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The Mindfulness Internal Attention (MIA) Framework: Uncovering the Attentional Mechanisms of Mindfulness Training

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Abstract

Attention is theorized to have a definitive role in mindfulness and its salutary effects. Yet, findings from more than two decades of research testing this central theoretical premise have been surprisingly mixed. To account for this paradoxical disparity between theory and findings, we propose the Mindfulness Internal Attention (MIA) framework. We theorize and review initial findings suggesting that mindfulness training primarily targets internal attention processes, which operate on internally generated or stored information and experience. Additionally, we theorize and review findings suggesting that mindfulness training affects executive functions and working memory processes shared between internal attention and late-stage external attention. In contrast, we theorize and review findings suggesting that mindfulness training does not affect early-stage external attention processes, which do not share cognitive resources with internal attention.

Finally, we propose methodological innovations and outstanding questions for future research to advance our understanding of the attentional mechanisms of mindfulness training.

Contents

INTRODUCTION

Mindfulness is a rapidly growing focus of science (Baminiwatta & Solangaarachchi 2021, Ferreira & Demarzo 2024), with a broad empirical literature documenting multiple salutary effects of mindfulness training on mental health and physical health outcomes (Bernstein et al. 2019b,

SIDEBAR 1: MINDFULNESS TRAINING AND MINDFULNESS INTERVENTIONS

Mindfulness training involves formal practice through meditation and often also entails informal practice during daily living. One common form of mindfulness meditation involves bringing attention to the sensations of breathing, noticing when the mind wanders with an accepting attitude, and then nonjudgmentally bringing attention back to the sensations of breathing. Informal mindfulness practices often entail bringing attention to present-moment experience (e.g., sensations, thoughts) with an attitude of acceptance during daily living. In clinical settings and in most mindfulness intervention research to date, mindfulness is often trained in ~8-week group interventions that include daily formal meditation practice and informal practice (Crane et al. 2017). Mindfulness meditation smartphone apps are an alternative, accessible, and widely used form of mindfulness training and are slowly becoming a focus of mindfulness intervention research (Lam et al. 2023, Wasil et al. 2020).

Creswell 2017, Goldberg et al. 2022). In parallel, over the past two decades, a growing number of people around the world have been engaging in mindfulness meditation, with an estimated one in five US adults practicing meditation in 2022 (Davies et al. 2024). The term "mindfulness" refers to a mental state and a form of mental training characterized by present-moment attention and awareness and a particular set of attitudes toward experience such as nonjudging, acceptance, and curiosity (see Sidebar 1 for a description of the forms and modalities of mindfulness training) (Bishop et al. 2004, Kabat-Zinn 2003, Lindsay & Creswell 2017). Critically, mindfulness training is designed to cultivate health and well-being through the training of attention (Hölzel et al. 2011, Malinowski 2013, Tang et al. 2015, Wielgosz et al. 2019). Yet, despite more than two decades of research on the attentional mechanisms of mindfulness training, the empirical evidence for the effects of mindfulness training on attention are, at best, mixed (Im et al. 2021, Whitfield et al. 2022, Yakobi et al. 2021). Solving this disparity between theory and empirical findings is critical, as the implementation of mindfulness training, grounded in assumptions regarding the fundamental roles of attentional training in mindfulness meditation, is rapidly growing (Creswell 2017, Davies et al. 2024). To account for this critical disparity, we propose the Mindfulness Internal Attention (MIA) framework and use it to review, organize, and integrate theory and research on the attentional mechanisms of mindfulness training.

Mindfulness: a mental state and a form of mental training characterized by present moment attention and awareness, nonjudging, acceptance, and curiosity

Attention: the product of limited information processing capacity that directs the brain's resources to process prioritized information

Acceptance: a mental attitude of nonjudgment, openness, and receptivity toward experience and a central mechanism of mindfulness training

THEORETICAL UNDERPINNINGS OF THE MINDFULNESS INTERNAL ATTENTION (MIA) FRAMEWORK

Internal Attention in Mindfulness Theory

Mindfulness training originated from the Buddhist traditions, which have a vast literature relating to mindfulness that has directly informed contemporary scientific theory and the study of mindfulness (Williams & Kabat-Zinn 2013). Early canonical Buddhist texts describe mindfulness training as involving mainly attention to internal experience (Goldstein 2013). For example, mindfulness training is often described as involving attention to four types of internal experiential objects, including body (e.g., breath, bodily sensations), hedonic tone of experience (e.g., pleasant, unpleasant, neutral), mind (e.g., thoughts, mental states), and mental phenomena (e.g., aversion, effort, tranquility) (Anālayo 2003, Bodhi 2011). Likewise, contemporary Buddhist scholarship also suggests that attention to internal experience is central in mindfulness meditation, which is described as involving attention to the breath, body, mind, and awareness itself (Dahl et al. 2015, Dunne et al. 2019, Thera 2014). Critically, even the forms of mindfulness meditation that involve attention to external stimuli (e.g., mindfulness of sounds and sights) typically also involve

substantial attention to internal experience, such as noticing internal reactions to external stimuli (e.g., bodily sensations, emotions, thoughts, mental imagery), monitoring for mind wandering, and disengaging from mind wandering (Kabat-Zinn 2013). Indeed, in the most practical sense, mindfulness meditation is typically conducted while sitting with the eyes closed, to limit exposure to external stimuli and enhance attention to internal experience.

Likewise, the psychological science of mindfulness emphasizes mindfulness training as involving attention primarily to internal experience and describes several internal attention (IA) processes and capacities cultivated through mindfulness training. IA operates on internally generated or stored mental representations and experience (e.g., thoughts, bodily sensations), whereas external attention (EA) operates on sensory-perceptual information from the environment (e.g., visual information). Theorized IA processes and capacities targeted by mindfulness training include attentional selection and sustained attention to internal experience (e.g., the sensations of breathing) as well as various IA control processes (i.e., executive control; Bishop et al. 2004, Brown et al. 2007, Hölzel et al. 2011). Important IA control processes described in this literature include monitoring the contents of awareness (i.e., meta-awareness) and the capacity to disengage from thought content and shift attention back to present-moment internal experience (Dahl et al. 2015, Malinowski 2013, Vago & Silbersweig 2012). Other IA control processes include broadening the scope or aperture of IA (e.g., whole body versus sensations of the breath in the nostrils; Lutz et al. 2015) and reducing preferential selection of various internal experiential objects (e.g., unbiased IA to pleasant experience versus unpleasant experience; Garland & Fredrickson 2019, Garland et al. 2015).

Importantly, we argue that IA processes and capacities are essential not only for monitoring and attentional selection of present-moment experience but also for cultivation of the attitudinal qualities of mindfulness during mindfulness training. These include attitudes such as nonjudging, acceptance, and curiosity toward experience (Bishop et al. 2004, Kabat-Zinn 2013, Shapiro et al. 2006). Indeed, training these attitudinal qualities requires the repeated and sustained attentional selection of internally generated attitudes and intentions to allow, accept, and be curious about experience (Lindsay & Creswell 2017). Accordingly, the repeated and sustained recollection of attitudinal qualities during mindfulness training is also, at least in part, subserved by IA capacities and processes.

Finally, mindfulness theory and empirical study have implicated multiple forms of internally directed cognition in the salutary mechanisms of action of mindfulness training (for reviews, see Gu et al. 2015, Hölzel et al. 2011, Wielgosz et al. 2019). These include, for example, meta-awareness (Lutz et al. 2015), decentering (Bernstein et al. 2015), reduced repetitive negative thinking (Mennin & Fresco 2013), nonreactivity to experience (Kabat-Zinn 2013), savoring (Garland & Fredrickson 2019), positive reappraisal of experience (Garland et al. 2015), and self-compassion (Segal et al. 2013). Importantly, IA processes subserve these various forms of internally directed cognition. For example, meta-awareness, defined as awareness of the processes in consciousness, reflects a capacity to monitor and attend to internal processes in consciousness (Dahl et al. 2015). As another example, positive reappraisal reflects the capacity to monitor and disengage from automatic internally generated negative appraisals and subsequent attentional selection of new appraisals (Garland et al. 2015). Thus, the cultivation of IA processes and capacities, including monitoring, selection, and disengagement of/from internal stimuli, is theorized to be a central change process that cuts across mindfulness training mechanisms of action.

Internal attention (IA): allocation of limited processing resources to internally generated or stored information and experience (e.g., thoughts, bodily sensations)

External attention (EA): allocation of limited processing resources to sensory-perceptual information from the environment (e.g., visual information)

Meta-awareness: awareness of the processes in consciousness or of subjective experience and a central mechanism of mindfulness training

Internally directed cognition: cognition involving internal attention to thoughts or to information in working memory or in long-term memory

External and Internal Attention: Cognitive Science Perspective

Attention is the product of limited information processing capacity that directs the brain's resources to process prioritized information (Desimone & Duncan 1995). Contemporary cognitive

neuroscientific models conceptualize attention as a principle that applies across cognitive and perceptual domains (Chun et al. 2011, Lavie et al. 2004, Oberauer 2019). That is, attention is not a singular construct or neural architecture but a selective neural strategy that characterizes information processing across multiple domains and systems of human cognition. These include systems processing external sensory-perceptual information as well as systems processing internally generated information or information stored in memory.

Respectively, contemporary neurocognitive models have distinguished between EA and IA (Chun et al. 2011, Dixon et al. 2014). EA involves the allocation of limited processing resources to sensory-perceptual information from the environment (e.g., visual information). EA is engaged when we are focused on information on a computer screen, on the road ahead of us when driving, or on a talk. In contrast, IA involves the allocation of limited processing resources toward internally generated information (e.g., thoughts, memories), such as information recalled from long-term memory or active in working memory (Chun et al. 2011, van Ede & Nobre 2023). IA is engaged when we are thinking about our to-do list, mind wandering, focusing on a sensation of pain in the body, or noticing our current mental state. Critically, the key role of IA is to bias or prioritize the processing of certain internally generated or stored mental representations over other competing internal and external stimuli (Myers et al. 2017).

Working memory: a set of cognitive processes for monitoring, updating, and maintaining mental representations in a highly active and manipulable state

Early-stage EA: attention to immediate ongoing external sensory-perceptual information

Late-stage EA: attention to the abstracted representations of external sensory-based information

Executive functions: a set of top-down control mechanisms that regulate human cognition

External and Internal Attention: Shared and Unique Resources and Processes

Although EA and IA systems and processes are interlinked, they are not one and the same (Chun et al. 2011, Dixon et al. 2014, Verschooren & Egner 2023). More specifically, the interdependence and shared resources and processes between EA and IA depend on the stage of processing of EA. While early-stage EA processing involves attention to immediate ongoing external sensory-perceptual information (Sherman & Turk-Browne 2024), late-stage EA processing involves attention to the abstracted representations of external sensory-based information (e.g., classification of stimuli, meaning of a word; Amir et al. 2022). Critically, cognitive science theory and empirical findings indicate that the processes involved in late-stage EA are likely shared with IA, whereas the processes involved in early-stage EA are not shared with IA (Verschooren & Egner 2023). Next, we review the theoretical basis and empirical evidence supporting this key premise.

Early-stage EA processes include alerting (vigilance to external sensory-perceptual stimuli) and exogenous orienting (reflexive selection of external sensory-perceptual stimuli) (Petersen & Posner 2012). In contrast, late-stage EA involves goal-directed processes and executive functions such as inhibitory control (inhibition of dominant responses; Miyake et al. 2000), shifting (switching between tasks or mental sets; Miyake et al. 2000), and updating, maintaining, and monitoring active representations in working memory (Diamond 2013, Miyake et al. 2000, Oberauer 2019, Sherman & Turk-Browne 2024). Critically, these late-stage processes enable inhibition of dominant responses to external stimuli, shifting between tasks that involve external stimuli, and updating of working memory contents based on external stimuli. However, these processes are also involved in IA when the inhibition of dominant responses, shifting between tasks, or updating the contents of working memory are based upon internal information. Accordingly, in contrast to the processes involved in early-stage EA, the goal-directed processes and executive functions involved in late-stage EA (e.g., inhibitory control, shifting, and updating) are shared and overlap with IA (see **Figure 1**).

Theory and findings from cognitive neuroscience support the key premise of shared processes and resources between late-stage EA and IA. First, interference between IA and EA is more likely observed at late-stage EA. At this later stage, the attended external sensory–based information has become abstracted and represented in working memory, which also holds representation of

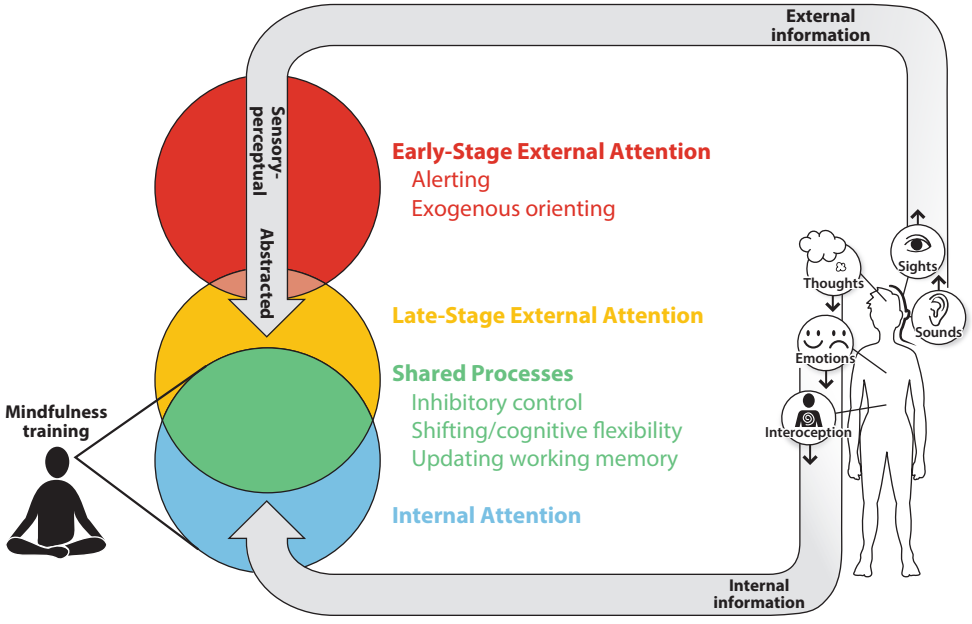

Figure 1

The proposed effects of mindfulness training on the cognitive processes involved in internal attention (IA) and external attention (EA). Early-stage EA processes and resources operate on immediate ongoing external sensory-perceptual information. Late-stage EA processes and resources operate on abstracted representations of external information. IA processes and resources operate on information in the mind (e.g., thoughts, emotions) or sensations generated within the body (e.g., interoception). IA is dependent on cognitive resources and processes that are shared with late-stage EA (represented by the green overlap between the IA circle and the late-stage EA circle) but are distinguished from early-stage EA processes. The Mindfulness Internal Attention (MIA) framework postulates that mindfulness training targets IA processes, including executive functions and working memory processes that are shared between late-stage EA and IA. These effects are not expected to generalize to early-stage EA processes. Figure graphics created by Sharon Amlani.

internal origin (Amir et al. 2022, Verschooren & Egner 2023). Indeed, working memory is considered an interface between internal and external information (Chun et al. 2011, van Ede & Nobre 2023). Since both internally and externally originated representations draw on working memory resources, they are vulnerable to cross-talk interference (Musslick & Cohen 2021), rely on shared gating and selection mechanisms (Verschooren et al. 2021), and compete for response selection (Myers et al. 2017, Verschooren & Egner 2023). Second, late-stage EA and IA are dependent on the same central and domain-general cognitive control processes and resources (Dixon et al. 2014, Oberauer 2019). This goal-directed system that is thought to govern late-stage EA processing also governs processing of internal events (e.g., memories, thoughts; Chun et al. 2011, Gazzaley & Nobre 2012, Oberauer 2019, Sherman & Turk-Browne 2024). For example, interference between concurrent IA and late-stage EA tasks points to shared goal-directed capacities or processes between late-stage EA and IA (Chun et al. 2011, Verschooren & Egner 2023). Moreover, the costs of switching between tasks requiring late-stage EA and IA are similar in magnitude to those of switching between late-stage EA tasks, suggesting a shared bottleneck in control of late-stage EA and IA (Verschooren et al. 2019). Moreover, neuroimaging research has documented substantial overlap in the brain areas activated during late-stage EA and IA (Gazzaley & Nobre 2012, Myers et al. 2017). Finally, brain decoding using multivariate pattern classification

Brain decoding: a set of methods to transform neuroimaging data into predictions of activated mental states

approaches suggests a common frontoparietal neural substrate of shared domain-general selection control mechanisms for both late-stage EA and IA (Panichello & Buschman 2021, Zhou et al. 2022).

Critically, cognitive neuroscience findings indicate that, in contrast to late-stage EA and IA processes, the cognitive resources involved in early-stage EA and those involved in IA processes are likely distinct and independent. First, whereas experimental findings have documented robust interference between late-stage EA and IA processes (Verschooren & Egner 2023), early-stage EA and late-stage EA or IA processes can function concurrently, with limited interference. For example, early-stage visual search does not substantially impair the maintenance of information in visual working memory and, vice versa, is not substantially impaired by visual working memory load (Woodman et al. 2001). Likewise, external sensory-perceptual distraction (e.g., auditory noise) impacts early-stage EA but not IA (Ziegler et al. 2018). Furthermore, event-related potential work has revealed that mind wandering states that rely on IA processes do not interfere with early-stage EA of deviant or unexpected auditory stimuli (Kam et al. 2013). Second, early-stage EA and late-stage EA or IA can be functionally dissociated and may be subserved by distinct cognitive resources, processes, and neural substrates. For example, the allocation of visual attention to an external object does not necessarily produce encoding of the attended object into working memory (Oberauer 2019, Tas et al. 2016). Relatedly, brain decoding work has documented that in contrast to the overlap between late-stage EA and IA control processes, early-stage EA and IA may have distinct neural substrates (Panichello & Buschman 2021). In summary, cognitive and neuroscientific theory and empirical findings suggest that cognitive resources and processes involved in IA are shared with late-stage EA, whereas the processes involved in early-stage EA are not.

THE MINDFULNESS INTERNAL ATTENTION (MIA) FRAMEWORK

As reviewed above, Buddhist thought and the conceptualizations of mindfulness in psychological science emphasize the important mechanistic roles of IA in mindfulness training and in its salutary mechanisms. However, contemporary research on mindfulness and attention has largely focused on EA measures and tasks, and accordingly it has so far yielded mixed findings supporting the effects of mindfulness training on attention (Im et al. 2021, Whitfield et al. 2022). Thus, to bridge theory and research on the attentional mechanisms of mindfulness, we propose the MIA framework. **Table 1** and **Figure 1** illustrate the tenets of the MIA framework. Based on the reviewed mindfulness theories, we propose that mindfulness training primarily targets and trains IA processes (Tenet 1). Based on the reviewed cognitive neuroscience findings, we postulate that mindfulness training affects executive functions and working memory processes shared between late-stage EA and IA (Tenet 2). However, because IA processes are subserved by cognitive resources that are distinct from early-stage EA processes, we propose that the effects of mindfulness training on IA are not likely to generalize to early-stage EA processes (Tenet 3). Finally, based on the reviewed theoretical mindfulness literature as well as findings on the roles of IA processes in mental health and behavioral control (see Sidebar 2), we postulate that IA processes play critical roles in the salutary effects of mindfulness training (Tenet 4). More specifically, we propose that the salutary effects of mindfulness training (e.g., improved mental health) are mediated, at least in part, by changes in IA processes (Tenet 4a). Likewise, we postulate that the salutary effects of mindfulness training are partially mediated by changes in executive functions and working memory processes shared between late-stage EA and IA (Tenet 4b). Conversely, we propose that the salutary effects of mindfulness training are not mediated by changes in early-stage EA processes that do not share resources with IA (Tenet 4c).

Table 1 Tenets of the Mindfulness Internal Attention (MIA) framework and summary of empirical evidence per tenet

MIA tenets	Summary of empirical evidence
Tenet 1. Mindfulness training primarily targets IA processes.	Initial findings suggest that mindfulness training may affect IA processes expressed in mind wandering, meta-awareness, interoceptive awareness, and attention to internal experience during meditation.
Tenet 2. Mindfulness training affects executive functions and working memory processes shared between late-stage EA and IA.	Meta-analytic findings provide strong evidence (based on randomized studies with active controls) that mindfulness training has small to moderate effects on executive functions, executive control, and working memory (e.g., Zainal & Newman 2023).
Tenet 3. Mindfulness training does not affect early-stage EA processes.	Meta-analytic findings suggest that mindfulness training does not affect early-stage EA processes, including alerting and exogenous orienting (e.g., Whitfield et al. 2022).
Tenet 4. IA processes play critical roles in the salutary effects of mindfulness training.	
Tenet 4a. The salutary effects of mindfulness training are mediated (or partially mediated) by changes in IA processes.	To the best of our knowledge, no studies to date have tested whether the effects of mindfulness training on IA processes mediate the salutary effects of mindfulness training.
Tenet 4b. The salutary effects of mindfulness training are partially mediated by changes in executive functions and working memory processes shared between late-stage EA and IA.	Preliminary findings indicate that changes in working memory and response inhibition following mindfulness training are associated with some of the salutary effects of mindfulness training (Jha et al. 2010, Sahdra et al. 2011).
Tenet 4c. The salutary effects of mindfulness training are not mediated by changes in early-stage EA processes that do not share resources with IA.	Null meta-analytic effects of mindfulness training on measures of early-stage EA processes (e.g., Whitfield et al. 2022) suggest that mediation of the salutary effects of mindfulness training via early-stage EA processes is likely null.

Abbreviations; EA, external attention; IA, internal attention.

In the next section, we review research testing the effects of mindfulness training on the cognitive processes involved in EA (executive functions, working memory, and early-stage EA processes) to examine empirical evidence for Tenets 2, 3, 4b, and 4c of the MIA framework. In the subsequent section, we review emerging research testing the effects of mindfulness on IA to examine

SIDEBAR 2: INTERNAL ATTENTION IN MENTAL HEALTH AND BEHAVIORAL CONTROL

Dysregulated IA plays critical roles in various forms of maladaptive internally directed cognition implicated in mental health problems, such as negative repetitive thinking, emotion dysregulation, cognitive reactivity, cognitive dyscontrol, and cognitive biases (Amir & Bernstein 2022). For example, evidence suggests that a narrowed scope of IA, difficulty disengaging IA from negative information, and impaired inhibition of negative information from working memory may underlie negative repetitive thinking such as rumination (Amir et al. 2021, Joormann 2010, Koster et al. 2011, Whitmer & Gotlib 2013). Likewise, regulated IA may serve as a salutary and protective factor by reducing maladaptive internally directed cognition and thereby promoting mental health (Amir & Bernstein 2022). Importantly, IA also contributes to the regulation and selection of adaptive behaviors by enabling the transformation of selected information in working memory into task-specific representations that guide action (Myers et al. 2017, van Ede & Nobre 2023). Collectively, these findings highlight the salutary properties of regulated IA and support the prediction that if mindfulness training indeed targets IA processes, then its salutary effects may be mediated by its effects on IA processes.

the existing empirical evidence for the remaining tenets of the MIA framework (i.e., Tenets 1 and 4a).

LOOKING OUT: EMPIRICAL REVIEW OF THE EFFECTS OF MINDFULNESS TRAINING ON THE COGNITIVE PROCESSES INVOLVED IN EXTERNAL ATTENTION

A growing body of mindfulness intervention research has tested the effects of mindfulness training on various measures of EA.[1] Meta-analyses of these studies have documented either nonsignificant effects of mindfulness training on measures of EA (Gill et al. 2020, Im et al. 2021, Whitfield et al. 2022) or small-sized effects (Hedge's g range = 0.17–0.29; Dunning et al. 2022, Sumantry & Stewart 2021, Verhaeghen 2021, Yakobi et al. 2021). Notably, although meta-analyses have systematically distinguished between different categories of EA processes (e.g., alerting, orienting, executive control), they have not been systematically organized around early versus late stages of EA processing. Thus, to examine whether existing findings are aligned with Tenets 2 and 3 of the MIA framework, we first review meta-analytic findings on the effects of mindfulness training on measures that primarily capture the processes that are engaged in late-stage EA and in IA (i.e., executive functions and working memory) and subsequently on measures that primarily capture early-stage EA processes (i.e., alerting, exogenous orienting).

Mindfulness Training Effects on Executive Functions and Executive Control

Based on Tenet 2 of the MIA framework, we reason that mindfulness training should affect measures that capture executive functions and executive control processes, which are engaged in late-stage EA and in IA. These processes are assessed via a variety of tasks requiring some level of abstraction of external stimuli (e.g., classification of stimuli, meaning of a word) and therefore they require late-stage EA processing of abstracted representations of external stimuli. These include inhibitory control tasks, capturing inhibition of dominant responses to external stimuli (Diamond 2013, Miyake et al. 2000); shifting or cognitive flexibility tasks, capturing the capacity to shift between tasks involving external stimuli (Diamond 2013, Miyake et al. 2000); and external sustained attention tasks, capturing executive control processes (Thomson et al. 2015).

Multiple meta-analyses, including those limited to more methodologically rigorous randomized controlled studies, found significant, although relatively small, effects across executive functions and executive control tasks (Hedge's g range = 0.15–0.34; Cásedas et al. 2020, Dunning et al. 2022, Im et al. 2021, Sumantry & Stewart 2021, Whitfield et al. 2022, Yakobi et al. 2021, Zainal & Newman 2023). Importantly, effects were found for passive control conditions (no

[1]The empirical review in this article is focused on studies testing the effects of mindfulness training on behavioral and performance measures of cognitive processes engaged in EA and IA. A modest but growing body of empirical work has documented the effects of mindfulness training on activation in brain areas and networks associated with EA and IA processes (see Tang et al. 2015 for a review and Rahrig et al. 2022 for a meta-analysis). To the best of our knowledge, the large majority of these functional neuroimaging studies of mindfulness training have not utilized analytic approaches (e.g., multivariate pattern classification) that enable inferences regarding the degree to which the measured patterns of brain activation indicate engagement of specific attentional processes (Lewis-Peacock et al. 2025, Poldrack 2011). Accordingly, these neuroimaging studies fall outside of the empirical scope of this review because they do not permit us to map findings onto dissociable early- and late-stage EA processes and IA processes, and therefore they do not enable an empirical test of the MIA framework. Below we discuss the potential promise of computational neuroimaging approaches to advance understanding of attentional mechanisms in mindfulness (see the section titled Brain Decoding of Internal Attention with Neuroimaging Data).

treatment or waitlist) and also for active control conditions (i.e., interventions with no mindfulness training) that control for placebo effects and nonspecific factors in mindfulness interventions (e.g., relationship with an instructor/therapist; Zainal & Newman 2023). Another meta-analysis did not similarly document an effect on executive functions (Gill et al. 2020), although it included the smallest number of studies relative to the other meta-analyses (9 versus 13–36 studies).

Most meta-analyses have also examined effects on specific executive functions. First, a number of meta-analyses found significant and small- to moderate-sized effects of mindfulness training on inhibitory control (Hedge's g range = 0.16–0.64; Cásedas et al. 2020, Sumantry & Stewart 2021, Verhaeghen 2021, Zainal & Newman 2023). However, meta-analyses that included only randomized controlled studies testing effects on inhibitory control documented mixed findings, with some reporting significant small- to moderate-sized effects (Hedge's g range = 0.19–0.64; Cásedas et al. 2020, Zainal & Newman 2023) and others reporting null effects (Whitfield et al. 2022, Zainal & Newman 2023). One of these meta-analyses documented small-sized effects, relative to active controls, which were limited to accuracy-based indices of inhibition (Hedge's $g = 0.19$) and were not found for reaction time–based indices of inhibition (Zainal & Newman 2023). These differential effects may account for mixed findings in the other meta-analyses.

Second, some meta-analyses found significant small-sized effects of mindfulness training on shifting and cognitive flexibility (Hedge's g range = 0.18–0.33; Sumantry & Stewart 2021, Verhaeghen 2021, Zainal & Newman 2023), while others did not find significant effects (Cásedas et al. 2020, Whitfield et al. 2022, Zainal & Newman 2023). Critically, among meta-analyses focused on randomized controlled studies, two indicated nonsignificant effects on shifting and cognitive flexibility (Cásedas et al. 2020, Whitfield et al. 2022). A third meta-analysis indicated that, in line with effects on cognitive inhibition, mindfulness training, compared to randomized active controls, led to small effects that were limited to accuracy-based indices of shifting (Hedge's $g = 0.20$) and were null for reaction time–based indices of shifting (Zainal & Newman 2023).

Finally, two meta-analyses examining the effects of mindfulness training on sustained attention tasks that require executive control found significant small-sized effects (Hedge's g range = 0.21–0.38; Verhaeghen 2021, Zainal & Newman 2023). Critically, one of these meta-analyses indicated that this effect remained significant in randomized controlled studies with active control conditions (Zainal & Newman 2023).

Together, in line with Tenet 2 of the MIA framework, most meta-analytic findings suggest that mindfulness training has small- to moderate-sized effects on executive functions and executive control processes that are engaged in late-stage EA and in IA (see **Table 1**). However, findings are inconclusive regarding the specific executive functions affected by mindfulness training (i.e., shifting, inhibitory control).

Mindfulness Training Effects on Working Memory

A number of meta-analyses have also examined the effects of mindfulness training on measures of working memory. Working memory relates to a set of cognitive processes for monitoring, updating, and maintaining mental representations in a highly active and manipulable state (Oberauer 2019, Sherman & Turk-Browne 2024). It contains both external and internal information and therefore lies at the interface between late-stage EA and IA (Chun et al. 2011, van Ede & Nobre 2023). Consequently, and importantly, most working memory processes, such as gating, updating, and inhibition, are engaged in late-stage EA and in IA (Baddeley 2012, Chun et al. 2011, Verschooren & Egner 2023).

Most meta-analyses testing the effects of mindfulness training on measures of updating and working memory have documented significant small to moderate effects (Hedge's

g range = 0.23–0.42; Cásedas et al. 2020, Sumantry & Stewart 2021, Verhaeghen 2021, Whitfield et al. 2022, Zainal & Newman 2023). These include three meta-analyses that focused only on randomized controlled studies, one of which included only studies with active control conditions (Cásedas et al. 2020, Whitfield et al. 2022, Zainal & Newman 2023). However, two meta-analyses that included a relatively smaller number of studies (6–8 versus 13–40 studies) found null effects (Im et al. 2021, Yakobi et al. 2021). Furthermore, one meta-analysis found small-sized effects on accuracy-based indices of working memory (Hedge's $g = 0.30$) and null effects on reaction time–based indices of working memory (Zainal & Newman 2023). Finally, one meta-analysis focusing on nonrandomized studies in stressful and high-demand contexts (i.e., active duty soldiers) documented that mindfulness training may have protective effects on working memory relative to the decline observed among controls (Δ standardized mean change = 0.53; Jha et al. 2022). Together, meta-analytic findings suggest that mindfulness training most likely has small to moderate effects on measures of working memory. As many of these measures capture monitoring, updating, and inhibition processes that are shared between late-stage EA and IA, these findings provide support for Tenet 2 of the MIA framework (see **Table 1**).

Mindfulness Training Effects on Early-Stage External Attention

Based on Tenet 3 of the MIA framework, we reason that mindfulness training should not affect measures that primarily capture early-stage EA processes. These include alerting tasks capturing vigilance to immediate external sensory-perceptual stimuli following an external cue as well as exogenous orienting tasks capturing reflexive selection of immediate external sensory-perceptual stimuli following a spatial cue (Fan et al. 2002, Posner & Petersen 1990). Multiple meta-analyses, including those that have found significant effects on the cognitive processes engaged in late-stage EA and in IA, have found null effects of mindfulness training on measures of early-stage EA processes, including alerting[2] (Verhaeghen 2021, Whitfield et al. 2022) and exogenous orienting (Sumantry & Stewart 2021, Verhaeghen 2021, Whitfield et al. 2022, Zainal & Newman 2023). Importantly, these null effects of mindfulness training on early-stage EA processes were found in meta-analyses that were limited to more methodologically rigorous randomized controlled studies and to studies with active control conditions (Whitfield et al. 2022, Zainal & Newman 2023). Thus, in line with Tenet 3 of the MIA framework, meta-analytic findings do not provide evidence that mindfulness training has a measurable effect on early-stage EA processes (see **Table 1**).

Cognitive Processes Involved in External Attention as Mediators of the Salutary Effects of Mindfulness Training

Based on Tenets 4b and 4c of the MIA framework, we reason that the effects of mindfulness training on the cognitive processes shared between late-stage EA and IA, but not early-stage EA processes, would partially mediate the salutary effects of mindfulness training. To the best of our knowledge, to date only two published studies have tested whether the salutary effects of mindfulness training are mediated by, or are associated with, changes in the cognitive processes shared between late-stage EA and IA (Jha et al. 2010, Sahdra et al. 2011). These studies suggest that working memory and response inhibition may account for some of the salutary effects of mindfulness

[2]Meta-analyses that included sustained attention tasks such as the Sustained Attention to Response Task (SART) in the alerting outcome category (i.e., Im et al. 2021, Sumantry & Stewart 2021) are not reported here. In contrast to alerting, which is an early-stage EA process, sustained attention tasks require executive control (Thomson et al. 2015) and therefore also capture late-stage EA. Accordingly, the effects of mindfulness training on sustained attention tasks are reported in the section titled Mindfulness Training Effects on Executive Functions and Executive Control.

training (i.e., improved negative affect and adaptive socioemotional functioning). However, these findings are limited, as mediation models in these studies did not include control group data and therefore did not test the effects of the mindfulness intervention on the putative mediator (Jha et al. 2010, Sahdra et al. 2011). Moreover, one of these studies conducted concurrent assessments of the mediator and outcome (Jha et al. 2010). The lack of other studies reporting mediation effects suggests a possible file drawer effect, wherein unpublished studies failed to detect mediation effects, or it may indicate that existing studies were not sufficiently powered to detect mediation. Thus, there is currently only preliminary and limited evidence supporting Tenet 4b of the MIA framework, indicating that some of the salutary effects of mindfulness training could be mediated by changes in late-stage EA processes (see **Table 1**).

Furthermore, to the best of our knowledge, no study to date has tested whether early-stage EA processes mediate the salutary effects of mindfulness training. However, the reviewed null meta-analytic effects of mindfulness training on measures of early-stage EA processes suggest that the noted mediation effects would likely be null. Indeed, an association between the intervention and the candidate mediator is essential for producing mediation effects. Accordingly, existing findings support Tenet 4c of the MIA framework and indicate that the salutary effects of mindfulness training are not likely mediated by changes in early-stage EA processes (see **Table 1**).

Summary of the Empirical Effects of Mindfulness Training on the Cognitive Processes Involved in External Attention

Generally, the empirical evidence for the effects of mindfulness training on late-stage and early-stage EA processes supports Tenets 2, 3, and 4c and provides preliminary support for Tenet 4b of the MIA framework (see **Table 1**). First, in line with Tenet 2, meta-analytic findings suggest that mindfulness training has robust effects (based on randomized controlled studies with active control conditions) on processes that are engaged in late-stage EA and in IA, including working memory, executive control, and executive functions. However, while the meta-analytic effects were consistently significant when tested across all executive functions, meta-analytic tests of the effects on two specific executive functions—shifting and inhibitory control—have found mixed results. Accordingly, more research is needed to evaluate whether and to what extent shifting and inhibitory control may be affected by mindfulness training. Second, in line with Tenet 3, meta-analytic findings suggest that mindfulness training likely does not affect early-stage EA processes, including alerting and exogenous orienting. Third, there is currently only preliminary and limited evidence supporting Tenet 4b of the MIA framework, and more research is needed to evaluate whether the salutary effects of mindfulness training are indeed mediated by changes in late-stage EA processes. Finally, in line with Tenet 4c, null meta-analytic effects of mindfulness training on measures of early-stage EA processes suggest that the salutary effects of mindfulness training are not likely mediated by changes in early-stage EA processes. Collectively, this body of experimental intervention research suggests that mindfulness training affects the cognitive processes shared between late-stage EA and IA, but not early-stage EA processes that are not shared with IA.

Critically, even though the significant and robust effects on working memory and executive functions were small to moderate in size, we believe that these effects are noteworthy, as they provide evidence for far transfer effects of mindfulness training. This is because the executive functions and working memory processes were measured via cognitive tasks that were very different from the mindfulness training that participants engaged in. For example, while these cognitive tasks typically involve providing fast and accurate responses to visual stimuli presented on a computer screen, mindfulness training often involves focusing attention on the sensations of breathing and monitoring for thoughts. Such far transfer effects, in which participants improve on tasks that

are remote from the trained tasks, are often not found in meta-analytic reviews of other forms of cognitive training, such as working memory training (Melby-Lervåg et al. 2016, Sala & Gobet 2019, Smid et al. 2020, von Bastian et al. 2022). Based on the MIA framework, these documented far transfer effects are enabled by sustained and frequent training of IA processes that affect and share resources with executive functions and working memory processes.

LOOKING IN: EMPIRICAL REVIEW OF THE EFFECTS OF MINDFULNESS TRAINING ON INTERNAL ATTENTION

Most studies on mindfulness training and attention have focused on cognitive tasks utilizing external sensory-perceptual stimuli, reviewed in the previous section. This focus on EA is not surprising, as the types of experimental paradigms by which attention has long been measured and quantified rely on the capacity to experimentally control the timing, content, and location of stimuli (Amir et al. 2021). Similar experimental control over the timing and content of internal experiential objects (e.g., thoughts) is, of course, far more challenging. Thus, the key constraints of the existing experimental paradigms through which attention is measured have, in practice, largely limited the empirical study of attention to EA (Petersen & Posner 2012).

A small but seminal field of research has begun to explore the effect of mindfulness training on IA to thoughts, bodily sensations, and other internal stimuli and experience (Treves et al. 2019, Turkelson & Mano 2022). To do so, these studies have utilized behavioral measures of IA processes or of internally directed cognitive processes that are subserved by IA[3] (Amir & Bernstein 2022). Notably, in contrast to measures of EA, which require experimental control over stimuli, these studies have applied measurement methods that depend on the detection of spontaneously occurring internal stimuli/experiences (e.g., thoughts) over which there is no experimental control (see Hadash & Bernstein 2019 for a review). Moreover, these behavioral measures include internal stimuli that are often common to mindfulness training such as bodily sensations and thoughts. Accordingly, they may be better suited to capture the IA processes targeted by mindfulness meditation compared to cognitive tasks utilizing external stimuli not common to mindfulness training such as numbers, words, or arrows on a computer screen. Specifically, studies testing the effects of mindfulness training on IA have focused on the effects of mindfulness training on mindfulness-related processes such as mind wandering, meta-awareness, interoceptive awareness, and IA and awareness during meditation. Below we review these studies to examine the empirical evidence for Tenet 1 of the MIA framework—that mindfulness training affects IA processes and capacities.

Mindfulness Training Effects on Mind Wandering with and Without Meta-Awareness

Mind wandering is a shift of attention away from the primary task or the external environment toward internally generated thoughts (Smallwood & Schooler 2015). Meta-awareness refers to awareness of the processes in consciousness or awareness of subjective experience, and it has been most often measured in the context of mind wandering, reflecting real-time awareness of mind

[3]Other studies focused on mindfulness training and self-reported IA. However, findings on the validity of self-report measures indicate that, in line with findings on self-reported EA (Clarke & Todd 2021, Van Bockstaele et al. 2023), self-reported IA is largely affected by expectations and beliefs (Ghanbari Noshari et al. 2023). Recent findings suggest that, as previously theorized (Davidson & Kaszniak 2015, Grossman 2011, Van Dam et al. 2018), the validity of self-reported IA among people with low IA capacities, such as meditation novices, may be substantially compromised (Hadash et al. 2023). Accordingly, similar to our review of mindfulness training and EA, we focus our review of mindfulness training and IA on studies utilizing behavioral measures of IA.

wandering (Bernstein et al. 2019a, Chu et al. 2023). Importantly, mindfulness training is conceptualized to lead to reductions in the frequency, length, and attentional capture of mind wandering by training the capacity for meta-awareness of mind wandering (Delorme & Brandmeyer 2019, Wielgosz et al. 2019). Indeed, meta-awareness is often conceptualized to be a central mechanism by which mindfulness training affects mental health and well-being, due to its roles in attentional regulation, decentering, and acceptance (Bernstein et al. 2015, Dahl et al. 2020, Lindsay & Creswell 2017). Critically, IA processes, such as the capacity to monitor and attend to the processes in consciousness and to disengage from the contents of mind wandering, are theorized to subserve the effects of mindfulness training on meta-awareness and mind wandering (Lutz et al. 2008, Smallwood & Schooler 2015).

Interoceptive attention: attention to sensations generated in the body (e.g., pain, hunger, temperature)

Mind wandering and meta-awareness are typically measured via experience sampling during cognitive tasks (Weinstein 2018). In probe-caught sampling methodologies, participants are intermittently probed to report on mind wandering with or without meta-awareness over the course of a task requiring sustained focused attention (Schooler et al. 2011). In self-caught sampling methodologies, participants are instructed to monitor and spontaneously report on their own events of mind wandering (Chu et al. 2023). Thus, while probe-caught methods capture the frequency of mind wandering with or without meta-awareness, self-caught methods predominantly capture spontaneous and self-initiated meta-awareness of mind wandering (and are typically compared with probe-caught methods; Schooler et al. 2011, Smallwood & Schooler 2015).

A growing literature has examined the effects of mindfulness training on mind wandering, utilizing probe-caught and self-caught approaches. Probe-caught sampling studies have reliably documented that mindfulness training reduced reports of mind wandering (Levinson et al. 2014, Mrazek et al. 2013, Turkelson & Mano 2022, Zanesco et al. 2016). Furthermore, one study documented that mindfulness training prevented the increases in probe-caught reports of mind wandering that were observed in the control group (Morrison et al. 2014). Finally, one probe-caught study has found that mindfulness training led to greater meta-awareness of being on task or off task (Jha et al. 2017). To the best of our knowledge, only two studies have focused on the effects of mindfulness training on self-caught meta-awareness and/or mind wandering. One study found reduced self-caught mind wandering following mindfulness training relative to controls, perhaps due to reductions in the frequency of mind wandering (Mrazek et al. 2013). Another study using self-caught and probe-caught methods found that intensive meditation retreats (of 1 month and 3 months) led to greater self-caught meta-awareness of mind wandering after controlling for the effect of the retreats on reduced probe-caught mind wandering (Zanesco et al. 2016).

Overall, initial studies utilizing probe-caught and self-caught sampling methods indicate that mindfulness training may reduce mind wandering and improve meta-awareness of mind wandering. Due to the central roles of IA processes in mind wandering and meta-awareness, these findings also provide preliminary support for Tenet 1 of the MIA framework by indicating that mindfulness training affects central proxies of IA processes and capacities.

Mindfulness Training Effects on Interoceptive Awareness and Attention

Interoception refers to the processing of internal bodily stimuli by the nervous system. Interoceptive awareness is an umbrella term that refers to features of interoception that are accessible to conscious self-report, including interoceptive attention to sensations generated in the body (e.g., pain, hunger, temperature; Khalsa et al. 2018). Mindfulness meditation often involves substantial training in interoceptive awareness and attention by means of IA to sensations of breathing, touch, pain, bodily posture, and movement and/or subtle sensations throughout the body (Weng et al. 2021). Indeed, interoceptive awareness and attention are considered central mechanisms of

mindfulness meditation, theorized to be essential for improving attention regulation, emotional awareness, and emotion regulation (Farb et al. 2015, Gibson 2019, Hölzel et al. 2011).

A number of studies have explored the effects of mindfulness training on measures of interoceptive awareness and attention. Most studies have focused on measures of interoceptive accuracy/sensitivity, which are based on comparisons of objective markers or experimental manipulations of interoceptive signals with subjective reports on the interoceptive experiences related to these signals (Hadash & Bernstein 2019, Suksasilp & Garfinkel 2022). One meta-analysis that included various measures of interoceptive accuracy documented significant, albeit small, effects of mindfulness training on interoceptive accuracy (Hedge's $g = 0.20$), though this effect was not sufficiently robust to possible publication bias (Treves et al. 2019). However, another meta-analysis that included only measures of interoceptive accuracy of heartbeats did not find a significant effect of mindfulness training (Khalsa et al. 2020). Three factors have been posited to account for the null or tenuous effects of mindfulness training on interoceptive accuracy tasks. First, a central limitation of most existing interoceptive accuracy tasks is that they are likely confounded, at least in part, by interoceptive signal intensity, and thus they may unintentionally capture construct irrelevant variance (e.g., physiological factors that increase heartbeat strength or salience; Desmedt et al. 2023). Second, most of the studies included in these meta-analyses relied on tasks that were, at least in part, confounded by beliefs about heart rate (Hadash & Bernstein 2019, Khalsa et al. 2020). Finally, all or most of these studies have focused on measures of interoceptive accuracy of heartbeats, which is not a typical focal interoceptive object of awareness in mindfulness training (Treves et al. 2019). Thus, the utility of commonly used measures of interoceptive accuracy of heartbeats for understanding interoceptive attentional change processes in mindfulness training may be limited. Other measures, such as of tactile sensitivity tasks or respiratory interoceptive accuracy tasks, may capture interoceptive accuracy of sensations that are more typically used as objects of IA in mindfulness training (Hölzel et al. 2011). While one study indicated greater tactile sensitivity following a 1-week body scan mindfulness meditation training (Mirams et al. 2013), two other studies failed to find differences between long-term meditators and nonmeditators in most indices of respiratory interoceptive accuracy (Daubenmier et al. 2013, Mylius et al. 2025).

An initial set of studies have sought to utilize the bodily sensation mapping methodology to quantify the location and various phenomenological features of internal bodily sensations (Hanley & Garland 2019, Hartmann et al. 2023, Nummenmaa et al. 2014). In this methodology, participants are presented with silhouettes of a human body and are asked to indicate the locations and phenomenological features (e.g., intensity, hedonic tone) of their present-moment bodily sensations. While this methodology captures a participant's experience of present-moment bodily sensations, it can also be used to capture processes related to IA to these sensations, such as biased IA toward unpleasant sensations or IA to sensations in a greater number of bodily regions. A study utilizing this methodology has found that an 8-week mindfulness training, relative to an active control group, was associated with a greater ratio of pleasant to unpleasant bodily sensations among chronic pain patients (Hanley & Garland 2019). Two other studies using this methodology revealed that previous meditation experience was associated with a greater number of bodily regions in which participants felt heartbeat sensations (Khalsa et al. 2020) and in which participants felt changes in sensations in response to emotional stimuli (Wainio-Theberge et al. 2025).

Recently, a promising brain decoding methodology has been proposed to measure interoceptive attention and awareness. This methodology is based on machine learning classifiers, trained using an experimental procedure to identify interoceptive attention to breathing from fMRI data. A small pilot intervention study using this brain decoding methodology has demonstrated that an 8-week mindfulness training ($n = 12$), relative to nonintervention ($n = 11$), led to greater

interoceptive attention to breathing, as assessed via machine learning classifiers of fMRI data during a sustained interoceptive attention task (Zuo et al. 2023).

Overall, initial findings indicate that mindfulness training may have effects on interoceptive accuracy, interoceptive attention, awareness of pleasant relative to unpleasant sensations, and attention to sensations in a broader range of bodily regions. Due to the central role of IA in the selection and accurate detection of interoceptive signals, these findings may also provide preliminary support for Tenet 1 of the MIA framework by indicating that mindfulness training may affect central proxies of IA processes and capacities.

Mindfulness Training Effects on Internal Attention During Meditation

Mindfulness meditation is theorized to be a primary modality for training IA processes and capacities. Likewise, during mindfulness meditation, mindfulness-related IA processes are expected to be most strongly engaged and expressed. These processes include, for example, sustaining attention to internal experience, monitoring the contents of awareness (i.e., meta-awareness), and disengaging from thought content and subsequently redirecting attention back to present-moment internal experience (Dahl et al. 2015, Hölzel et al. 2011, Malinowski 2013). Moreover, the development of IA processes and capacities during meditation is thought to be essential for targeting important mindfulness mechanisms such as acceptance and decentering (Bernstein et al. 2015, Lindsay & Creswell 2017). Accordingly, measures assessing IA processes during mindfulness meditation may be essential for detecting and quantifying IA mechanisms of mindfulness training and, in turn, for understanding how these IA mechanisms develop over the course of mindfulness training.

To date, several behavioral tasks have been developed to measure and thereby study IA processes during mindfulness meditation (see Hadash & Bernstein 2019 for a review). The most commonly used tasks assess attention to breathing during meditation. These include measures utilizing real-time (probe-caught and/or self-caught) reports of attention to breathing during meditation (e.g., Mindful-Breathing Exercise and Meditation Breath Attention Scores Task; Burg & Michalak 2011, Frewen et al. 2008). Another approach to measure attention to breathing involves real-time reports of breath counting during meditation (Breath Counting Task; Levinson et al. 2014). Preliminary findings from studies using these measures indicate significant differences in behaviorally measured IA to breathing during meditation between meditators and meditation novices (Levinson et al. 2014), between pre and post mindfulness training (Frewen et al. 2014, Levinson et al. 2014), and between a mindfulness intervention group and a randomized active control condition (Isbel et al. 2020a).

Recently, the Mindful Awareness Task has been developed to measure IA to a broader range of experiential objects (e.g., bodily sensations, mental events, hedonic tone) and to capture the temporal dynamics of IA during meditation (e.g., the duration of periods of sustained IA to present-moment experience; Hadash et al. 2023). In this task, participants provide real-time self-caught reports on the objects of their attention during meditation via button presses and verbal labels. Qualitative coding methods as well as computational algorithms are used to calculate indices reflecting mindfulness-related IA processes and capacities (see **Figure 2**). Preliminary findings from a study utilizing this task indicate that previous mindfulness meditation training is moderately to strongly associated with a higher frequency of IA to experience during meditation, including greater attention to bodily sensation, mental events, thoughts, and unpleasant experiences (Hadash et al. 2023). Findings also indicate that previous mindfulness meditation training is moderately to strongly associated with improved capacities for sustained IA to present-moment experience during meditation (Hadash et al. 2023). Together, this emerging body of research provides preliminary support for Tenet 1 of the MIA framework by suggesting that mindfulness training may affect key IA processes and capacities during meditation.

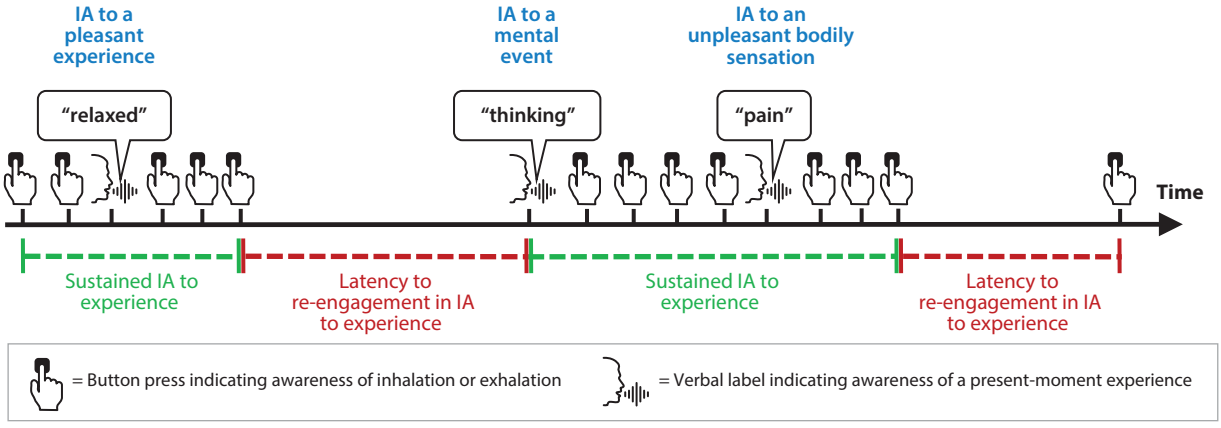

Figure 2

Measurement of mindfulness-related internal attention (IA) processes using the Mindful Awareness Task. The Mindful Awareness Task is a validated behavioral measurement methodology of mindfulness-related IA processes (Hadash et al. 2023). In this task, participants provide real-time self-caught reports on the objects of their IA during mindfulness meditation via button presses and verbal labels. The frequency of IA to different experiential objects—bodily sensations, mental events, and pleasant and unpleasant experiences (marked in *blue*)—is estimated based on qualitative coding of participants' verbal labels. Sustained IA to present-moment experience is quantified as the duration of time periods in which participants continuously indicate engaging in IA to their experience via verbal labels and button presses (marked in *green*). The latency to re-engagement in IA to experience following lapses in attention is quantified as the duration of time periods in which participants do not provide any indication of IA to their experience—i.e., no button presses or verbal labels (marked in *red*). Readers are referred to Hadash et al. (2023) for more information on the Mindful Awareness Task and additional scores capturing mindfulness-related IA processes.

Summary of the Empirical Effects of Mindfulness Training on Internal Attention

Generally, the empirical evidence for the effects of mindfulness training on IA processes provides initial support for Tenet 1 of the MIA framework—i.e., that mindfulness training affects IA processes and capacities (see **Table 1**). Preliminary findings suggest that mindfulness training may affect IA processes expressed in reduced mind wandering, enhanced meta-awareness, greater interoceptive awareness, and improved attention to internal experience during meditation. Moreover, the meta-analytic findings reviewed in the previous section, suggesting that mindfulness training affects working memory and executive functions that are engaged in IA, provide additional support that mindfulness training may affect IA processes. Furthermore, to the best of our knowledge, no published study to date has tested whether the effects of mindfulness training on IA processes mediate the salutary effects of mindfulness training. Accordingly, we were not able to test Tenet 4a of the MIA framework (see **Table 1**). Importantly, due to the limited scope and methodological limitations of this emerging body of research on the effect of mindfulness training on measures and proxies of IA, the evidence supporting Tenet 1 of the MIA framework is preliminary. Accordingly, we argue that the IA mechanisms of mindfulness merit greater attention in field-wide research.

LOOKING AHEAD: FUTURE DIRECTIONS FOR RESEARCH ON MINDFULNESS TRAINING AND INTERNAL ATTENTION

As reviewed, most studies on mindfulness training and attention have focused on cognitive tasks utilizing external stimuli, while research on the IA mechanisms of mindfulness training is preliminary and limited in scope. Accordingly, the acronym MIA also ironically underscores the current state of the field, wherein research on the IA mechanisms of mindfulness training is "missing in

action" and limits our empirical understanding of the attentional mechanisms of mindfulness. To address this gap, below we highlight key future directions for research on mindfulness training and IA, based on the MIA framework, the reviewed literature, and recent methodological advances in the capacity to measure and study mindfulness-related IA processes (see the section titled Future Issues for a summary).

Integrating Emerging Measures of Internal Attention into Mindfulness Research

We argue that a promising means to advance empirical understanding of the attentional mechanisms of mindfulness is through further development and integration of methods designed to measure mindfulness-related IA processes into mindfulness research (Hadash & Bernstein 2019). Critically, compared to the reviewed small to moderate effect sizes of mindfulness training on measures of executive functions and working memory, integrating measures that more specifically capture mindfulness-related IA processes into mindfulness training research may reveal larger effect sizes, potentially indicating more meaningful effects. Below, we highlight four measurement paradigms or approaches that we believe may be promising as a basis for additional study of IA in mindfulness training.

Behavioral measures of internal attention during meditation. As noted, mindfulness meditation is theorized to be a primary modality for training IA processes and capacities. Moreover, it is during mindfulness meditation that mindfulness-related IA processes are most strongly engaged and expressed (Dahl et al. 2015, Hölzel et al. 2011, Tang et al. 2015). Accordingly, utilizing behavioral measures of IA during meditation may be critical for advancing our understanding of the mechanisms of mindfulness. As reviewed above, several behavioral tasks have been developed to study IA during mindfulness meditation. Importantly, some of these measures have demonstrated evidence of reliability and validity (see Hadash & Bernstein 2019 for a review). Research on real-time reports of attention to breathing and breath counting during meditation supports the construct validity of these approaches in assessing attention to breathing during meditation (e.g., Mindful-Breathing Exercise, Meditation Breath Attention Scores Task, and Breath Counting Task; Burg & Michalak 2011; Frewen et al. 2008, 2011, 2016; Isbel et al. 2020a; Levinson et al. 2014; Wong et al. 2018). However, recent studies attempting to replicate the initial convergent validity findings for the Breath Counting Task have been unsuccessful and have questioned its construct validity as a measure of sustained IA that generalizes beyond the task's context (Ching & Lim 2023, Goldberg et al. 2020, Treves et al. 2025). Research on the Mindful Awareness Task supports its construct validity in measuring a variety of mindfulness-related IA processes (Hadash et al. 2023). These include monitoring for a range of experiential objects (e.g., bodily sensations, mental events, pleasant and unpleasant experiences), sustained IA to present-moment experience, and re-engagement in IA to present-moment experience following lapses in attention (see **Figure 2** and Hadash et al. 2023). To the best of our knowledge, only one published study to date has used one of these measures (the Breath Counting Task) in a randomized controlled design to test the effects of mindfulness training on IA during meditation (Isbel et al. 2020a). We argue that it is important that future randomized mindfulness training studies use these measures to test these effects and to test whether, as theorized, such effects prospectively mediate the salutary outcomes of mindfulness training.

Experimental simulation of internal experience to assess internal attention. A central challenge to the study and measurement of IA has been the need to experimentally control the timing, content, or features of internal experiences such as thoughts. Such control is essential to enable the study and measurement of IA via the same experimental paradigm through which EA has long

been studied and measured. The recently developed Simulated Thought Paradigm (Amir et al. 2021) was designed to tackle this problem by simulating internal experience to provide experimental control over the timing and content of stimuli that mimic thoughts. In this methodology, idiographic own-voice audio stimuli are utilized to experimentally simulate the content and experience of a person's thoughts (e.g., "I'm so lonely"). These simulated thought stimuli are delivered within established cognitive-experimental tasks to capture processes such as selection of, or disengagement from, specific types of thought content, such as sticky thought content with strong emotional valence (Amir et al. 2021). Importantly, no study to date has tested the impact of mindfulness training on greater control over IA selection and disengagement from thought content by means of the Simulated Thought Paradigm. Future studies could use this methodology to test these effects and their mechanistic roles in the salutary outcomes of mindfulness training.

Retrocueing tasks assessing internal attention. Retrocueing tasks are an emerging methodological paradigm used to measure IA (Griffin & Nobre 2003, Landman et al. 2003). The key feature of these tasks is that they utilize retrocues, which direct attention to information that is not perceptually available but is instead currently stored in working memory or in long-term memory. Most frequently, retrocues are presented during the retention periods of standard working memory tasks, in which information is actively maintained in working memory. A large literature has now amassed that has utilized the retrocueing paradigm to demonstrate the key properties and capacities of IA (Myers et al. 2017, Souza & Oberauer 2016, van Ede & Nobre 2023). For example, recent studies have utilized retrocueing paradigms to distinguish different ways that information can be removed from working memory through IA, such as suppression of information, replacement with different information, and clearing of information (DeRosa et al. 2024, Kim et al. 2020). Related work has also shown that information with high emotional valence is more difficult to remove from working memory (Bruning et al. 2023). Mindfulness training emphasizes training IA to release information that is currently within the focus of working memory, including repeated training in releasing sticky content such as information with strong emotional valence. Nevertheless, to our knowledge, retrocueing tasks have been utilized only in one study to test for the effects of mindfulness training on IA processes, with findings suggesting that mindfulness training may improve the capacity to remove negatively valanced contents from working memory (Amir et al. 2024). Importantly, future studies could continue to use and adapt retrocueing tasks to potentially study mindfulness-related IA processes such as removal and clearing operations of working memory content.

Brain decoding of internal attention with neuroimaging data. An additional promising direction for measuring IA processes cultivated in mindfulness training involves using multivariate predictive models to decode IA states based on functional neuroimaging data collected during meditation (Lewis-Peacock et al. 2025). In recent years, several cross-sectional studies have demonstrated above-chance decoding accuracies of internally directed cognition and IA states in meditation (e.g., breath attention, mind wandering) based on electroencephalogram (EEG), magnetoencephalography (MEG), and fMRI data (Aviad et al. 2025, Chaudhary et al. 2022, Pandey et al. 2023, Weng et al. 2020, Zhigalov et al. 2019). A recent mindfulness intervention study utilized decoding approaches to demonstrate that an 8-week mindfulness training led to more frequent interoceptive attention states during a sustained interoceptive attention task (Zuo et al. 2023). Future studies could use these promising decoding methods in the context of mindfulness meditation, or during the IA tasks reviewed in the previous subsections (e.g., the Mindful Awareness Task), to continue to test these effects and the mechanistic roles of IA processes in mediating the salutary outcomes of mindfulness training. For example, brain decoding approaches have been a major tool utilized in combination with retrocueing paradigms to study the representational

properties of IA—the patterns of brain activity that correspond to IA states and processes (DeRosa et al. 2024, Kim et al. 2020, Myers et al. 2017, van Ede & Nobre 2023, Zhou et al. 2022). Future studies could combine these approaches to test the effects of mindfulness training on IA and on the neural substrates of mindfulness-related IA states and processes.

Shared Resources Between Mindfulness-Related Internal Attention and External Attention

Future research is needed to better map and understand the degree to which IA processes cultivated in mindfulness training may lead to changes in EA processes. While the reviewed meta-analytic evidence documenting small to moderate effects of mindfulness training on processes engaged in late-stage EA supports a degree of shared resources with mindfulness-related IA processes, these processes may also rely on unique resources that are not shared across these forms of attentional processing. For instance, sensory processing of interoceptive signals in mindfulness training may be subserved by domain-specific IA capacities that are distinct from those involved in late-stage EA processes (Farb et al. 2015, Khalsa et al. 2018). However, monitoring and disengaging from task-unrelated thought may be a mindfulness-related IA process that affects late-stage EA processes and/or shares resources with late-stage EA processes (Dahl et al. 2020, Malinowski 2013). Moreover, it may be that in some cases, mindfulness-related IA processes potentially affect or modulate early-stage EA, in line with findings suggesting that early-stage EA may be affected by mind wandering, a phenomenon referred to as perceptual decoupling (Smallwood & Schooler 2015).

We thus propose future directions to delineate the degree of shared resources between IA processes cultivated in mindfulness training and EA processes. First, future research could examine whether changes in IA processes (i.e., monitoring and disengaging from task-unrelated thought) mediate the effects of mindfulness training on the cognitive processes involved in late-stage EA. Indeed, only a single published study to date tested whether changes in IA processes (reduced mind wandering) mediated the effects of mindfulness training on cognitive processes involved in late-stage EA processes (Mrazek et al. 2013). Instead, the large majority of existing studies of attention in mindfulness training have examined either EA or IA processes in isolation rather than in relation to one another. Second, study of the effects of intensive high-dose mindfulness training on IA and EA processes is also needed. Although the meta-analytic evidence presented in this review suggests that mindfulness training does not affect early-stage EA processes, initial findings indicate that 6 months of mindfulness training as well as intensive meditation training in 3-month retreats may affect early-stage EA processes (Isbel et al. 2020b, MacLean et al. 2010, Zanesco et al. 2019). Future research is needed to test whether these effects are reliable, and if so, what are their mechanisms of action. For example, such effects may occur through a direct effect of intensive high-dose mindfulness training on early-stage EA or through top-down modulation of early-stage EA via IA due to reduced perceptual decoupling. Third, although most mindfulness interventions entail substantial training in IA, some forms of mindfulness training may emphasize attention to external sensory-perceptual stimuli (e.g., sights, sounds) in addition to training in IA (e.g., noticing internal reactions to external stimuli, monitoring for mind wandering). Future studies could test whether these forms of mindfulness training may lead to effects on early-stage EA. Fourth, an initial set of studies documented limited associations between behaviorally assessed mindfulness-related IA processes during meditation and late-stage EA processes (i.e., task switching, working memory; Hadash et al. 2023, Levinson et al. 2014, Treves et al. 2025). However, additional research examining associations between individual differences in mindfulness-related IA processes and early- and late-stage EA is needed to better understand the shared and/or unique capacities and processes underlying these forms of attention.

Finally, future research is needed to better understand the mixed and inconclusive findings regarding the effects of mindfulness training on shifting and inhibitory control—cognitive processes shared between late-stage EA and IA. For example, studies could examine possible mechanistic or methodological explanations for the meta-analytic finding that mindfulness training affects accuracy-based indices of executive functions while not affecting reaction time–based indices of executive functions (Zainal & Newman 2023). One potential mechanistic explanation that could be explored in future studies is that accuracy-based indices of executive functions may better reflect cognitive control processes and resources that are shared between IA and late-stage EA; by contrast, reaction time–based indices may be more susceptible to influences from involuntary attentional processes, which are not shared between IA and EA (Prinzmetal et al. 2005). An alternative methodological explanation that could be explored in future studies is whether reaction time–based indices of executive functions tasks have substantial psychometric limitations compared to accuracy-based indices (Draheim et al. 2021).

The Roles of Internal Attention Processes in the Salutary Effects of Mindfulness Training

Findings from the clinical and cognitive science literatures have documented the salutary properties of IA processes in mental health and in behavioral control (see Sidebar 2). Accordingly, the MIA framework predicts that, if mindfulness training indeed targets IA processes, its salutary effects will be mediated (or partially mediated) by changes in IA processes, including the cognitive processes shared between late-stage EA and IA (see Tenets 4a and 4b in **Table 1**). However, as reviewed above, there is limited study of the mechanistic roles of IA processes, as well as of the cognitive processes involved in late-stage EA processes, in the salutary effects of mindfulness training. Accordingly, sufficiently powered randomized controlled mindfulness intervention studies are needed to test the mediating roles of IA processes, including the shared processes between IA and late-stage EA, in the salutary outcomes of these interventions.

Moreover, many established mechanisms of mindfulness are theoretically subserved by IA (e.g., meta-awareness, acceptance, positive reappraisal of experience). Thus, study of the roles of IA in these internally directed cognitive mechanisms (Amir & Bernstein 2022) may be important for advancing understanding of the pathways through which IA may affect the salutary outcomes of mindfulness (e.g., mental health). For example, attitudinal qualities such as acceptance and curiosity may be subserved by IA capacities to repeatedly select and sustain internally generated attitudes and intentions. Likewise, positive reappraisal of experience may be subserved by the IA capacities to monitor and disengage from automatic internally generated negative appraisals and subsequent attentional selection of new appraisals.

Finally, theory suggests that different IA processes may function as unique or shared mechanisms of different forms of mindfulness meditation training. For example, sustained selective attention of interoceptive stimuli may function as an attentional mechanism of focused attention meditation training, which entails training in focusing attention on a present-moment experiential object (e.g., the sensations of breathing in the abdomen; Lutz et al. 2008). However, the capacity to broaden the scope or aperture of IA may be an attentional mechanism of open monitoring meditation training, which entails training in present-moment attention to anything that occurs in experience (Lutz et al. 2015). Other IA processes, such as monitoring the contents of awareness and disengaging from task-unrelated thought, may be important attentional mechanisms of both focused attention and open monitoring meditation training (although they are theorized to be more developed in open monitoring meditation; Lutz et al. 2008). Future research could compare forms of mindfulness meditation training (e.g., focused attention versus open monitoring)

or employ a dismantling study design (e.g., compare mindfulness training with and without open monitoring) in order to examine the shared and unique effects of different forms of mindfulness meditation training on IA processes.

CONCLUSIONS

In this article, we sought to address a paradox that has emerged from more than two decades of research on the effects of mindfulness on attention. Why does mindfulness training, an intervention so explicitly grounded in the training of attention, have such limited and mixed evidence of impacting attentional processes? We proposed the MIA framework, highlighting IA processes as key mechanisms of mindfulness, to account for this critical disparity between theory and empirical findings. We reviewed empirical findings suggesting that, in line with the MIA framework, mindfulness training affects the cognitive processes involved in late-stage EA and in IA but not in early-stage EA. However, research on the IA mechanisms of mindfulness training is preliminary and modest in scope, limiting our empirical understanding of the attentional mechanisms of mindfulness. Accordingly, we proposed future directions for research on the IA mechanisms of mindfulness guided by the MIA framework, the reviewed literature, and recent methodological advances in the capacity to measure and study mindfulness-related IA processes. We hope that the proposed framework, review, and directions for future research may help catalyze research that will advance our understanding of the attentional mechanisms of mindfulness.

FUTURE ISSUES

The following may be promising future directions for research to advance understanding of the attentional mechanisms of mindfulness.

1. Integrating emerging behavioral measures of mindfulness-related internal attention (IA) processes during meditation—such as the Mindful Awareness Task (see **Figure 2**)—into mindfulness training research.
2. Integrating cognitive-experimental tasks with own-voice simulated thought stimuli to assess IA selection and disengagement from thought content into mindfulness training research.
3. Integrating retrocueing tasks to assess IA processes—such as clearing of emotional information from working memory—into mindfulness training research.
4. Using brain decoding of IA states from functional neuroimaging data in mindfulness training research.
5. Delineating the shared and unique resources and capacities underlying mindfulness-related IA processes and late-stage external attention (EA) processes.
6. Examining whether, as predicted by the Mindfulness Internal Attention framework, changes in IA processes or late-stage EA processes mediate (or partially mediate) the salutary effects of mindfulness training.
7. Examining the roles of IA processes in established mindfulness mechanisms (e.g., acceptance).
8. Examining the shared and unique IA mechanisms of different forms of mindfulness meditation training (e.g., focused attention, open monitoring).

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