles of mindfulness that cultivate nonreactive observations or discernments that provide knowledge about the objects of experience and experience itself (e.g., Dreyfus, 2011). This stands in contrast, however, to those forms of mindfulness practice that emphasize the need to suspend any involvement in discursive thoughts whatsoever (Dunne, 2011, 2015). According to such styles, one does not seek to suppress thoughts, but one instead experiences thoughts just as mental events, rather than representations of reality. Adopting such a style of practice, one fails to follow the practice instructions if one seeks to cultivate any form of discursive thoughts or judgments, even when the discursive content consists of accurate and nonreactive observations about present experience, such as “I am agitated” (Chambers et al., 2009; Dunne, 2011, 2015).

The difficulty in specifying mindfulness as a cognitive process stems also from the drive to arrive at a single definition to cover all styles of mindfulness, and, in some cases, Buddhist sources have been used to support this type of monolithic definition (e.g., Hölzel et al., 2011). The history of Buddhist debates, however, shows that even in its original Buddhist context, no universally accepted definition applied to all styles of practice (see the special issue of *Contemporary Buddhism* edited by Williams & Kabat-Zinn, 2011). Instead, each Buddhist school or lineage sought to defend its own account of mindfulness, and this usually involved a critique of other approaches as somehow wrongheaded. If one heeds these arguments, one may conclude that there is only one true version of mindfulness (namely, the one supported by the particular Buddhist tradition that one has consulted), and one may fail to appreciate the full and diverse range of approaches to mindfulness even within Buddhism. It seems preferable to have analytical tools that enable one to explore various styles of practice—whether Buddhist or secular—in a way that can account for these variations and that also provide greater specificity than the operational definition mentioned above. With this in mind, we will now turn to one such tool.

A Phenomenological Matrix of Mindfulness Practices

To facilitate empirical research on mindfulness, we propose here a phenomenological matrix that serves as a heuristic tool for mapping various styles and stages of mindfulness practice into a multidimensional space. This approach avoids some of the problems evident in the various meanings of mindfulness sketched above. While these meanings remain useful for many contexts, we have noted that approaching mindfulness as a trait (Meaning [a] in The Meanings of Mindfulness section) leads to contradictory

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findings. Interpreting mindfulness as a soteriological process (Meaning [b]) is often too broad to guide empirical research. And up to this point, discussions of mindfulness as a cognitive process (Meaning [c]) make it difficult to account for differences in practice styles and levels of expertise, while also lacking the specificity required to formulate mechanistic hypotheses. The multidimensional phenomenological matrix proposed here addresses these problems, in part by decomposing mindfulness into different dimensions that can be used to map multiple practice styles and levels of expertise. A similar dimensional approach has been advocated for characterizing mental disorders (Hyman, 2007).

The approach presented here, which draws on previous efforts (Chambers et al., 2009; Hölzel et al., 2011; Lutz et al., 2008), focuses on the phenomenology of mindfulness practice. This model is elicited by a key question: when one is engaged in a formal mindfulness practice, what observable, instructable, and manipulable features of experience are most relevant to training in mindfulness? The seven features uncovered through this question will be discussed in detail below. They fall into two groups: (a) three primary, orthogonal dimensions: object orientation, dereification, and meta-awareness; *orthogonal* here means that the primary dimensions can change, at least locally, independently from one another; and (b) four secondary qualities: aperture, clarity, stability, and effort. The first three dimensions are "primary" in that they are main targets for all styles of mindfulness training and they likewise distinguish different styles. The next four are "secondary qualities" in that they describe highly relevant features of experience that are affected by mindfulness practices. All features are manipulable in that they are targeted—directly or indirectly—by the instruction set for the practice. According to traditional Buddhist accounts, trained practitioners can also report reliably on these dimensions (Dbaṇ-phyug-rdo-rje, 2009; Gunaratana, 2002; Namgyal et al., 2004; Ñāṇamoli & Bodhi, 2009). Because the dimensions in question are aspects of experience itself, the model is phenomenological. However, as is demonstrated in the second half of this paper, we maintain that by employing the methodology of neurophenomenology, one can generate fruitful hypotheses about neurophysiological and/or behavioral correlates or mechanisms for the phenomenology of mindfulness practices. In other words, one can guide one's research on the neurophysiology and neuropsychology of mindfulness by examining those practices phenomenologically in terms of the features of experience that they manipulate.

This multidimensional phenomenological model is not intended to be an exhaustive or exclusive account. One could produce a more detailed model, but likely at the expense of making this tool more difficult to use. Likewise, alternative accounts are possible, but we believe that the present model is well-suited to the present state of research findings. Overall, this model is especially inspired by the formal practices of mindfulness found in various contemporary contexts, including the many mindfulness-based therapies now in use as well as Buddhist practices in various traditions. Sources for this account are primarily the written instructions and descriptions found in the psychotherapeutic literature (Kabat-Zinn, 1990; Segal, Williams, Teasdale, & Kabat-Zinn, 2012), Buddhist traditional accounts (Dbaṇ-phyug-rdo-rje, 2009; Gunaratana, 2002; Namgyal et al., 2004; Ñāṇamoli & Bodhi, 2009), and contemporary meditation manuals (Goldstein & Kornfield, 2001; Suzuki & Chadwick, 2011), along with scholarly analyses of traditional practices (Anālayo, 2003; Bodhi, 2011; Dreyfus, 2011; Dunne, 2011, 2015; Gethin, 2011; Sharf, 2014; Van Schaik, 2004). As conveyed in Figure 1, points plotted in the model's multidimensional space are thus hypothetical, in that they are not yet supported clearly by phenomenological data gathered from practitioners. In keeping with the sources used, the phenomenological features of the various plotted states would be explicitly reported only by experts, and more inexperienced practitioners, lacking expertise in phenomenological description, would often require a probe or some other method such as an experimental task to enable adequate reporting about their states. This framework would be greatly enhanced by gathering first-person data from mindfulness practitioners at various levels, where the collection method would focus especially on the phenomenological features of engaging in formal mindfulness practice. However, such data are not yet available, and its collection remains an important desideratum for mindfulness research.

This framework is meant to serve as a heuristic to generate and communicate research hypotheses on the cognitive functions and neural mechanisms underlying mindfulness practices. To illustrate the use of the model, we map various styles of practice and levels of expertise, but their precise mapping in this space is necessarily provisional. The extension of this model to other forms of meditation or even other contexts is a tempting possibility, but one that is clearly beyond the scope of this article. This framework can also be used to describe maladaptive states found in mental disorders as also indicated in Figure 1. For the sake of simplicity, the present model restricts its mapping of mindfulness practices on specific dimensions of experience that are themselves related in complex ways to interactions among multiple neuroanatomical networks. A more comprehensive model would also account for the embodiment of these phenomenological dimensions (e.g., specific body postures, proprioceptive and sensory experience; see Kerr, Sacchet, Lazar, Moore, & Jones, 2013), embedded in a specific cultural/social context (as would occur in one's ethical or altruistic motivation, or in the context of a teacher/student relationship). Dynamical system theories (Clark, 1998) and recent formulations of "4E" cognition (embodied, embedded, extended, enacted cognition; Menary, 2010) could offer a promising framework to generalize the current approach to explicitly reference the body and the environment in the model at multiple levels.

In the remainder of this section, we will first note some key features that are shared by mindfulness practices, and then we will unpack the model's three functional dimensions and four qualities along with some examples of how various styles of practice and levels of expertise can be represented in the model's multidimensional space. The

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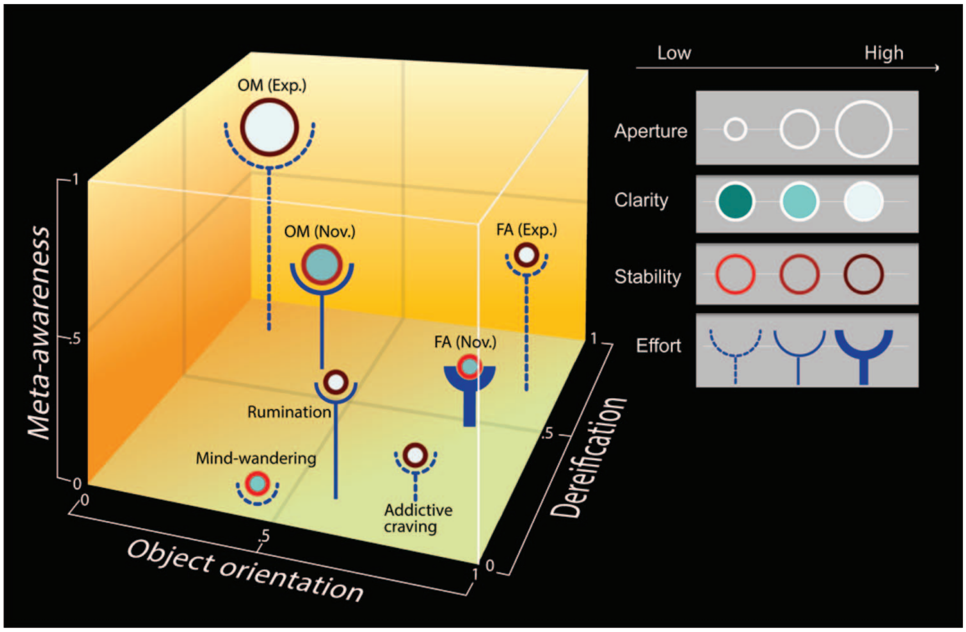
Figure 1
A Phenomenological Matrix of Mindfulness-Related Practices



Note. This figure maps two standard mindfulness-related practices, focus attention meditation (FA) and open monitoring meditation (OM), and three mental states (rumination, mind-wandering, and addictive craving) relevant for psychopathology on a multidimensional phenomenological space. Exp and Nov stand for expert and novice practitioners. The three primary dimensions of this space are object orientation, dereification, and meta-awareness. They are mapped on the Euclidian space. The four secondary dimensions correspond to the qualities of aperture, clarity, stability and effort. These four qualities are represented, respectively, by the diameter of a circle, fill color of the circle, color of the perimeter of the circle, and by the width of a supporting stalk. See text for details about the meditation states. Here, mind-wandering is represented as an effortless state (dashed line) of absorption (low meta-awareness) where the content of experience is phenomenally interpreted as accurate depictions of reality (low dereification). Addictive craving is depicted as a state strongly and repeatedly oriented toward the object of addiction (high object orientation). Rumination is represented as a state where the person is aware of stable intrusive thoughts (some meta-awareness) that are, however, still experienced as "real" (low dereification). See the online article for the color version of this figure.

remainder of this article will then explore the model and selected relevant research on mindfulness training (MT) in behavioral, cognitive, and neuroscientific terms.

Shared contextual features. The model proposed here assumes four general features that are shared across the family of practices that we identify as mindfulness-related. They are (a) physical posture, (b) nonaversive affect, (c) axiological framework, and (d) task-set maintenance or retention. While these features are necessary ingredients for mindfulness practice, they are not explicitly represented in the model because they are less significant in distinguishing styles of practice. Physical posture, for example, is generally understood to be a key element in practice, such that some postures are considered more useful than others when cultivating mindfulness in formal meditation. Nevertheless, most styles of mindfulness do not thematize training in physical posture as a targeted outcome of practice (note, however, the strong emphasis placed on posture in Zen practice).

Another common feature across most styles is the importance of a nonaversive affective tone. In contemporary clinical practice, practitioners are often taught that, as thoughts and feelings arise during mindfulness meditation, one should maintain an accepting or friendly attitude toward them (Bishop et al., 2004; Shapiro, Carlson, Astin, & Freedman, 2006). Likewise, the Buddhist *Vipassanā* style brought to North America from modern Burma often emphasizes the importance of cultivating loving-kindness (Pali, *mettā*) along with mindfulness. Although this explicit emphasis on loving kindness does not appear to have been an element in Burmese practice itself (Fronsdal, 1998), traditional textual sources do maintain that, for meditation practice, one must sustain an attitude of nonaversion (Pali, *adosa*)—a term that can be interpreted to mean loving kindness (Buddhaghosa, 1976). In the Tibetan practices that can be construed as styles of mindfulness, such as one-pointed focused-attention (FA) meditation and *Dzogchen* meditation, a session of formal meditation inevitably includes the cultivation of compassion (Van Schaik, 2004), and although some other Buddhist traditions such as Zen may not explicitly thematize compassion or loving kindness, they often use aesthetic appreciation as a means to generate the appropriate affective context for meditation practice (Carter, 2007). Thus, although mindfulness meditation can be embedded within a wide range of affective frames (such as acceptance, loving-kindness,

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compassion, nonaversion or aesthetic appreciation), important to the practice is a common assumption of the need to cultivate a positive—or at least nonaversive—affective attitude.

Similarly, under the rubric of "axiology" fall a range of contextual factors concerning the values, goals, and especially the ethics that inform mindfulness practice. Again, many approaches are possible, and even within Buddhism, traditions disagree about the precise goals and ethical frameworks for contemplative practice (Dunne, 2015). In modern clinical contexts, issues such as ethics are often left implicit, in part because mindfulness is often framed in terms of a notion of secularity that construes ethics as a personal matter (McMahan, 2008). Nevertheless, even when ethical or spiritual issues are downplayed due to concerns about secularity, mindfulness interventions are often still delivered within an implicit framework of values and ethics (Wilson, 2014). Across all of these axiological approaches—whether they be the explicit ethics of Buddhist traditions or the implicit values of a clinical intervention—one common element appears to be the motivation to reduce suffering (Wilson, 2014).

These various contextual features all relate to "task-set maintenance or retention," a final shared aspect of mindfulness practices that is not articulated separately in our model. In its broadest sense, this global feature of mindfulness involves the capacity to sustain the context created by physical posture, affective tone, and axiological concerns. It also includes the retention of the specific practice instructions for formal meditation. As noted, while task-set retention influences and is supported by the dimensions of meta-awareness and stability, it is best conceived as a global process that emerges from the interaction of all dimensions of mindfulness.

Functional dimension 1: Object orientation. This dimension, which is modulated by many styles of mindfulness, concerns the phenomenological sense that an experience or mental state is oriented toward some object or class of objects. By object, we mean here that one is aware of some particular thing. This intentional object can arise through perception, memory, or imagination. It is crucial to note that the relevant phenomenological feature is not the actual selection of an object, but rather the sense that the state is strongly (or weakly) oriented toward an object, even when no object is clearly selected. For example, when one is seeking to find a person in a crowd, off-target objects (e.g., other persons) do not present themselves phenomenally as strongly selected, but the state nevertheless seems to bear strongly on an object, namely, the person sought. This construct parallels endogenous orienting of attention in psychology which is manipulated by displaying a cue or other instruction indicating, for example, where in space a target is likely to occur (Posner & Petersen, 1990). This specific aspect of object orientation has also been studied, for instance, in the so-called omitted stimulus paradigm using event-related potentials (Tarkka & Stokic, 1998). An example from FA meditation may include attention focused on the arising of thoughts (see descriptions in the section Focused-attention [FA] meditation). With practice, one can perceive a gap in the arising of thoughts, during which the practitioner maintains the orientation of the mind toward the field of awareness where thoughts had arisen.

On this dimension, a high magnitude occurs in states of high selective-focus on an object, as in advanced FA styles of meditation or in some spontaneous states such as erotic fantasy and desire. Low magnitude occurs with mind-wandering ("zoning out"; see Figure 1), or in some meditation states that result from deliberately reducing any intentional stance toward objects. This includes some styles of open monitoring (OM) practice (see Figure 1 and descriptions in the section on Open-monitoring [OM] meditation). Some Buddhist traditions maintain that object orientation can be suspended entirely in certain meditative states (Dbaṇ-phyug-rdo-rje, 2009).

Functional dimension 2: Dereification. The dimension of dereification reflects the degree to which thoughts, feelings, and perceptions are phenomenally interpreted as mental processes rather than as accurate depictions of reality. For example, during rumination, a script including thoughts such as "I am a failure" may arise, and when it does, it can appear to be an accurate description of oneself such that a depressed mood is enhanced or sustained (see *rumination* in Figure 1). Or when thinking about a stressful conversation that occurred yesterday, the series of thoughts that represent the event in one's mind may present themselves as a replaying of the memory of the conversation, to the point that a physiological stress response is induced. Likewise, when thinking about one's favorite food, the thoughts that represent the food can be taken to be real in such a way that one salivates (see *addictive craving* in Figure 1). These are all instances of high reification, in that thoughts present themselves as if the objects or situations they represent are occurring in the present moment. At a higher magnitude on the dimension of dereification, as would occur with training involving OM styles of meditation, creative problem solving and perspective taking may be enhanced (Colzato, Ozturk, & Hommel, 2012). These skills involve the capacity to engage flexibly with different lines of thought without reifying any particular line as the only solution and without feeling emotionally attached to one particular interpretation. At the highest end of this dimension, thoughts lose their representational integrity and are experienced simply as mental events, situated and embodied within a field of sensory, proprioceptive, affective, and somatic feeling tones. This is one reason that many mindfulness practices may emphasize attention to bodily sensations as a gateway to promote awareness of this embodied field. For instance, the awareness of subtle fluctuation of bodily sensations associated with a particular thought may result in its eventual dereification.

The dimension of dereification involves a capacity that occurs without explicit training. For example, the moment of becoming aware that one is daydreaming includes the recognition that although the daydream may seem real, it is actually just a series of thoughts or impressions in phenomenal experience. Losing the capacity to

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represent reality, the internal train of thought in the daydream dissipates. In our view, all styles of mindfulness meditation train this capacity deliberately, and in the psychological literature on mindfulness, dereification is referred to as "phenomenological reduction" (Varela, 1996) or simply "mindful attention" (Papies, Barsalou, & Custers, 2012). As will be explained later, it is also a key component of "decentering" (Williams, 2010), "cognitive defusion" (Hayes, 2004), or "metacognitive insight," whereby "thoughts are perceived to be transient, insubstantial mental events rather than accurate representations of reality" (Chambers et al., 2009, p. 562).

To accomplish dereification, one may begin by using a cognitive reappraisal such as "This is just a thought." In many formal mindfulness practices, an ability to perceive thoughts in this way is developed over the course of dealing with distractions that perturb focus on the target object, and novices often use this form of reappraisal to disengage from distractors. In these instances, the process of dereification is developed as an element of a reappraisal process. But as training progresses, dereification can be sustained as a stance toward experience without relying on frequent reappraisals. In some more advanced practices, the explicit focus on an object is dropped in favor of a state that involves sustaining an awareness of the field of experience itself without any explicit object (see the discussion of OM in the Open-monitoring (OM) meditation section). In such practices, dereification may be spontaneously maintained just by sustaining the meditative state.

Some authors such as Hölzel and colleagues (2011) describe a phenomenon similar to dereification as the "disidentification with the static sense of self" whereby, at a novice level, "mindful, nonjudgmental observation fosters a detachment from identification with the contents of consciousness." We understand this to be a species of the more general capacity for dereification, in which phenomenal content is experienced as just a mental process. Disidentification targets specifically the way those mental contents are involved in the construction of a static sense of self, but this does not occur with all cases of dereification. For example, in dereifying the memory of a stressful argument, one perceives the recollection of the event as actually a series of thoughts; experienced in this way, the memory no longer induces stress. Such dereification, however, does not require that one's sense of being a static self has changed. For a similar example involving images of food, see Papies and colleagues (2012).

Functional dimension 3: Meta-awareness. The dimension of meta-awareness involves monitoring of experience. It has been defined as the mental state that arises when attention is directed toward explicitly noting the current contents of consciousness (Schooler, 2002; Smallwood & Schooler, 2015). A canonical example of meta-awareness is realizing that one's mind has wandered (Schooler, 2002). This definition has intuitive appeal due to its commonality, but it provides little descriptive information about the phenomenology of this experience. Specifically, it does not distinguish between an introspective, inward turn of attention and a background awareness of features of experience outside the current focus of attention. In the former case, the contents of awareness are perceived by directing attention inward. In the latter case, with respect to an instance of mind-wandering, a subtle feeling of conflict might emerge in consciousness while one's attention still maintains its focus on the stream of thoughts that comprise the mind-wandering episode. The awareness of this conflict may occur prior to turning inward and becoming aware of being off-task itself as an object. In this way, and as will be described later, we understand this background awareness to be the basis for the inward turn that constitutes introspection, and we likewise maintain that background awareness always occurs within the context of some task-set.

The capacity of background awareness is critical in all forms of mindfulness practice, but it is especially important in so-called OM meditation (Lutz et al., 2008), where it can be primed by instructions such as "let go of expectations," or "rest the mind in awareness."

Background awareness includes the capacity for features of experience to be noticed while a person *simultaneously* maintains a primary focus on a given object. In the context of a Stroop task, for example, one can become aware of the sense of conflict created by the incongruent semantic content of the Stroop stimulus (e.g., the word *blue*) even while remaining focused on the color of the stimulus (e.g., red ink). To further illustrate this point, imagine the following: A subject is given the instruction to gaze at a picture and report on the age of the person in the picture. The picture shown, however, depicts a person in deep distress with a gruesome injury that induces a strong affective reaction in the subject. If the subject follows the instruction and focuses on the picture so as to assess the age of the individual, the subject will not be deliberately attending to any affective reaction to the picture. Nevertheless, if asked to report on their affective state afterward, the subject can still do so effectively. The capacity for this reporting thus occurs without any deliberate inward turn of attention, in that the experience of viewing the image arises in such a way that, without any additional effort, it already includes the information that enables one to make a subsequent report about features of the experience (such as one's affective response) that are not about the visual object itself (i.e., the skin wrinkles used to gauge age).

As noted earlier, this capacity to detect the "background" or lived subjective context of one's object-focused experience contrasts with an "inward turn" of attention, often characterized as "introspection," or retrospective second-order judgment (Fleming & Dolan, 2012; Overgaard & Sandberg, 2012). In introspection, one explicitly turns one's attention inward and observes one's affective state or other such phenomenally inward features. In contradistinction to introspection, background awareness permits, within the experience of an object focus, access to other aspects of experience beyond the object *without* making the inward turn that occurs in metacognition when one thinks about one's mental processes. For instance, while watching a beautiful sunset, having a low-level of background awareness means that the perceiver is exclusively immersed in the visual object, whereas having a high-level of background awareness means that the perceiver can also simultaneously access other features of experience such as an affective tone of awe. Through background awareness, one can likewise be aware of co-occurring environmental stimuli such as sounds, smells, and climactic conditions. This awareness of off-object features of the experience occurs without losing focus on the object itself.

Furthermore, in this model, the introspective turn of attention is often preceded by a moment of background awareness in which some off-object feature of the experience becomes salient and redirects attention inward. For example, in the context of mindfulness of breathing, one might remain focused on the sensations of breathing and yet still notice a feeling of agitation; at that point, one might then introspect so as to examine the agitation. In such cases, background awareness can be viewed as a process constitutive of introspection. On the basis of this line of interpretation, we maintain that meta-awareness can actually be sustained (e.g., in OM meditation), whereas the example of sudden awareness of mind-wandering would suggest a phasic event.

This account of meta-awareness, whereby it is tied to background awareness, leads to testable predictions. For example, in this model, off-object features should be spontaneously integrated in experience without decreasing the discriminability of the visual scene. As such, increases in background awareness should augment the ability to detect distraction, assess the stability of attention, and monitor corporeal and affective tones in a manner that does not interfere with, and likely supports sustained focus on an object or task.

As noted, this account of meta-awareness as including background awareness assumes that it always occurs in the context of task-set retention, a capacity closely linked to working memory (Varela, 1996). Consider, for example, the task-set consisting in voluntarily focusing on a visual target for a long period. After some time, an auditory event might capture one's attention. In the case of low background awareness, the capture of attention by the sound is not explicitly noticed because attention is absorbed in the object (which is now the auditory event, and not the visual target) with little attention devoted to the background. The occurrence of the sound may then initiate an episode of mind-wandering, such as a chain of thoughts about the source of the sound. Provided that the original task-set is being retained, at some point the background awareness will become sufficiently strong that the conflict between the task-set and the information provided by background awareness will become salient, such that one notices that one is thinking about the sound instead of focusing on the visual target. This experience would correspond to a moment of meta-awareness of mind-wandering.

In contrast to a case with low background awareness, a person with a high degree of background awareness will more easily detect that the unexpected sound has disturbed the central focus on the task-set. In this case, we would expect that the combination of high background awareness and strong retention of the task-set would inhibit the mental elaboration associated with the sound and enable reestablishment of the task more quickly, with less effort, and with a smaller felt impact of the distraction (see the section entitled Qualitative dimension 3: Stability).

As articulated here, meta-awareness can thus be understood as the interaction between the information provided by background awareness and the context of its interpretation as provided by the retention of a task-set. Thus, meta-awareness operates within the moment-to-moment trajectory, or retention (Varela, 1996), of a task-set, voluntary or not, which can create its motivational and intentional contexts and which provides the framework within which contents detected by background awareness become salient. Compared to the traditional definition of meta-awareness, the present conceptualization allows meta-awareness to be studied as a sustained and graded process and to be investigated as an embodied, intentional, and dispositional lived process.

Task-set retention is a feature of all meditation practices, in that any practice minimally requires the retention of the instruction set that constitutes the meditation, but some meditative styles involve a task-set that is especially conducive to the training necessary for the cultivation of background awareness. For example, FA styles involve a task-set that requires practitioners to sustain attention from moment-to-moment on a selected object. Background awareness is thought to be enhanced through such practices by intentionally maintaining a well-defined task-set that requires practitioners to sustain focus on an object while still monitoring the quality of their attention on the object (Anālayo, 2003; Dbaṇ-phyug-rdo-rje, 2009; Dunne, 2011, 2015; Gethin, 2015).

The notion of task-set retention is related to the Buddhist terms *sati* (in Pali) or *smṛti* (in Sanskrit), when they are understood not in their broad usage, but rather in the narrow sense of retention articulated in technical Buddhist works on mind and cognition (Dreyfus, 2011). The notion of background awareness relates to Buddhist analyses of "reflexive awareness" (Sanskrit, *svasaṃvitti*) and also to the term *samprajanya* (Sanskrit), when it is used in the technical sense of "monitoring" (Dunne, 2015). However, it is important to note that the distinction between these two notions is not always explicit in Buddhist accounts, and our notion of meta-awareness as involving the interaction of task-set retention and background awareness is not meant to map directly onto any Buddhist theories.

It is also important to note that in Buddhist sources, background awareness is not always clearly distinguished from dereification, such that the meta-awareness of thoughts is sometimes understood to dereify thoughts. This tendency to treat meta-awareness and dereification as identical also appears in the psychological literature, where accounts of "cognitive defusion" (Hayes, 2004) and "decentering" (e.g., Fresco et al., 2007) do not clearly distinguish these capacities. However, in a phenomenological account of mindfulness practices, it is important to differentiate meta-awareness from dereification because high meta-awareness can occur without dereification. For example, some subjects with anxiety disorders will have a

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heightened background awareness of bodily states such as an elevated heart rate, and that awareness can itself trigger a series of thoughts connected to anxiety, where the heightened background awareness is being interpreted in terms of an implicit task-set about avoiding threats. Because these thoughts are taken to be actual depictions of reality, they serve to heighten or sustain the anxiety (see the mapping of a ruminative state in Figure 1 as an illustration). In order to represent such cases, where heightened meta-awareness can even be dysfunctional, for our purposes, dereification must be, by definition, separated from meta-awareness.

In terms of the developmental trajectory that occurs with meditation practice, at the lower level of meta-awareness that occurs in novice practitioners of FA, these practitioners do gain an increased capacity to report on how often they are distracted, but unlike experts, they do not detect minor perturbations in attention before those perturbations develop into full-blown distractions; likewise, novices are likely not able to report reliably on more finely grained aspects of experience such as subtle affective features. One traditional claim is that expertise in meta-awareness (e.g., through training in an OM style of meditation) permits broad and finely grained access to the phenomenal features of the context, background, self-related, or affective frame within which an object is being held in mind, and with sufficient expertise, this state can be sustained for some period without any explicit object focus (Dbaṇ-ph-yug-rdo-rje, 2009).

Qualitative dimension 1: Aperture. The aperture dimension reflects the broadness of the scope of attention and is identical to the classical optical analogy of the "spotlight of attention" (James, 1890) and Broadbent's (1958) filter model of attention. Aperture can be either narrow (small circle on Figure 1), as during concentrative practice with a well-defined object such as the breath (e.g., FA on Figure 1), or wide open (large circle), as during "choiceless awareness" meditation (e.g., OM Figure 1).

Qualitative dimension 2: Clarity. Clarity refers to the degree of vividness with which an experience occurs. In experiences with strong object orientation, vividness manifests as a sense that an object is especially clear or salient. This construct is in line with the fact that attention can change contrast appearance (Liu, Abrams, & Carrasco, 2009). It is also in line with the notion of visual vividness in the particular case of mental imagery. During depressive rumination, for instance, the object of attention will usually be phenomenally more vivid than during mind-wandering (Gold, Jarvinen, & Teague, 1982). In cases of high clarity with high meta-awareness, other, nonobject features of the experience, such as affective tone, will seem vivid or intense. In many styles of mindfulness practice, expertise always involves high clarity, but because a high degree of clarity or vividness can destabilize a beginner's meditation, clarity is also deliberately modulated with techniques that increase or decrease it as needed (Namgyal et al., 2004).

Qualitative dimension 3: Stability. As a phenomenal feature, stability indicates the degree to which experience presents itself as persisting over time. Stability refers to either a spontaneously arising state or an intentionally cultivated state. An example of a spontaneous state with high stability is persistent rumination. An example of high stability in an intentionally cultivated state is FA meditation on an object when its content, for instance, a visualized colored disk, presents itself phenomenally as highly stable and not easily perturbed across time. In other mindfulness styles, a stable state need not always be one in which the phenomenal contents are unchanging. For example, in OM styles such as choiceless awareness, the moment-by-moment flow of changing thoughts and sensations may appear as the phenomenal content, but the targeted contemplative states— one high in meta-awareness and low in reification—may be stable and unperturbed from the practitioner's phenomenal standpoint when attending to this aspect of experience.

Another way to conceptualize this dimension with respect to intentional cultivation of specific states is in terms of task-set retention or maintenance. In this context, stability is a proxy term for the degree of maintenance of a given task-set. Although stability may be equally high during a spontaneously arising state and an intentionally cultivated state, these will be distinguished in the model by being in nonoverlapping locations along other dimensions (see Figure 1, expert FA meditation vs. rumination).

In psychology, similar constructs have been studied, for instance in research on trial-to-trial variability in behavioral or neurophysiological measures of vigilance (Lutz et al., 2009; Zanesco, King, Maclean, & Saron, 2013), or in the recovery function in response to aversive stimulation (Schuyler et al., 2014).

Qualitative dimension 4: Effort. This dimension refers to the phenomenal impression that one's current mental state is easy or difficult to sustain. When effort is high, a deliberate attitude of control is present, whereas when effort is low, the state seems to require little deliberate intention to be maintained. Due to the limited capacity of voluntary attention, it is difficult to sustain a high degree of effort. A large body of studies has investigated the consequences of sustained effort. One of the consequences of sustained effort expenditure is ego depletion, which lowers one's capacity to inhibit maladaptive responses to environmental challenges (Baumeister, 2003). Thus, cultivating expertise that is behaviorally adaptive with lower required effort will likely enhance a meditation practitioner's capacity to integrate multiple dimensions of the intended goals of practice (e.g., cultivation of equanimity and compassion). Maintaining such a meditative stance in daily life with little effort could increase the frequency by which a practitioner is able to monitor and inhibit maladaptive responses to experiential challenges. Effort can be measured by parametrically manipulating motor or cognitive task demands while collecting self-reports (e.g., Schmidt, Lebreton, Cléry-Melin, Daunizeau, & Pessiglione, 2012). Mindfulness practices generally require a careful modulation of effort; initial stages of practice require considerable effort, but as practitioners advance, the continued application of too much effort can be an obstacle.

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Focused Attention (FA) and Open-Monitoring (OM) Meditations as Examples

The functional and qualitative dimensions mentioned earlier can be used to plot specific states in different styles of mindfulness practice within the phenomenological space represented by Figure 1. Our approach provides tools for researchers to map multiple states emerging from different styles of practice at different levels of expertise. It is important to note that the same set of mindfulness instructions could lead to noticeably different points in the phenomenological space due to individual differences between practitioners, including the way that they interpret and implement instructions. Thus, practitioners with the same mindfulness instructions may plot differently in the space, while phenomenological data of those who receive different instructions might produce similar plots given sufficiently overlapping phenomenal accounts. Likewise, development from novice to expert could differ significantly, with different developmental pathways leading to the same phenomenological results. For these reasons, effective use of this tool requires that researchers avoid the temptation to equate mindfulness instructions with any particular phenomenological state. Each instruction set (or traditional description) might explicitly state or imply some ideal phenomenological characteristics of the target mindful state, and plotting these target states can be useful. Nevertheless, the actual phenomenal experience of practitioners is likely to differ from any ideal target.

By way of example, we have plotted the hypothetical phenomenological characteristics of FA and OM styles of practice at both novice and expert levels. These plots have been produced based on various instruction sets and descriptions, and they should not be taken as actual plots of any individual's phenomenology. FA and OM, moreover, are themselves broad categories that encompass a wide range of practices. While hypothetical plots of this kind can be useful, in actual use, plots would primarily be generated through phenomenological data gathered from subjects supplemented by experimental observations from tasks designed to assess location along a given dimension. In short, such plots are to be taken simply as illustrations that require the support of actual data obtained from phenomenological and experimental inquiry.

Focused-attention (FA) meditation. In our examples, FA novice practitioners have somewhat elevated meta-awareness and dereification. They are strongly focused on an object with considerable effort, but only middling in clarity and stability, and the aperture of focus is fairly narrow (see Figure 1). Typically, the FA practitioner is instructed to sustain selective attention moment-by-moment on a specific object with a fairly narrow focus such as the sensations caused by the breath at the nostrils or abdomen. For novices in particular, distractions occur readily, and practitioners must develop enough meta-awareness to notice the occurrence of distractions, and they must have the capacity for enough dereification to disengage from distractors and reorient attention to the object.

As practitioners advance in FA practices, most accounts suggest that their capacity for both meta-awareness and dereification increases as a result of practice. Perturbations in attention can be noticed before they become full-blown distractions, and dereification of distractors occurs quickly and easily. In comparison to novices, experts experience greater clarity, as evinced, for example, in the capacity to notice finely grained features of the object. Stability on the object increases to a high degree, and overall, the state involves much less perceived effort.

Open-monitoring (OM) meditation. The other style of practice plotted in the figure is OM (for an overview, see Goldstein & Kornfield, 2001; Gunaratana, 2002; Lutz et al., 2008; Namgyal et al., 2004; Suzuki & Chadwick, 2011). This category also encompasses a wide range of practice styles that share especially an emphasis on the cultivation of meta-awareness. Often, practitioners begin with an FA practice, through which they initially calm the mind and reduce the effect of distractions. As FA advances, the cultivation of meta-awareness as a monitoring skill becomes the main point of transition to OM practice. One aims to remain only in the monitoring state, attentive moment-by-moment to anything that occurs in experience without focusing on any explicit object. When FA is used to transition to OM, the practitioner gradually reduces the focus on an explicit object, and the monitoring faculty is correspondingly emphasized. Although the enhancement of the monitoring use of meta-awareness continues until no explicit focus is maintained, the monitoring itself does not create any new explicit focus. Thus, while in FA the monitoring through meta-awareness detects the affective tone of a state as a background feature of the primary focus, in OM, the affective tone is detected with little or no explicit selection of an object. Because phenomenal effort is said to induce object selection, OM instructions often emphasize a release of effort as crucial to the state.

As plotted in the Figure 1, the hypothetical phenomenology of a novice OM practitioner involves reduced object orientation, as the novice emphasizes meta-awareness and decreases focus on objects. Meta-awareness is thus increased relative to an FA novice, and because effort would increase object selection, effort is reduced. The capacity for dereification, which is crucial to reducing focus on objects, is also increased relative to an FA novice. Lacking expertise, the novice experiences a medium degree of clarity and stability. To the degree that object orientation remains, the phenomenal sense of aperture is broad.

The hypothetical plot of the OM expert involves an even broader sense of aperture with a pronounced reduction in object orientation. Expertise especially requires a high degree of meta-awareness (the main target of OM practice), and it also involves a high level of dereification commensurate with the greatly decreased object orientation. Hypothetically, in the OM expert both dereification and meta-awareness are increased relative to FA expert, as these qualities are more explicitly trained by OM practice and an excess of meta-awareness could perturb the FA expert's focus on an object. Effort for the expert is minimal, and the

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state is markedly stable. Finally, the expert experiences high clarity, with a finely grained awareness of affective tone and its flux, and a capacity to report accurately on the state's features, such as clarity and stability.

A Neurocognitive Investigation of Mindfulness Practices

This section explores the phenomenological matrix of mindfulness through the lenses of psychology and cognitive and affective neuroscience. Here, we relate the phenomenological model presented earlier with representative research on mindfulness practice and training from behavioral, physiological, anatomical, and neuroimaging perspectives. We do not assume that a one-to-one mapping between these phenomenological dimensions and activity in specific brain regions is plausible because studies concerning emotion and cognition have shown that brain regions' functions are inherently multidimensional and that structurally different regions can perform the same function (Pessoa, 2014). Instead, we assume that multiple mappings between phenomenology and brain function are possible, but whatever mapping is used will necessarily assume a many-to-many relationship between brain functions and phenomenological features. Next, we briefly describe three neural networks that are often reported in research on mindfulness or in studies that are directly relevant to the dimensions described in our model (Fox, Spreng, Ellamil, Andrews-Hanna, & Christoff, 2015; Tang et al., 2015). They are the central executive network (CEN; Corbetta & Shulman, 2002; Posner & Petersen, 1990), the default mode network (DMN; Gusnard, Raichle, & Raichle, 2001; Raichle et al., 2001), and the salience network (Seeley et al., 2007). This section then reviews observations obtained in mindfulness research in many contexts, including while practitioners are at rest, engaged in formal practice, engaged in experimental tasks or experiencing daily life.

We have chosen to focus on these particular networks because, among the various possible approaches, these networks are particularly useful for relating the model's seven phenomenological dimensions to neural mechanisms. In other words, this approach is especially useful for suggesting ways that researchers can generate empirically tractable hypotheses about various styles of mindfulness practice. Again, we explicitly do not wish to reduce any of the phenomenological dimensions to one brain network, as any one-to-one mapping between phenomenological dimensions and brain structures or brain networks is arguably highly problematic (Anderson, 2014).

Putative Neural Networks Implicated in Mindfulness Training

The central-executive network (CEN). The first network of interest in our approach is the CEN or so-called dorsal top-down attentional system. The CEN refers here to the bilateral dorsolateral prefrontal cortex (PFC), ventrolateral PFC, dorsomedial PFC, and lateral parietal cortices (Seeley et al., 2007) including also rostrolateral PFC (Fleming, Weil, Nagy, Dolan, & Rees, 2010). The CEN is responsible for selection, planning, and decision making in the context of goal-oriented behavior, as well as for maintaining and manipulating information in working memory (Miller & Cohen, 2001). These functional roles of the CEN likely subserve the capacity to select, orient, and maintain an object in the mind, and this relates to the object orientation dimension. The CEN is also relevant to the capacity for moment-to-moment monitoring of experience, an aspect of the meta-awareness dimension.

Default-mode network (DMN). The second network of interest is the DMN. Anatomically, the DMN encompasses regions in the anterior and posterior midline (posterior cingulate cortex [PCC] and precuneus and within the medial PFC), the lateral parietal cortex, and the medial temporal lobe (Gusnard et al., 2001). This "default network" was initially identified during passive, uncontrolled tasks (Gusnard et al., 2001) and is consistently observed at rest using intrinsic functional connectivity MRI measures. The function of the default mode has been related to participants' spontaneous thoughts or mind-wandering (Fox et al., 2015; Mason et al., 2007). Regions of the DMN are also typically activated during tasks that ask participants to engage in internal mentation such as mentalizing, projecting oneself in the future, self-referential thought or decision making (Amodio & Frith, 2006; Andrews-Hanna, Reidler, Sepulcre, Poulin, & Buckner, 2010; Buckner & Carroll, 2007). Overall, this network is hypothesized to play a role in building and updating internal models of the world based on long-term memories about the self or others. The DMN is not monolithic and can be anatomically and functionally fractionized into subnetworks, where the midline core (PCC, and anterior medial PFC) are the central hubs of this network (Andrews-Hanna et al., 2010). Considering that the functional role of this network is complex and spans multiple functional domains, its specific involvement in mindfulness-related practices is likely to be highly context-specific and modulated by one's meditation-related worldview and the specific practices in which an individual engages. Some styles of mindfulness practice actively seek to cultivate a form of suspension of discursive thought, or a sense of one's social self, particularly when the focus of the meditation is a sensory object like the breath (e.g., FA meditation). As reviewed later, being engaged in such practices tends to reduce brain activity in this network. By contrast, this set of regions may not be deactivated during other forms of mindfulness practice such as OM meditation, which does not actively suppress discursive thinking. OM practice emphasizes monitoring the process of discursive thinking: noticing the arising, appearance, and disappearance of thoughts. Activity in DMN during these practices is largely unknown.

The salience network (SN). The third network of interest is the SN, which comprises the bilateral anterior insulae and the dorsal anterior cingulate cortex (Seeley et al., 2007). The SN also includes subcortical structures, namely, the amygdala and the substantia nigra/ventral tegmental area, which are important for detecting emotional and reward saliency. The SN largely overlaps with the so-called bottom-up/ventral attentional system

(Corbetta & Shulman, 2002) involved in signaling behaviorally relevant incoming stimuli. The SN plays a critical role in detecting and orienting the organism toward salient external or internal events in a bottom-up fashion. In one model, the SN acts to break or switch the current attentional focus upon the occurrence of an unexpected event (Corbetta & Shulman, 2002; Seeley et al., 2007) to facilitate the flexible and adaptive access of a salient internal stimulus (e.g., pain) or external event (e.g., unexpected visual event) to the CEN. Extending this view, Craig (2009, 2010) and Damasio (Damasio, Everitt, & Bishop, 1996) proposed a model where the insula, in interactions with the thalamus and brainstem (Damasio & Carvalho, 2013), instantiates, from moment-to-moment, high-order neural representation of all subjectively perceived feelings central for subjective awareness or "conscious presence" (see also Seth, Suzuki, & Critchley, 2011, for a recent mechanistic model). In this view the anterior insulae/dorsal anterior cingulate cortex acts as a hub whose activity is correlated with changes in subjective feeling states and that flexibly connects not only with fixed anatomical pathways (e.g., amygdala, right temporoparietal junction), but also dynamically integrates a broad variety of neural systems (e.g., Jabbi, Bastiaansen, & Keysers, 2008). This broader model accounts for salient and alerting affective states, such as fear, which activate the sympathetic automatic nervous system, but could also instantiate parasympathetic-related affective states such as calm, positive feeling (Craig, 2010).

This broader functional conceptualization of the SN, referred to sometimes as the "sentient self" network, is in line with some key aspects of the meta-awareness dimension that occur in the immediacy of the present moment. Aspects of the moment-to-moment monitoring capacity in mindfulness practices are likely to involve also the dynamical interplay between the SN and the subcomponents of the CEN that play a role in monitoring, integrating, evaluating, and maintaining information beyond the immediate present (lateral PFC). The specific role of the SN and CEN in meta-awareness capacity and metacognition/introspection, as presented earlier, need further investigation (see a recent discussion in Fleming & Dolan, 2012).

The Phenomenological Matrix of Mindfulness as a Heuristic

The phenomenological framework aims to serve as a heuristic tool to generate scientific hypotheses. As a caution, it is critical to temper the phrenological temptation to reduce the model, in a neuroscientific context, to any specific brain network. Theoretically, as contemplative expertise develops, corresponding changes in brain function will not be exhibited in single, isolated networks or brain regions. Rather, such changes will be expressed in the reorganization of interrelated, coherent large-scale networks, and as such network-level descriptions likely are the most useful explanatory level for capturing some key features of highly practiced meditative states (Lutz & Thompson, 2003).

Despite the somewhat arbitrary nature of the phenomenological coordinates depicted in Figure 1, a central hypothesis of our model is that the relative position of these practices in the phenomenological matrix (PM) reflects neurophysiological bottlenecks arising from access, conflict and resources within and between these networks during meditation practice. For instance, within the PM framework, we posit that FA meditation for novices demands a high value along the object orientation dimension that initially reduces the resources allocated to the meta-awareness dimension. This relationship is somewhat reversed during OM meditation (see Figure 1).

We predict that, when a practitioner's phenomenology remains steadily in a particular location in the phenomenological space of the model during a meditation session, this experiential state will be associated with brain activity that includes a specific functional relationship between CEN, SN, and DMN. An important prediction from this approach is that these functional relationships are plastic and should shift as a result of meditation training. This hypothesis is illustrated in Figure 1 by FA meditation experts showing a high value in object orientation and stability, as well as a relatively high value in meta-awareness. While this proposal is still largely speculative in the context of meditation research, it is now a plausible prediction in light of research on spatially independent patterns of intrinsic brain networks (Calhoun & Adali, 2012; Jack et al., 2013) and by an alteration of these patterns in clinical populations such as depressed or anxious patients (Menon, 2011). The potentially reciprocal nature of activation of these large-scale networks and their functional roles have started to be explored in the context of meditation sessions or meditation expertise, and is a promising avenue of research (Hasenkamp & Barsalou, 2012).

Next, we provide a selective overview of current findings from studies examining mindfulness research from behavioral, physiological, anatomical, and neuroimaging perspectives. We have thematically organized them along the dimensions of the model, with a particular focus on these three networks to determine if a research base in support of our model is emerging.

Role of Object Orientation in Mindfulness-Related Practices

A growing literature reports improvements in attention and working memory with mindfulness training (for a recent review, see Tang et al., 2015). In line with this, studies investigating the neural effects of MT report functional changes in nodes of the CEN (e.g., Brefczynski-Lewis, Lutz, Schaefer, Levinson, & Davidson, 2007) as well as downstream sites within sensoriperceptual cortices on which the CEN exerts top-down modulation of activity (e.g., Kerr et al., 2013). Here is a selective review of key findings revealing mindfulness-related changes in attention and working memory, as well as mindfulness-related changes in neural nodes of the CEN, emphasizing in particular its connection with the object orientation dimension of the model.

We propose that of the myriad components of attention and working memory that have been identified, endog-

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enous attentional orienting is most akin to the object orientation dimension described herein. Endogenous attentional orienting refers to voluntarily directing attention to a specific (selected) stimulus. In addition to its role in externally directed attention to guide input-level perceptual processing, endogenous orienting is critical for internally directed attention via encoding and maintenance of information in working memory (see Jha, 2002). To determine if endogenous orienting is indeed akin to the proposed object orientation dimension, we delineate four prominent functional markers of orienting (Mangun, 1995) and review evidence suggesting that MT may improve the efficiency of these identified markers.

One functional marker of endogenous orienting is improved performance. In the Attention Network Test (ANT, Fan, McCandliss, Sommer, Raz, & Posner, 2002), for example, the orienting subsystem of attention is characterized by faster target detection reaction times for those targets appearing at locations at which attention was directed prior to the target onset versus targets appearing at unattended locations. Comparisons between a group receiving an 8-week mindfulness training course akin to MBSR to a no-training control group revealed more efficient orienting scores after training for the MT versus control group (Jha, Krompinger, & Baime, 2007; see also Hodgins & Adair, 2010; van den Hurk, Giommi, Gielen, Speckens, & Barendregt, 2010). Jha and colleagues (2007) reported that after training, MT participants were specifically faster than controls on the spatial cue condition of the ANT, suggesting greater efficiency in willfully directing attention to the cued location for fast target detection. This pattern has not been found during shorter-form MT (Tang et al., 2007), a 1-week retreat (Elliott, Wallace, & Giesbrecht, 2014), or found to be different from incentivized control (Jensen, Vangkilde, Frokjaer, & Hasselbalch, 2012). Further studies are warranted to explore the impact of MT dose, experience, and motivation as it relates to behavioral measures of attentional orienting.

A second marker of endogenous orienting is greater evoked neural activity to stimuli containing attended versus unattended features. Attended features are those determined, a priori, by the task-set, to be relevant for the task at hand. In tasks requiring detection of a target of a particular color, for example, endogenous attention is proposed to be willfully oriented toward internal representations of that color. The amplitude of early evoked activity within visual cortex is larger for stimuli comprising the attended versus unattended color. In a recent study by Moore, Gruber, Derose, and Malinowski (2012), participants were given a Stroop task that required them to report the color of the ink regardless of the color word containing the ink. MT-naïve participants were recruited to participate in an MT training program for 16 weeks, which required 10 min of mindful breathing exercises daily. The event-related potentials (ERPs) to congruent and incongruent words were measured for the training group and a no-training control group. While responses were unchanged over time in the control group, the MT group demonstrated greater amplitudes in the so-called N200, or N2, ERP, in left occipito-temporal sites, suggesting improved selection for target colors used in the Stroop task. No differences in N2 amplitude were found between congruent and incongruent words. These results suggest that MT may improve early, perceptual feature processing, in line with the known effects of attentional selection for color. In addition, synchronous activity in EEG studies of attention report that orienting of attention increases phase locking of theta activity (e.g., Sauseng, Hoppe, Klimesch, Gerloff, & Hummel, 2007), and recent studies of MT in long-term retreatants reported greater phase locking to T2 (the second target) in an attentional blink task (Slagter et al., 2007). From these data, the suggestion is that MT positively affects preferential processing of attended stimuli during tasks that require fast conscious access to the information.

A third marker of endogenous attentional orienting is biasing of activity in early perceptual neurons. Changes in alpha power (7–14 Hz) are an electroencephalography (EEG) signature of neural biasing as a result of attentional orienting. Greater alpha power is observed in electrodes tracking unattended versus attended information, prior to presentation of the stimulus itself. Recently, Kerr and colleagues investigated if an 8-week MBSR course in MT-naïve participants might improve the efficiency of this biasing of baseline activity using magnetoencephalography (Kerr et al., 2013). Participants were cued by the word *hand* or *foot* to indicate which body part would be subsequently receiving somatosensory stimulation. After training, the MBSR group, relative to controls, demonstrated greater alpha oscillatory power within the hand area of somatosensory cortex after being presented with the word *foot* relative to the word *hand*. The authors interpreted this finding as reflecting improved biasing of cue-triggered activity after MT.

A fourth neural marker of endogenous orienting is engagement and reliance on frontal and parietal cortices in the service of attentional orienting. When these regions are damaged or temporarily disabled, there are performance impairments in the ability to disengage attention from the attended locations, as seen in disorders like visual neglect (Driver, Baylis, & Rafal, 1992). Recently, Hasenkamp, Wilson-Mendenhall, Duncan, and Barsalou (2011) tracked brain activity in the CEN when experienced meditators engaged in a mindfulness of breathing exercise during functional MRI (fMRI) scanning. During the period of time when participants indicated that they were disengaging attention from nontask related mental content and engaging attention toward the mindfulness exercise, increased activity was observed in the CEN, with large right-lateralized clusters in the lateral PFC (dorsal and ventral) as well as the lateral inferior parietal cortex. These data are consistent with longitudinal findings from a 3-month training with FA meditation that demonstrated increases in EEG activation within frontal and parietal electrodes during mindfulness of breathing as assessed by oscillatory EEG activity (Saggar et al., 2012).

These four markers of endogenous attentional orienting are typically described in the context of orienting to "objects" as units of information comprising specific per-

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ceptual or conceptual form. Yet, the CEN has been found to support orienting to information about goal and mood states as well (Ochsner & Gross, 2005). Regardless of the specific features of the information (i.e., a perceptual form or a goal state), endogenous orienting is critical for the maintenance and manipulation of this information over time. This capacity, known as working memory, has been found to increase with mindfulness training (e.g., Jha, Stanley, Kiyonaga, Wong, & Gelfand, 2010; Mrazek, Franklin, Phillips, Baird, & Schooler, 2013).

Working memory is also used in the service of keeping task goals active over a protracted period of task engagement. From this perspective, if mindfulness training improves working memory, there may be an improved ability to keep attention engaged in the task at hand, instead of mind-wandering to task unrelated thoughts. Recent studies have found that, indeed, mindfulness training reduces mind-wandering indexed by self-report and task performance measures (Morrison, Goolsarran, Rogers, & Jha, 2014; Mrazek et al., 2013; Zanesco et al., 2013).

In addition to reduced mind-wandering, an improved ability to orient and maintain attention to ongoing task goals may improve conflict monitoring, which is the ability to detect deviations away from the current task goal. A short-form training program with goals and instructions related to a mindfulness training, known as integrated mind–body training, was found to reduce conflict monitoring scores on the ANT (Tang et al., 2007). One explanation for this improvement in conflict monitoring is that MT improved endogenous orienting, allowing for better selection of target information and better maintenance of task goals, so that deviations away from these goals was less frequent. In support of this supposition, improved sustained response inhibition was observed after 3 months of FA training and related to improvements in self-reported psychological adaptive functioning (Sahdra et al., 2011).

While there are principled reasons to attribute improved conflict monitoring scores or reduced mind-wandering to improvements in endogenous attentional orienting with mindfulness training, it is unlikely that the object orientation dimension acts alone to produce benefits. Conflict monitoring could improve because of a reduced emotional reactivity associated with detection of an error, which could be due to improvements in the dereification dimension. Similarly, performance improvements could result from improvements in meta-awareness; with better meta-awareness allowing for course corrections following errors, for example. Thus, the dynamic, interactive nature of the dimensions will require further consideration.

Role of the Dereification Dimension in MT

Lessening of the reification of thoughts as true depictions of reality through mindfulness practice can have large effects on the strategies individuals use in coping with psychological and physical suffering. One of these strategies is the regulation of experiential avoidance, a common consequence of chronic pain. In the first report of the clinical use of mindfulness training to mitigate the effects of such pain, Kabat-Zinn (1982) stressed the fundamental utility of patients learning to observe thoughts as simply events in the mind with no a priori truth value. That is, by using formal meditation practice to develop a stance toward thoughts not as reflecting the nature of reality, but as passing mental phenomena, patients were better able to view thoughts about pain (e.g., "It's killing me," "This will never end" "I can't stand it") as separate objects and not statements of truth. This dereification process, in Kabat-Zinn's words, "appears to produce a spontaneous (and momentary) uncoupling of the sensory component of the pain from the affective and cognitive dimensions" (p. 35) that contributed to significant reductions in subjective pain ratings. That such learning can be sustained in the long term is supported by 3-year follow-up results of an MBSR intervention for the treatment of fibromyalgia pain (Grossman, Tiefenthaler-Gilmer, Raysz, & Kesper, 2007). A recent critical review of the mindfulness intervention for pain literature finds that 9 of 11 studies of clinical pain found significantly lower pain intensity ratings after mindfulness-based interventions (Reiner, Tibi, & Lipsitz, 2013). While these clinically significant findings point to the utility of MT, they cannot be unambiguously attributed solely to dereification processes. Mechanistic studies of the constituent processes responsible for efficacy are in their infancy.

These findings are, however, supported by experimental work focused on another aspect of understandable, though often maladaptive coping—defensive or self-protective anticipation of upcoming painful stimuli and responses to actually painful stimuli. In an electrophysiological study of pain anticipation, Brown and Jones (2010) found markedly lower anticipatory activations of multiple cortical structures in meditators generally engaged in FA and mindfulness practices compared to a nonmeditating control group. Grant, Courtemanche, and Rainville (2011) examined fMRI activations in response to accurately cued warm and painful stimuli in long-term Zen practitioners and age-matched controls. The meditators showed increased pain tolerance compared to controls and increased sensory-related activations in anterior cingulate cortex, thalamus, and insula in response to painful stimuli, which were accompanied by *decreased* activations of CEN and structures including the PFC, amygdala, and hippocampus. Further, lower pain sensitivity was predicted by decreased functional coupling between CEN and pain sensory-related regions. These authors interpret these findings as neurophysiological evidence in favor of the instantiation of a nonevaluative stance toward strong sensation in the meditators, directly in alignment with Kabat-Zinn's (1982) articulation. In concert with this finding, Lutz, McFarlin, Perlman, Salomons, and Davidson (2013) examined responses to anticipatory and stimulation-related responses to thermal pain in expert practitioners of open presence meditation. Lutz and colleagues found increased pain-related activations in the dorsal anterior insula and anterior midcingulate in practitioners, even though they rated the experience as less unpleasant than controls. However, in contrast with Grant et al. (2011), there were marked reductions in these areas during anticipation of pain compared with novice meditators. Lutz et al. (2013) stress the nonevaluative, accepting, moment-to-moment experiential stance cultivated by the investigated practices as eliminating the conditions that establish the anticipatory anxiety normally felt when aware of impending physical pain.

Examining the effect of MT on responses to social evaluative threat represents another way in which dereification, particularly with respect to judgments about oneself in relation to others' expectations, may account for observed effects of diminished physiological responses to acute social stressors (for a meta-analysis of the standard response to social evaluative stressors see Dickerson & Kemeny, 2004). In a highly controlled randomized longitudinal study, Rosenkranz et al., 2013 examined physiological stress responses before and after the Trier Social Stress Test (TSST, Kirschbaum, Pirke, & Hellhammer, 1993) in individuals before and after completing an 8-week MBSR course. The subjects in the MBSR course were compared to an active control intervention carefully matched to the structure and nonspecific social context of MBSR, where the program for the active control group that has itself been shown to promote wellbeing without explicitly training mindfulness (Health Enhancement Program [HEP]; MacCoon et al., 2012). Capsaicin was used to induce an inflammatory skin response and applied at the start of the TSST. While skin blister proinflammatory cytokines (interleukin 8 and tumor necrosis factor alpha) and salivary cortisol responses did not differ by group after training, the area of the neurogenic inflammatory response (reddening or flare) was potentiated after HEP but not MBSR. In addition, the diurnal slope of cortisol responses was steeper in the MBSR compared with HEP groups after training, a pattern associated with improved cognitive and psychological functioning (Rosenkranz et al., 2013). The observation of no flare sensitization in the MBSR group suggests that the mindfulness training buffered against the explicit social-evaluative threat of the TSST. Such an effect may hinge upon effective dereification of negative self-perceptions within a classic scenario of the imposition of the judgments of unfeeling authority figures, a major component of the TSST.

In line with these results, in a randomized active control (health education) longitudinal study of compassion-based meditation, Pace et al. (Pace et al., 2010; Pace et al., 2009) found decreased interleukin 6 and cortisol activations after the TSST in the meditation training group, but only for those who practiced above the median amount of meditation sessions per week. A major component of the instruction in this study was to motivate an understanding that "instinctive emotional responses to others do not reflect reality" (Pace et al., 2009, p. 90).

Dereification is also central in mindfulness-related research on, and treatment of, depression. Mindfulness-based cognitive therapy (MBCT) specifically treats ongoing ruminative processes that tend to occur even when acute episodes resolve—notably, these ruminative processes are associated with increased probability of relapse. In this context, dereification, or decentering (Barnard & Teasdale, 1991; Segal et al., 2012; Teasdale et al., 1995) refers to the ability to observe repetitive negative thinking as a temporary and impersonal process in the mind. This decentering capacity is thought to be a core protective mechanism against the increased proliferation and accessibility of negative self-related content, which is known to increase risk for recurrence and chronicity in depression. As such, MBCT has repeatedly been shown to effectively prevent depression relapse (Segal et al., 2010; Teasdale et al., 2000), as extensively reviewed in Dimidjian and Segal (2015) in this special issue. In a novel study that modeled repetitive negative thinking (memory bias recall), Van Vugt, Hitchcock, Shahar, and Britton (2012) found that when individuals with recurrent depression who were in complete or partial remission underwent MBCT, they had more positive and less negative recollection bias for memorized lists of valenced words. The authors interpreted these findings as evidence that MBCT decreases the "stickiness" of negative ruminative thoughts and depressogenic thinking while increasing the probability of positive associations.

Little is known within neuroscience about the mechanism of dereification. As reviewed earlier, the DMN is activated during processes that engage the "thinking mind" or the "social self" and should be downregulated during the dereification (or decentering) of thoughts. In support of this possibility, Pagnoni (2012) noticed differences in the skewness of the fMRI blood-oxygen-level-dependent (BOLD) signal in ventral posteriomedial cortex, a region of the DMN, between experienced Zen meditators and meditation-naive controls who were engaged in attention-to-breathing meditation (i.e., FA meditation). They proposed that that the relative frequency of states of elevated ventral posteriomedial cortex activity (e.g., the skewness) was lower in meditators during this task, which would be expected if there were less spontaneous task-unrelated thought processes occurring; in addition, the same parameter also predicted behavioral performance on a task measuring sustained attention conducted outside the scanner. Similarly, Brewer and colleagues (2011) found that the DMN, in particular the PCC, was deactivated when experienced meditators were engaged in various styles of meditations including open awareness, (a form of OM). Furthermore, functional connectivity analysis revealed stronger coupling in experienced meditators between the PCC and regions of the CEN both at baseline and during meditation. The authors argued that these brain patterns are consistent with alleged decreased mind-wandering as a result of meditation training.

In addition to the literature on mind-wandering, some insight can be gleaned from related psychological constructs like reappraisal. The distinction between reappraisal and dereification is that dereification occurs when mental content (such as the thought, "I may fail my exam") is no longer experienced as representing reality. In this example, the worry about the exam, if effectively dereified, would be replaced by the sense of knowing that this was just a thought without inherent predictive validity. In contrast, reappraisal would be when the thought, "I may fail my exam" is replaced by thoughts such as, "My whole grade

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doesn't depend upon this exam," or "I've done well on homework and have studied hard, so I should do ok."

In this account, momentary dereification may also be an element of the reappraisal process itself. As is the case with "self-distancing" (Kross, Duckworth, Ayduk, Tsukayama, & Mischel, 2011; Kross, Gard, Deldin, Clifton, & Ayduk, 2012), dereification may facilitate elimination of an earlier interpretation of mental content and enable the new interpretation provided by the reappraisal process. With this in mind, we note that revising one's initial perception of a picture of an injured person as being just a picture taken from a movie (reappraisal) typically down-regulates the activity of subcortical affective regions like the amygdala (Urry et al., 2006). The reappraisal process brings into cognition more awareness of the interpretive thinking that ordinarily contributes to the subjective unquestioning sense of the picture as depicting real events.

A high reification value (an unquestioning sense of reality about one's mental representations) could thus be implemented by high engagement of the emotion or cognitive appraisal systems coupled with a uncontrolled activation of prefrontal brain regions implicated in affect generation (Disner, Beevers, Haigh, & Beck, 2011). Lack of regulatory control over emotion or cognitive appraisal is a hallmark of most psychopathologies. For instance, addiction (see Figure 1) and depression are two disorders characterized by high reification of craving or worrisome thoughts, respectively. There is growing evidence that addiction-related greater-than-normal activity in reward circuitry (Peters, Kalivas, & Quirk, 2009), and likewise unregulated activation of fear and other emotional appraisal systems associated with depression are manifestations of maladaptive appraisal processes (Disner et al., 2011). Similar neuroscientific models of maladaptive appraisal processes have been proposed in anxiety (Etkin & Wager, 2007) and risk-taking behavior in adolescence (Ernst & Fudge, 2009). This form of emotion regulation is modulated by other prefrontal networks that are part of the CEN, or SN (Ochsner & Gross, 2005). The recruitment of such networks could mediate cognitive aspects of dereification such as the disengagement of attentional resources from the reifying process. In this framework, the dereification of the perceived object or process should reduce the mental absorption into the object (for a recent example see Papies et al., 2012). In line with this literature, Westbrook et al. (2013) demonstrated how just the briefest training in mindfulness can have important effects on the experience of craving and activation of craving-related brain regions in smokers actively desiring to quit. Similarly, in a randomized 8-week longitudinal study, Desbordes et al. (2012) examined amygdala responses to positive, neutral, and negative pictures from the International Affective Picture System after training in mindful attention, cognitively based compassion training or a health-education control condition. Sixteen hours of mindful attention training (MAT) and a mean of 10 hr of meditation practice was found to significantly decrease right amygdala activation to the images overall, and specifically to positive images. No change in right amygdala response was found for either the cognitively based compassion training or health education groups. These data suggest that MAT (including both FA and OM components) can facilitate down regulation of emotional arousal. Lower emotional arousal to picture stimuli may represent a present-centered attention to the stimuli as the documentary evidence they represent, rather than an occasion for viewing them as evocative of the emotional states they represent. In this sense MAT may provide a basis for a kind of dereification of participants' normative empathic responses to the stimuli.

Taken together, despite the paucity of data, accumulating evidence suggests that various aspects of dereification or decentering are associated with changes in BOLD activity in brain regions activated during the appraisal of thoughts or emotions.

Role of Meta-Awareness Dimension in MT

Research on meta-awareness and MT is still in its infancy. Thus, this section remains largely provisional. As reviewed earlier, the SN is likely to play a role in implementing key aspects of meta-awareness that occur in the immediacy of the present moment. The moment-to-moment monitoring capacity emphasized in mindfulness practices are likely to involve the dynamic interplay between SN and the subcomponents of the CEN that play a role in monitoring, integrating, evaluating and maintaining information beyond the immediate present. The meta-awareness dimension reflects the ability to detect distraction, assess the stability of attention, and monitor corporeal and affective states in a manner that sustains focus on an object or task. As displayed on Figure 1, meta-awareness is expected to gradually increase as a result of FA meditation and to be the central feature of practices in OM meditation (e.g., for a beginner *Vipassanā* practitioner, or a participant in MBSR; see Lutz, Brefczynski-Lewis, Johnstone, & Davidson, 2008). As will be reviewed, meta-awareness in meditation has started to be explored in relation to protocols measuring present-centeredness and nonreactive awareness of sensory or affective events, and in relation to tasks measuring the monitoring of mind-wandering and of error-awareness.

Several studies have explored the idea that MT-related improvement in meta-awareness increases meditators' awareness of bodily signals. Empirical results that support this proposal are still mixed. In support of this idea, Farb et al. (2007) found that focusing in the present moment after an MBSR intervention compared to being engaged in self-related narrative processes enhanced activity of interoceptive signals in areas such as the insula and secondary somatosensory cortex and reduced activity in DMN linked to self-related thoughts. The authors also reported increased connectivity between the insula and a portion of the CEN (dorsolateral PFC), and decreased connectivity between the insula and a portion of the DMN (medial PFC). Counter to this hypothesis, two behavioral studies reported null findings. Khalsa et al. (2008) did not find that experienced meditators had a better performance on a heartbeat detection task, a standard measure of interoception. In a more recent study Melloni et al. (2013) replicated these

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null effects and reported that meditators and novices that completed a MBSR intervention did not differ from nonmeditators on cardiac interoceptive sensitivity. The authors proposed that this negative finding is partially be due to the fact that awareness of heartbeat sensations is not cultivated explicitly in mindfulness meditation and proposed that another visceral source (other than cardiac one) may be necessary to disentangle the influence of meditation on interoceptive sensitivity. Daubenmier, Sze, Kerr, Kemeny, and Mehling (2013) also replicated such null effects overall, but go on to report specific measures of respiratory interoception, which are significantly better in meditators versus nonmeditators.

As OM meditations specifically foster a nonreactive awareness of the stream of experience without deliberate selection of a primary object (e.g., a painful sensory sensation), another common prediction is that such bare awareness reduces the elaborative thinking that is typically stimulated by evaluating, avoiding, or rejecting an unpleasant experience (see also the Role of the Dereification Dimension in MT section). In line with this idea, Slagter et al., 2007 reported that 3 months of intensive OM meditation reduced elaborative processing of the first of two target stimuli (T1 and T2) presented in a rapid stream of distracters, as indicated by a smaller T1-elicited P3b, a brain electrical potential index of resource allocation. Moreover, this reduction in resource allocation to T1 was associated with improved detection of T2 compared to before the retreat and compared to the control participants. This finding suggests the meta-awareness might reduce the propensity to "get stuck" on a target, as reflected in less elaborate stimulus processing and the development of efficient mechanisms to engage and then disengage from target stimuli in response to task demands. This regulation should particularly reduce emotional reactivity during experiences like physical pain by cultivating an effortless, open, and accepting awareness of the painful sensation, without reacting or being absorbed in the contents of the experience such as negative mentation or avoidance feelings which precede or follow nociception. In support of this prediction, Perlman, Salomons, Davidson, and Lutz (2010) found that expert meditators experienced less unpleasantness in response to a painful thermal probe when cultivating OM instead focusing their attention away from the painful sensation. The specific role of meta-awareness and dereification in pain regulation needs further elaboration. Figure 1 shows how the meta-awareness dimension is presumably higher during OM than FA practices.[1]

The practice of OM is frequently preceded by FA meditation on a selected object (e.g., the breath sensation, see Figure 1). FA aims at gradually developing concentration and rapidly detecting distraction, but also to enhance the meta-awareness faculty. Meta-awareness in this context can be operationalized as the monitoring faculty that remains vigilant to distractions and that detects episode of mind-wandering. Exploring this idea, a recent study (Allen et al., 2012) asked meditation practitioners during FA meditation on the breath to report when they had realized their mind had wandered. Consistent with previous reports (Mason et al., 2007), episodes of mind wandering were associated with activity in the DMN, whereas awareness of mind wandering activated the SN. Along this line, the study of an error awareness task (EAT) offers another experimental strategy to measure meta-awareness. During one version of EAT, a stream of color words is presented serially in incongruent fonts. Participants received training to respond to each word by pressing a button on go trials and to withhold this response during no-go trials. Under specific experimental conditions, participants tend to forget to withhold and have to report the awareness of error by pressing another button. Allen et al. recently used the EAT task outside the scanner and an affective Stroop task (i.e., using negative images like a snake) to explore this possibility in a well-matched randomized longitudinal study pre/post a 6-week meditation intervention (Allen et al., 2012). While Allen et al. did not find a significant Group × Time interaction on EAT performance measures or the fMRI results, they showed that individual differences in practice adherence in the meditation group predicted improvements in EAT response inhibition, which has been linked to activation of anterior insula and cingulate cortex. Interestingly, the amount of meditation practice also predicted recruitment of the SN for these participants when processing negative stimuli in the scanner. Allen et al. proposed that the progressive development of a meditation skill might be correlated with a gradual recruitment of the bottom-up attention system for cognitive control. Together, this accumulating evidence indicates that mindfulness training affects processes related to meta-awareness and that the SN is repeatedly recruited during these processes. Direct neural and behavioral evidence for a meditation-related improvement in meta-awareness is still needed.

Empirical Evidence for Secondary Qualities in the PM

There are few studies on the secondary qualities in the PM, as briefly reviewed here.

Secondary dimension 1: Aperture. A promising approach to study the aperture dimension is to compare FA and OM practices (see Figure 1). While FA usually maintains a narrow aperture toward a selected object, aperture is specifically broadened during OM practice. Van Leeuwen, Singer, and Melloni (2012) recently compared aspects of this feature during these two practices by measuring the speed of allocation of spatial attention to a global pattern compared to a local detail during a standard global-to-local task (Navon, 1977). During this task, participants are usually faster at detecting the global target than the local one, the so-called global precedence effect. As predicted, during this task, meditators with FA training responded faster to a local feature than controls, but this effect was significantly reduced after an OM retreat. Com-

[1] In meditation systems like Mahamudra or Dzogchen, the maximum in this dimension, above OM, is reached during "nondual" practices, akin to open presence meditation (for details, see Lutz, Dunne, & Davidson, 2006).

pared to novices, another group of meditators trained in both FA and OM disengaged their attention faster from the dominant global level. Overall, these findings suggest an enhanced ability for meditators to allocate and adjust the focus of attention between global and local levels. This ability was linked to enhanced neural processing of target level information, as measured by ERPs. Future research is needed to expand this research from assessing the size of a visual aperture to characterize also changes in the aperture encompassing the field of awareness itself.

Secondary dimension 2: Clarity. The phenomenal construct of clarity presented here parallels the cognitive notion of visual vividness, as studied in the particular case of mental imagery. Little is known regarding the neural correlates of clarity. Interestingly, the activation in insular cortex during compassion meditation was a function of the phenomenal clarity of the meditation as verbally reported (Lutz, Brefczynski-Lewis, Johnstone, & Davidson, 2008). In line with improvements in perceptual clarity, MacLean et al. (2010) reported improvements in visual perceptual thresholds in the context of a sustained attention continuous performance vigilance task after three months of intensive FA retreat experience compared to a matched control group. This finding was replicated when the control group engaged in their own 3-month retreat.

Secondary dimension 3: Stability. Stability refers to the capacity to sustain attentional engagement on a specific task over a period of time. Decreases in attentional stability are associated with disorders such as attention-deficit/hyperactivity disorder and schizophrenia (e.g., Castellanos, Sonuga-Barke, Milham, & Tannock, 2006), where performance impairments and response time variability are key indices of impaired stability. There is growing evidence that attentional stability increases with mindfulness training. In a study by Lutz et al. (2009), those who had completed a 3-month intensive retreat demonstrated improved stability on a task involving detection of target tones. Retreat participants versus controls had reduced response time variability and enhanced theta-band phase consistency over anterior brain areas, both suggesting an improved ability to maintain attentional engagement over time. In addition to behavioral and neural effects, there is evidence that perceptual stability is also improved with meditation training. In a study by Carter et al. (2005), adept practitioners were found to have prolonged rivalry dominance in a binocular rivalry task compared to durations observed in nonmeditators. This effect was only observed during or after periods of FA but not compassion meditation practice. Recently, Zanesco et al. (2013) also found decreased response time variability during a response inhibition task after 1 month of intensive *Vipassanā* practice (very similar to the training examined in Lutz et al., 2009) compared to a meditation-experience-matched control group. Decreased reaction time variability was associated with training-related increases in participants' felt concentration, suggesting phenomenological aspects of meditation experience explicitly cultivated during training are related to behavioral performance. These results suggest that intensive meditation training may improve attentional stability, but it may be exclusive to intensive training that emphasizes FA as well as OM practices.

Secondary dimension 4: Effort. The subjective feeling of effort or exertion is well-studied in cognitive science in the context of physical or mental effort. For instance, manipulating task demand to increase difficulty is typically associated with increase BOLD activity in CEN and subcortical reward circuitry (Schmidt et al., 2012). Little is currently known about subjective effort during meditation. Tang et al. (2007) found a marked global reduction in regional cerebral blood flow, paired with enhanced behavioral measures of attention following integrated mind–body training, which deliberately cultivates a form of effortless attention, but not following a relaxation training. In the context of more active attention-related practice such as FA, the standard claim from contemplative traditions is that attentional control becomes gradually effortless with expertise (illustrated in Figure 1). In support of this claim, one study observed an inverted *U*-shaped curve in CEN activity in expert and novice meditators during FA in which those learning a skill initially had increased activation, yet eventually showed less activation (Brefczynski-Lewis et al., 2007). This finding is consistent with the idea that at the most advanced levels, the regulative skills are invoked less and less frequently, and the ability to sustain focus thus could become progressively experienced as subjectively effortless.

The study of effort in meditation must also control for test effort resulting from demand characteristics (e.g., meditators being more invested in the outcomes of the study than the controls). Jensen et al. (2012) elegantly outlined this methodological issue by assessing MBSR-related improvement in attentional performance in comparison to control participants who either received financial incentive or not. As hypothesized, controls with financial incentive significantly outperformed controls without incentive, and their performance was comparable to the MBSR group on some measures. Despite this confounding effect, the MBSR group still outperformed the two groups of controls on measures of selective attention and visual working memory ability. The authors concluded by raising a cautionary concern about many of the observed findings on attention in the mindfulness literature.

Summary

There has recently been a broad and growing enthusiasm for drawing on contemplative practices as a potential strategy to study the human mind, to reduce mental distress, increase wellbeing and psychological health, and recently, to improve educational practices (Davidson et al., 2012). Along with this growing interest, there is a risk that oversimplification and lack of rigor with regard to the construct of mindfulness will hamper this nascent field of research.

Here, we have selectively reviewed the growing body of evidence from clinical research, neuroscience, and cognitive science on mindfulness practices and explored the opportunities and challenges of contemplative science, especially in relation to mindfulness practices. We have done

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so in three steps. First, we discussed conceptual issues related to the transdisciplinary and multidisciplinary nature of this emerging field of research. We then addressed these issues by proposing a novel phenomenological and neurocognitive framework for investigating the effects of mindfulness practices. One major utility of this approach was to provide a descriptive language that may enable cross-field understanding and mechanistic exploration of the processes underlying the effects of mindfulness-based interventions and practices. Finally, we used this framework to review representative physiological, anatomical, and neuroimaging research on mindfulness training and practice.

Methodological Limitations of Mindfulness Research

The results cited herein were selective, anchored around the working model we proposed. A broader outgrowth of this effort is to promote a critical perspective on the research base within the emerging field of contemplative neuroscience. Extant critiques emphasize methodological limitations such as the lack of randomized placebo-controlled designs, the lack of specificity on instructor qualifications, and the limitations in documenting the integrity or amount of training, including accurate record of practice time (see Goyal et al., 2014). While these are certainly areas in which the field needs to advance beyond the few examples that exist to date (e.g., MacCoon et al., 2012), there are other issues that need to be addressed in future work, including individual differences in benefits and their underlying mediators, biases against publishing null effects or negative effects—such as null effects on interoception capacity (Khalsa et al., 2008) or working memory (Morrison et al., 2014)—uncharacterized dose-response profile, possible aversive effects (e.g., Kennedy, 1976), and greater specificity of the processes and mechanisms that are targeted by training. Thus, there is much work ahead and methodological rigor must grow in this regard.

A prominent concern that the lack of methodological controls may inflate the frequency or magnitude of reported benefits of contemplative training is certainly valid. Jensen et al. (2012) recently investigated this methodological issue by investigating the specificity of MBSR-related effect on attention. Comparing MBSR to four control groups, they found that some MBSR-induced effects were confounded by test effort, while some of these effects remained specific to MBSR training. More broadly, general conclusions that "contemplative training," described in monolithic and underspecified terms, produces or fails to produce salutary effects is also problematic. For example, Goyal et al. (2014) conclude that their meta-analyses revealed that attention and positive mood do not change with meditation training. This is problematic for three reasons. First, attention and mood were not targeted dimensions of the contemplative training that was provided in the majority of the clinical studies they reviewed. Second, the metrics used to index training-related change lacked precision. Attentional measures in many studies were akin to neuropsychological tools used to index brain damage, more so than precise experimental manipulations that target specific aspects of attention, such as improved perceptual sensitivity or response inhibition. Third, metrics used to index change may not have accounted for the changing nature of the construct that was being probed, such as "positive mood." While hedonic pleasure may have been considered positive before training, eudemonic joy may better capture positive mood after. In sum, greater precision in defining the components and targets of training paired with metrics to best index isolated, identifiable, and potentially mutable component processes may help advance this research.

Finally, a critical issue—yet one that has not yet been critically investigated—concerns a fundamental question: Regardless of the domains targeted by any specific instruction, what do individuals actually do when they engage in any contemplative practice? This question bears on both intra- and interindividual differences. As with any skill, how and what one practices is generally determinative of later outcomes. In this regard, recognized experts and articulate teachers can provide essential insights as to their own process of learning and practice. It is, we believe, imperative that future research prioritizes the development of nuanced first-person methods to better characterize how individuals engage with indicated instructions and practice contexts in ways that may ultimately better account for observed outcomes, whatever their valance and magnitude.

Future Directions of Research

The proposed framework serves as a heuristic and provisional tool to generate mechanistic hypotheses. Future research will be required to identify independent physiological and behavioral markers of each of these dimensions. Further, some of the dimensions could be split into subdimensions. For instance, the object orientation dimension could be subdivided along different aspects of attention (sustained, selective, disengagement) or implicit or explicit working memory (see Teasdale & Chaskalson, 2011a, 2011b). The meta-awareness dimension could be subdivided along different aspects of metacognition (i.e., retrospective judgment about one's cognition) or reflexive awareness. The dereification dimension could be subdivided and extended into aspects related to the content of experience from aspects related to the nature of subjective experience itself. The current model is only a first step toward characterizing the understanding that one gains through mindfulness meditation about one's habits and assumptions about personal identity and emotional responses. The recent interest in investigating the effect of contemplative practices on children and adolescents (Davidson et al., 2012) could offer a promising research opportunity to disentangle these dimensions by virtue of the possible interaction of developmental changes and locations along these dimensions.

For the model to have empirical utility, phenomenological descriptors will need to be developed and data collected using first- and second-person perspectives in a way that can locate an individual's phenomenological experience of mindfulness meditation within the model space. This means that the methods of phenomenological inquiry must probe the model dimensions, whether directly or

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indirectly. One future challenge will be to investigate how a practitioner from a given meditation tradition will be able to map meditative 1st-person categories into this model. A multidisciplinary approach will be mandatory.

This model is predicated upon the idea that first-person categories across a group of individuals can eventually be related to patterns of activity in multiple brain networks as well as to behavioral measures on tasks appropriately designed to tap locations along model dimensions. As reviewed here, aspects of this neuroimaging program of mapping meditative practices have already started. These premises should also be tested using a model-free approach to identify independent spontaneous networks, independently of first-person data, or by causally manipulating these networks (e.g., using transcranial magnetic stimulation). This approach could help identify novel traits along these dimensions in nonmeditating populations.

As noted earlier in the section Shared contextual features, this model assumes—and, thus, does not examine—a number of features central to the context of mindfulness practice. Issues such as the role of ethics, affect, intention, bodily posture, the student–teacher relationship, the practice community, and the environment or setting for practice are all likely to be key ingredients for training in mindfulness. Given the importance of these contextual features, further research on the way that they modulate mindfulness training is a crucial desideratum for our model, but such research will certainly be challenging. The role of intention, for example, is highly complex. While some intentional sets might increase movement in a positive direction along one dimension, the same intention may retard movement along another. Paradoxically, letting go of outcomes or explicit intentions could actually increase positive movement along multiple dimensions.

Another complex contextual issue is the role of ethics and axiological frameworks. In particular, mindfulness practices are now incorporated in a variety of axiological frameworks ranging from traditional religious contexts to educational settings (Flook et al., 2010), military training (Jha et al., 2010), and other contemporary societal contexts such as law (Orenstein, 2011). What role do ethics and values play in the implementation and sustaining of these practices? What is the impact of ethical and axiological contexts on the phenomenology of mindfulness? As such issues are further examined, the model proposed here may require modification, or perhaps multiple models will be necessary to account for radically different societal and axiological contexts.

Finally, there is accumulating evidence highlighting the effects of these practices not only on brain functions and structures, but also on peripheral biological processes relevant for health and longevity (see, for instance, Carlson, Speca, Patel, & Goodey, 2004; Jacobs et al., 2011; Pace et al., 2009, 2010). A future avenue of research will be to measure the impact of mindfulness practices beyond the cognitive and affective neurosciences, including health and wellbeing outcome measures, economic impacts, educational achievements, prosociality, environmental footprint, and leadership and community building.

In closing, we emphasize that by formulating this model, our central aim is to offer a tool for generating novel hypotheses and stimulating rigorous and beneficial scientific research in a way that further develops, revises or even supersedes this model itself.

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