AMERICAN PSYCHOLOGICAL ASSOCIATION

Psychological Assessment


ISSN: 1040-3590

2023, Vol. 35, No. 3, 242–256
https://doi.org/10.1037/pas0001194

# Looking Inside the Black Box of Mindfulness Meditation: Investigating Attention and Awareness During Meditation Using the Mindful Awareness Task (MAT)

Yuval Hadash, Liad Ruimi, and Amit Bernstein
Observing Minds Lab, Department of Psychology, School of Psychological Sciences, University of Haifa

Training attention and awareness in mindfulness meditation is theorized to be essential for the cultivation of mindfulness and its salutary outcomes. Yet, the empirical foundation for this central premise in mindfulness science is surprisingly small due to a limited methodological capacity to measure attention and awareness during mindfulness meditation. Accordingly, we set out to measure and study these processes in a laboratory study ($N = 143$, 76.92% female) using a novel behavioral measurement paradigm—the mindful awareness task (MAT). We empirically characterized attention and awareness during mindfulness meditation and found novel behavioral evidence indicating that, as long-theorized, these processes were related to previous mindfulness meditation practice, attitudinal qualities of mindfulness, attention regulation, and mental health. Furthermore, we found that the accuracy of self-reported mindfulness was, paradoxically, dependent on behavioral capacities for mindful awareness; and that sustained visual attention and executive functions, measured via cognitive-experimental tasks, were not meaningfully related to attention and awareness during mindfulness meditation. In contrast, the MAT demonstrated sound psychometric performance as a measure of mindful awareness, and may overcome significant limitations of extant mindfulness measurement methods. Collectively, findings challenge conceptual and methodological assumptions in mindfulness science, provide a novel paradigmatic direction for research on mindfulness, and present long-awaited evidence that attention and awareness during mindfulness meditation may indeed be fundamental to its practice, cultivation, and salutary functions.

***Public Significance Statement***
Mindfulness meditation is implemented in a variety of settings and applications. Yet we lack empirical evidence, and methods to study, a central premise of this intervention approach—that training attention and awareness through mindfulness meditation is essential to its practice and salutary functions. Using a novel behavioral measurement paradigm, we provide long-awaited support for this central premise and show that this paradigm may help advance empirical understanding of mindfulness.

*Keywords:* assessment of mindfulness, attention in mindfulness meditation, behavioral measurement of mindfulness, meta-awareness, mindfulness mechanisms

*Supplemental materials:* https://doi.org/10.1037/pas0001194.supp



This article was published Online First December 15, 2022.
Yuval Hadash https://orcid.org/0000-0001-7354-5608
Liad Ruimi https://orcid.org/0000-0002-9936-2364
Amit Bernstein https://orcid.org/0000-0003-4010-9070

The authors want to thank: Or Harel for his help with the qualitative coding of the data; research assistants Ortal Gretchin, Tzlil Abarbanel, Elad Flusser, Chen Bar Cohen, Shaden Ghanem, Chen Joseph, and Lachan Sharabi for their help in carrying out the study; and Nicholas T. Van Dam and Simon B. Goldberg for their feedback on the article.

Yuval Hadash received funding from a Mind and Life Institute Varela Award (Grant No. 2015-Varela-Hadash, Yuval). Amit Bernstein received funding from the Israel Science Foundation (Grant No. 2046/17), and the Caesarea-Rothschild Foundation. The authors declare that they have no known conflicts of interest to disclose.

Some of the reported findings were previously presented at the 2018 International Conference on Mindfulness (Amsterdam, Netherlands) and at the 2018 International Symposium for Contemplative Research (Phoenix, Arizona, United States).

Yuval Hadash played lead role in conceptualization, data curation, formal analysis, funding acquisition, investigation, methodology, project administration, software, validation, visualization and writing of original draft, supporting role in resources and equal role in writing of review and editing. Liad Ruimi played supporting role in formal analysis, validation and writing of review and editing. Amit Bernstein played lead role in resources and supervision, supporting role in conceptualization, formal analysis, funding acquisition, methodology, project administration and validation and equal role in writing of review and editing.

All reported data are deposited in the Open Science Framework (https://osf.io/a679v). This study was not preregistered.

Correspondence concerning this article should be addressed to Amit Bernstein, Observing Minds Lab, Department of Psychology, School of Psychological Sciences, University of Haifa, Mount Carmel, Haifa 3498838, Israel. Email: abernstein@psy.haifa.ac.il

## Attention and Awareness in Mindfulness Meditation

Mindfulness and mindfulness-based interventions—focused on training attention and awareness through mindfulness meditation—are now widely implemented in a variety of settings, most notably clinical and mental health applications (Bernstein et al., 2019; Van Dam et al., 2018). Likewise, a growing scientific literature has documented multiple salutary effects of mindfulness meditation on outcomes such as mental health, stress, well-being, pain, and addiction (Goldberg et al., 2022; Wielgosz et al., 2019). Buddhist and contemporary psychological theories propose that *training attention and awareness during mindfulness meditation* is an important mechanism of action of mindfulness, essential for producing its salutary effects for mental health (Dahl et al., 2015; Goldstein, 2013; Hölzel et al., 2011; Thera, 2014). Yet, despite its importance for mindfulness science, the empirical foundation for this central premise about mindfulness meditation is surprisingly limited (Im et al., 2021; Lao et al., 2016; Treves et al., 2019). This critical gap in our empirical knowledge of mindfulness is, in large part, a byproduct of the field's limited capacity to measure and quantify attention and awareness from moment-to-moment *during* mindfulness meditation (Garland & Gaylord, 2009; Van Dam et al., 2018).

Two fundamental dimensions of mindful awareness[1] may be critical to conceptualizing, and thereby advancing measurement and empirical understanding of attention and awareness during mindfulness meditation—the *objects* and *temporal dynamics* of mindful awareness (see Figure 1a; Hadash & Bernstein, 2019). First, Buddhist and contemporary theory suggest that mindfulness practice involves awareness of various experiential objects, such as body (e.g., bodily sensations), mind (e.g., emotions, thoughts), and hedonic tone (e.g., pleasant experience, unpleasant experience; Goldstein, 2013; Kabat-Zinn, 2013; Thera, 2014). Accordingly, these theories propose that mindful awareness of different experiential *objects* (e.g., body, mind, pleasant experience, unpleasant experience) is functionally linked to specific salutary outcomes of mindfulness practices (Anālayo, 2003; Hölzel et al., 2011). For example, mindful awareness of the body has been theorized to stabilize awareness and increase awareness of emotional states (Hölzel et al., 2011; Segal et al., 2013); mindful awareness of mental events has been theorized to enhance emotion and attention regulation (Hasenkamp et al., 2012; Vago & Silbersweig, 2012); mindful awareness of pleasant experience has been theorized to produce upward spirals of positive emotions (Garland et al., 2010; Garland & Fredrickson, 2019); and mindful awareness of unpleasant experience has been theorized to increase distress tolerance and reduce experiential avoidance (Batchelor, 2019; Crane, 2017; Hölzel et al., 2011). Thus, mindful awareness of different experiential objects may be important for gaining a larger variety of benefits from mindfulness practice.

The *objects of mindful awareness* during meditation are also thought to reflect at least two important capacities and processes trained in mindfulness meditation and foundational to its salutary functions—meta-awareness and broadened and unbiased awareness (Garland & Fredrickson, 2019; Wielgosz et al., 2019). For example, meta-awareness, defined as awareness of experiences and processes in consciousness, may be reflected in increased mindful awareness of experiential objects (Lutz et al., 2015). Broadened and unbiased awareness may be reflected in a balance between mindful awareness of different types of experiential objects (e.g., pleasant and unpleasant experience; Garland et al., 2015).

In addition to the objects of mindful awareness, Buddhist and contemporary theory also emphasize that attention and awareness during mindfulness practice are expressed as temporal processes—in dynamic or alternating sequences of mindful states and mindless states (i.e., states with no awareness of present moment experience; Anālayo, 2003; Hasenkamp et al., 2012; Malinowski, 2013; Thera, 2014). These *temporal dynamics of mindful awareness* are thought to reflect at least two important capacities and respective processes trained in mindfulness meditation and foundational to its salutary functions—sustained mindful awareness and reengagement in mindful awareness following the onset of mindless states (see Figure 1b; Bishop et al., 2004; Brown et al., 2007; Hölzel et al., 2011; Vago & Silbersweig, 2012). For example, sustained mindful awareness is thought to reduce the frequency of mind-wandering and negative repetitive thoughts and to facilitate concentration, curiosity, decentering, equanimity, and insight (Anālayo, 2003; Brewer et al., 2013; Brown et al., 2007; Dunne et al., 2019). Likewise, the capacity to notice and disengage from automatic thinking and reengage in mindful awareness is thought to enable decentering from these thoughts, reduce the duration of mind-wandering and negative repetitive thoughts, and increase attentional control and behavioral choice (Bernstein et al., 2015; Vago & Silbersweig, 2012; Wielgosz et al., 2019).

Thus, Buddhist and contemporary theories suggest that attention and awareness expressed in the objects and temporal dynamics of mindful awareness are fundamental to the practice, cultivation, and salutary functions of mindfulness. Yet, the empirical foundation of these central theoretical claims is surprisingly limited. First, we do not yet know whether and how previous experience with mindfulness meditation may train and impact attention and awareness during meditation; and more specifically, how the objects and temporal dynamics of mindful awareness change due to previous experience with mindfulness meditation (Dahl et al., 2015; Lutz et al., 2008, 2015). Furthermore, we do not have empirical evidence supporting the putative salutary functions of attention and awareness during mindfulness meditation, such as the ways in which the objects and temporal dynamics of mindful awareness during meditation are associated with attitudinal qualities of mindfulness, attention regulation, and mental health (Van Dam et al., 2018; Wielgosz et al., 2019).

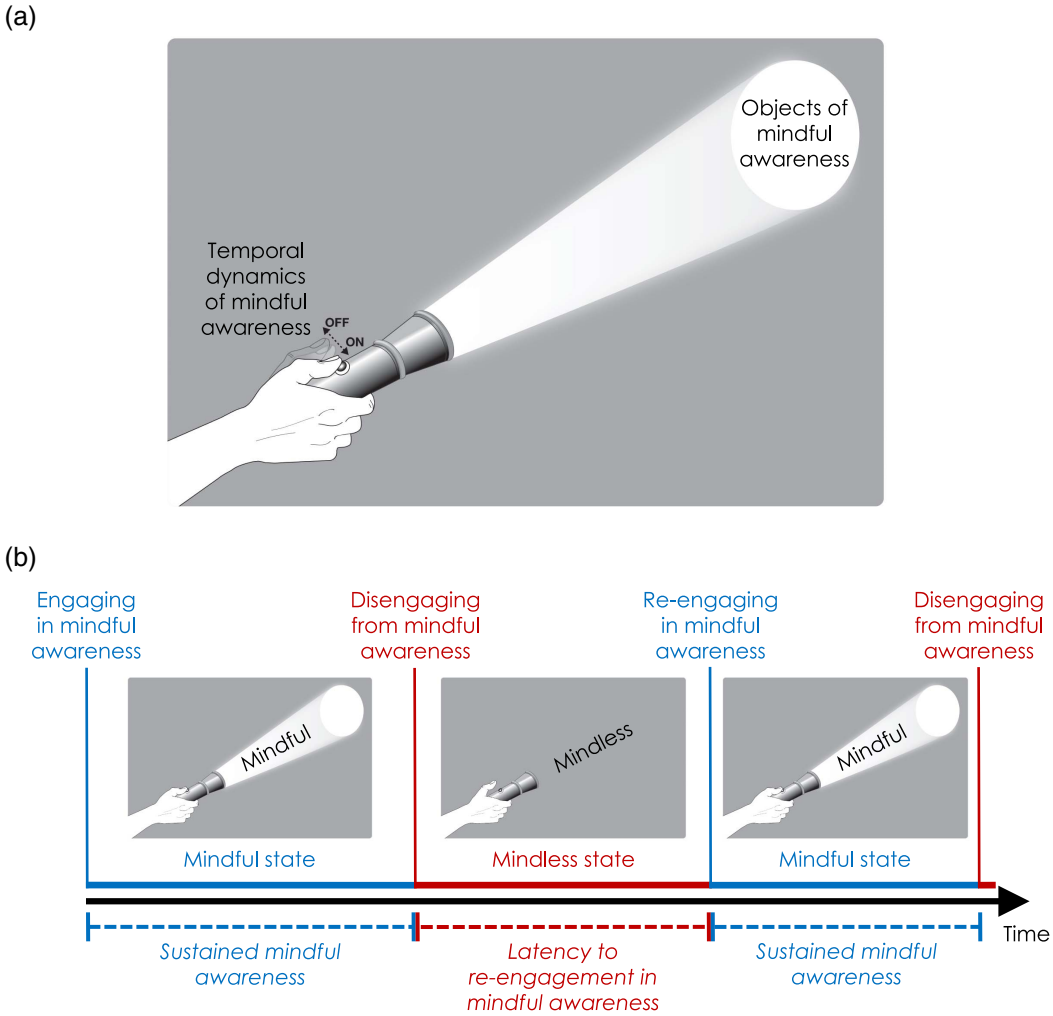
## Measurement of Attention and Awareness in Mindfulness Meditation

In recent years, leading scholars have argued that these critical gaps in contemporary science of mindfulness are, in large part, a byproduct of the field's limited capacity to measure and quantify attention and awareness in mindfulness meditation (Davidson & Kaszniak, 2015; Garland & Gaylord, 2009; Van Dam et al., 2018). To date, three major approaches have been taken to measure and study these, and related, mindfulness processes. These include self-report measures of mindfulness, cognitive-experimental tasks measuring attention and executive functions, and behavioral measures of mindfulness.

[1] We use the term *mindful awareness* to refer to aspects of mindfulness related to attention and awareness which are distinct from attitudinal qualities of mindfulness (Kabat-Zinn, 2013; Lindsay & Creswell, 2017).

**Figure 1**

*Two Dimensions of Mindful Awareness: Objects and Temporal Dynamics of Mindful Awareness*




*Note*. (a) Mindful awareness is represented by the flashlight and its beam of light. The objects of mindful awareness are represented by the direction in which the flashlight is pointed, causing it to illuminate specific types of present moment experiences (e.g., body, hedonic tone, mind). The temporal dynamics of mindful awareness are represented by turning the light on (i.e., mindful states) and off (i.e., mindless states) over time. (b) Mindfulness processes reflected in the duration of mindful and mindless states—sustained mindful awareness and latency to reengagement in mindful awareness. Figure adapted from "Behavioral assessment of mindfulness: Defining features, organizing framework, and review of emerging methods" by Y. Hadash and A. Bernstein, 2019, *Current Opinion in Psychology*, *28*, pp. 229–237 (https://doi.org/10.1016/j.copsyc.2019.01.008.). Copyright 2019 by Elsevier. Adapted with permission. See the online article for the color version of this figure.



## Self-Report Measures of Mindfulness

The most commonly used measurement methodology entails self-report methods, which include self-report scales and experience sampling (Davidson & Kaszniak, 2015; Sauer et al., 2013; Van Dam et al., 2018). Several existing mindfulness scales have demonstrated acceptable levels of reliability and validity (Baer, 2019). However, some studies suggest that these measures may also capture construct-irrelevant variance (e.g., neuroticism, affect; Goldberg et al., 2016, 2019; Van Dam et al., 2018), and most of these scales were not designed to assess attention and awareness during mindfulness meditation (Tanay & Bernstein, 2013). Notably, self-report methods are limited by threats to their validity due to retrospective recall biases and demand characteristics (Grossman, 2008; Van Dam et al., 2018). Moreover, as mindfulness practice involves the cultivation of awareness of one's own awareness (i.e., meta-awareness), the accuracy or validity of self-reported mindful awareness might paradoxically and problematically depend on peoples' capacities for mindful awareness (Davidson & Kaszniak, 2015; Van Dam et al., 2018).

## Cognitive-Experimental Tasks Measuring Attention and Executive Functions

A second approach has applied established cognitive-experimental tasks measuring attention and executive functions to quantify the

cognitive capacities thought to subserve mindful awareness (Lao et al., 2016; Van Dam et al., 2018). For example, sustained attention tasks have been proposed to measure the cognitive capacities thought to subserve sustained mindful awareness, and tasks measuring executive functions (e.g., task switching) have been proposed to measure the cognitive capacities thought to subserve disengagement from mind-wandering and reengagement in mindful awareness (Bishop et al., 2004; Chiesa et al., 2011; Hölzel et al., 2011; Malinowski, 2013; Vago et al., 2019). However, whereas extant cognitive-experimental tasks are explicitly designed to measure and quantify external sensory-perceptual, typically visual, attention (Amir et al., 2021), mindfulness practice usually involves internally directed attention such as attention to bodily sensations and mental events (Hadash & Bernstein, 2019). Accordingly, the cognitive capacities involved in internally directed attention in mindfulness meditation may be distinguished from those involved in sensory-perceptual cognitive-experimental tasks (Chun et al., 2011; Dixon et al., 2014; Levinson et al., 2014). Indeed, evidence regarding the effects of mindfulness practice on cognitive tasks measuring attention and executive functions are, at best, mixed (Chiesa et al., 2011; Gallant, 2016; Im et al., 2021; Lao et al., 2016; Vago et al., 2019). These findings raise critical questions regarding the functional significance of the cognitive processes measured by these tasks for mindfulness practice.

## Behavioral Measures of Mindfulness

Due to the limitations of extant approaches to measurement of mindfulness, researchers have begun to develop and test behavioral measures of mindfulness, some of which are focused on measuring mindful awareness during meditation (Frewen et al., 2008; Levinson et al., 2014). These behavioral measures are designed to quantify attention to, awareness of, or attitudes toward, present moment experience. Importantly, experimental stimuli in these measures are present moment experiential objects of mindful awareness common to mindfulness training (e.g., breath, interoception, mental events; Hadash & Bernstein, 2019). Below, we briefly review existing behavioral measures and methodological approaches used to measure mindfulness (see Hadash & Bernstein, 2019, for a more comprehensive review).

Several existing behavioral measures of mindfulness utilize real-time reports of mindful awareness of the breath using button presses during a 10–20-min focused attention meditation (e.g., Meditation Breath Attention Scores Task; Frewen et al., 2008). Preliminary findings support the construct validity of their scores as indices of mindful awareness of the breath and acting with awareness, but not as indices of other facets or properties of mindfulness (Burg & Michalak, 2011; Frewen et al., 2008, 2011, 2016). A second approach used in the Breath Counting Task involves real-time reports of breath counting to measure sustained mindful awareness of the breath. Importantly, findings provide initial evidence of the construct validity of the task's score as an index of mindfulness, and more specifically as an index of sustained mindful awareness of the breath (Levinson et al., 2014; Wong et al., 2018). A third approach used in interoceptive sensitivity/accuracy tasks (e.g., Heartbeat Detection Tasks) compares subjective reports of an interoceptive experience with objective markers or experimental manipulations of that experience (See Treves et al., 2019, for a review). Evidence supporting the construct validity or known-groups validity of these task's scores as indices of mindfulness processes are sparse—findings suggest that these tasks do not differentiate long-term meditators from non-meditators and that mindfulness training may only lead to small improvements in these tasks (Hadash & Bernstein, 2019; Treves et al., 2019). Finally, a fourth approach has been used to measure attitudes toward present moment experience by means of experimental elicitation of a present moment experience (e.g., fear) concurrent with an implicit measurement of attitudes toward the elicited experience. Findings provide initial evidence for the construct validity of the scores of a task implementing this approach as a measure of nonjudging and disidentification from experience (Hadash et al., 2016).

Importantly, although some existing behavioral measures of mindfulness demonstrate acceptable preliminary psychometric properties, these measures do not provide a comprehensive measurement of the objects and temporal dynamics of mindful awareness during meditation. Most existing behavioral measures of mindfulness have been designed to assess mindful awareness of the breath in focused attention meditation—one specific experiential object of mindful awareness (Burg & Michalak, 2011; Frewen et al., 2008; Levinson et al., 2014). Although important, these behavioral measures were not designed to measure or quantify mindful awareness of other experiential objects such as bodily sensations (other than the breath), mental events, and hedonic tone. Moreover, existing measures were not designed to detect the dynamic moment-to-moment expression of mindful awareness during meditation, and therefore, lack the temporal resolution needed to capture processes expressed in the temporal dynamics of mindful awareness during meditation (Hadash & Bernstein, 2019).

## The Present Study

Extant measurement methods, including self-report scales, cognitive-experimental tasks, and behavioral measures of mindfulness, provide a limited capacity to study and advance understanding of attention and awareness during mindfulness meditation. This has led to critical gaps in our empirical knowledge of the roles of attention and awareness during mindfulness meditation in the practice, cultivation, and salutary functions of mindfulness. Accordingly, we set out to study these processes by means of a novel behavioral paradigm measuring the objects and temporal dynamics of mindful awareness during meditation—the mindful awareness task (MAT). In a laboratory study, we used the MAT to empirically examine the following four aims and thereby address fundamental gaps in the measurement of, and empirical understanding of, attention and awareness during mindfulness meditation. *Aim 1:* To empirically characterize attention and awareness during mindfulness meditation. *Aim 2:* To test whether and how previous meditation practice predicts attention and awareness during mindfulness meditation. *Aim 3:* To study whether and how attention and awareness during mindfulness meditation are associated with attitudinal qualities of mindfulness, attention regulation, and mental health. *Aim 4:* To investigate the psychometric performance of the MAT relative to self-report measures and cognitive-experimental tasks in measuring mindful awareness. In this study, participants performed the MAT, cognitive-experimental tasks measuring sustained visual attention and task switching, and self-report measures of mindfulness, attention (dys)regulation, and mental health.

## Method

### Participants

One hundred forty-three adult participants from a university community completed the study, ages 19–51 years, $M(SD) = 26.52(5.41)$ years. Sample size was determined a priori to enable the detection of associations between MAT scores and criterion variables of moderate magnitude (power = .95 for detecting $r \geq .30$, two-tailed). Most participants were female (76.92% female); Jewish (98.6% Jewish, 0.7% Arab, 0.7% Russian); secular (74.8% secular, 16.1% traditional, 9.1% religious); undergraduate students (4.9% high-school diploma, 74.8% BA students, 7.0% BA degree, 9.1% MA students, 4.2% MA or a PhD degree); single (75.5% single, 13.3% cohabitation with partner, 9.1% married, 2.1% divorced or single parents); and did not have children (94.4% did not have children). Participants income levels were diverse (37.8% below-average income, 21.7% average income, 39.9% above-average income, 0.7% did not report income).

Twenty-three-percent of participants ($n = 33$) reported previous mindfulness meditation practice, including $M(SD) = 3.89(8.32)$ months of regular mindfulness meditation practice; $M(SD) = 1.94(3.44)$ days in mindfulness meditations retreat(s); and $M(SD) = 10.76(42.69)$ mindfulness meditation sessions in mindfulness-based interventions or mindfulness meditation groups (see Supplemental Materials, for additional details). Ten percent of participants ($n = 14$) reported previous practice of meditation styles that do not emphasize the cultivation of mindfulness (e.g., transcendental meditation) *and* no previous mindfulness meditation practice (see Supplemental Materials, for description of meditation style classification). Persons were *not* eligible to participate if: (a) <18 years of age; (b) uncorrected vision problems; and (c) Hebrew as second language, or self-reported lack of fluency in speaking or reading Hebrew. Participants received monetary compensation or course credit for their participation. One participant chose to discontinue study participation. The study received human subjects research ethics approval.

### Procedure

Following informed written consent, participants completed an online baseline trait self-report assessment battery at home. One week later they completed an assessment session in the lab, in which they first performed the MAT immediately followed by experience sampling and state self-report assessment of mindful awareness during the MAT. Participants then performed the sustained attention to response task (SART) and alternating-runs task switching paradigm (ARTS) which were counter-balanced, and finally completed the previous meditation experience questionnaire.

### Measures

#### *MAT*

During the MAT, participants performed a 20-min mindfulness meditation in which they were instructed (a) to monitor a wide range of prominent present moment experiences (e.g., sensations, emotions, thoughts), and (b) to direct their awareness to their breath when they do not notice any experience. To measure attention and awareness during meditation, participants were also instructed (a) to verbally state a label describing each experience they notice (e.g., "warm," "happy," "worried"), and (b) to press a button whenever they notice their inhalation or exhalation (see Figure 2a). Notably, the MAT instructions are similar to instructions of several traditional Buddhist and contemporary forms of mindfulness sitting meditation, in which mental labeling of experience is used along with mindfulness of the breath (Anālayo, 2003; Goldstein, 2013; Kabat-Zinn, 2013; Mahasi, 1978; Segal et al., 2013).

To quantify the objects of mindful awareness during meditation, qualitative coding of the content of participants' verbal labels during the MAT was used to compute scores for meta-awareness, mindful awareness of body, mind, thinking, pleasant and unpleasant hedonic tone (see Figure 2). To quantify the temporal dynamics of mindful awareness, the timing and order of labels and button presses were analyzed to divide and classify the 20-min meditation into mindful sequences, mindless sequences, and sequences that could not be classified as mindful or mindless. The durations of mindful and mindless sequences were used to compute scores for mindful awareness time, sustained mindful awareness, and latency to reengagement in mindful awareness (see Figure 2). See Supplemental Materials, for a detailed description of the MAT procedure, label coding procedure, sequence classification algorithm, and computation of all task scores.

#### *SART*

The SART is a go/no-go continuous performance task and was used to quantify sustained visual attention (Robertson et al., 1997). See Supplemental Materials, for a description of the task procedure and computation of task scores.

#### *ARTS*

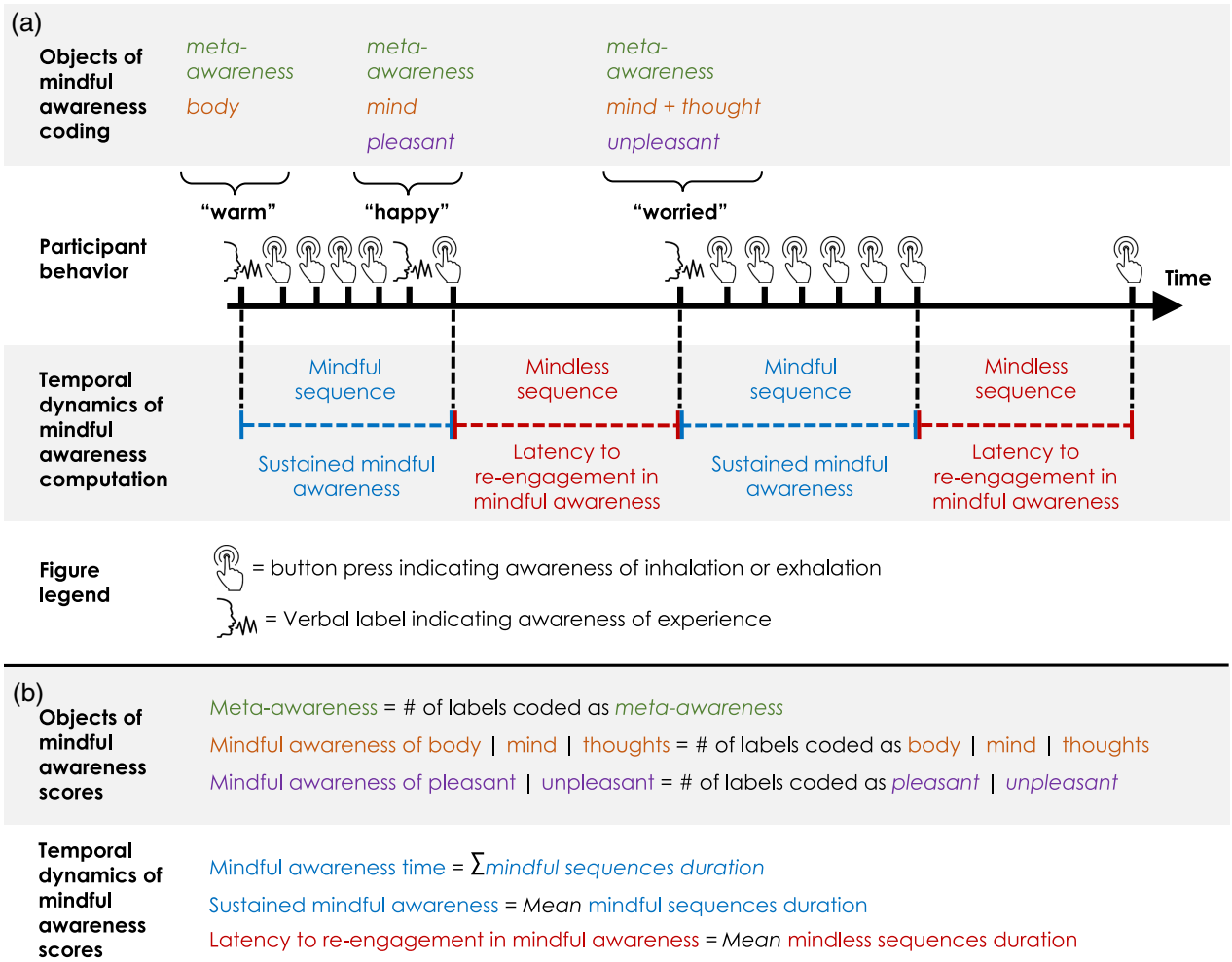
The ARTS paradigm was used to quantify executive functions and levels of interference between competing tasks (Kiesel et al., 2010). See Supplemental Materials, for a detailed description of the task procedure and computation of task scores.

#### *Self-Report Scales*

The *previous meditation experience questionnaire* was composed based on existing guidelines (Lutz et al., 2007; Van Dam et al., 2018) to assess participants previous experience in meditation (see Supplemental Materials, for description). The *Mindful Attention Awareness Scale* was used to measure self-reported trait present moment attention and awareness (Brown & Ryan, 2003). The *Five Facet Mindfulness Questionnaire* was used to measure the following self-reported trait facets of mindfulness: observing, describing, acting with awareness, nonjudging, and nonreactivity (Baer et al., 2006). The *State Mindfulness Scale* was used to measure self-reported state mindful awareness, mindful awareness of body, and mindful awareness of mind during the MAT mindfulness meditation (Tanay & Bernstein, 2013). The *Multidimensional Assessment of Interoceptive Awareness* was used to measure the following self-reported trait dimensions of interoceptive awareness: noticing, emotional awareness, self-regulation, and attention regulation (Mehling et al., 2012). The *Drexel Defusion Scale* was used to measure self-reported trait decentering (Forman et al., 2012; Hadash et al., 2017). *Toronto Mindfulness Scale—Curiosity* subscale was used to measures self-reported state curiosity toward present moment experience (Lau et al., 2006). The *Attentional*

**Figure 2**

*MAT Times-Series Data, Data Analytic Methodologies, and Scores Computation*




*Note.* (a) Time periods in which participants continuously indicated mindful awareness via verbal labels and button presses were classified as mindful sequences. Time periods in which participants did not provide any indication of mindful awareness—no button presses indicating awareness of the breath and no verbal labels reflecting awareness of present moment experience—were classified as mindless sequences (see Supplemental Materials, for detailed description of the sequence classification algorithm). (b) The number of labels reflecting meta-awareness, and mindful awareness of body, mind, thoughts, pleasant and unpleasant hedonic tone were tallied to quantify the frequencies of mindful awareness of these experiential objects. The temporal dynamics of mindful awareness scores were quantified based on the duration of mindful and mindless sequences. MAT = mindful awareness task. See the online article for the color version of this figure.

*Control Scale* was used to measures self-reported trait capacity to control attention (Derryberry & Reed, 2002). The *Mind-Wandering Questionnaire* was used to measure self-reported trait mind-wandering (Mrazek et al., 2013). The *Patient Health Questionnaire–9* was used to measure self-reported levels of depression symptoms (Kroenke et al., 2001). The *Penn State Worry Questionnaire* was used to measure self-reported trait levels of worry (Meyer et al., 1990). The *Beck Anxiety Inventory* was used to measure self-reported levels of anxiety symptoms (Beck et al., 1988). All scales were translated and back-translated from English to Hebrew by staff fluent in Hebrew and English using structured guidelines (Geisinger, 1994; See Supplemental Materials, for references of Hebrew translations of most measures). Internal reliabilities for all scales and subscales were above acceptable levels ($\alpha \geq .70$) and for most scales and subscales were good or excellent ($\alpha \geq .80$; see Table S2 in Supplemental Materials for $\alpha$ values).

### *Experience Sampling of State Mindfulness Processes*

Single-item experience samples were administered immediately after the MAT to measure state self-reported mindfulness processes during the MAT. Experience samples were composed to capture the following processes: meta-awareness, mindful awareness of body, mind, pleasant, and unpleasant experience, sustained mindful awareness, and latency to reengagement in mindful awareness (see Table S3 in Supplemental Materials for item wording).

**Table 1**
*Descriptive Statistics and Reliabilities of MAT Scores*

| Dimension | MAT score | *M* (*SD*) | Split-half reliability[a] | Interrater reliability[b] |
|---|---|---|---|---|
| Objects of MA | Meta-awareness | 23.38 (19.29) | .92[c] | .99[c] |
| | MA of body | 11.69 (12.99) | .88[c] | .99[c] |
| | MA of mind | 8.03 (7.48) | .85[c] | .99[c] |
| | MA of thoughts | 5.57 (6.67) | .86[c] | .99[c] |
| | MA of pleasant | 1.37 (2.09) | .65[c] | .97[c] |
| | MA of unpleasant | 7.57 (8.12) | .82[c] | .98[c] |
| Temporal dynamics of MA | MA time | 564.35 (307.06) s | .94 | — |
| | | 47.04% (25.58%) | | |
| | Sustained MA | 42.92 (51.45) s | .82[c] | — |
| | Latency to MA | 11.97 (7.41) s | .88[c] | — |

*Note*. Objects of mindful awareness scores reflect the number of labels representing meta-awareness, and mindful awareness of body, mind, thoughts, pleasant and unpleasant hedonic tone during the 20-min MAT mindfulness meditation. $N = 143$. MAT = mindful awareness task; MA = mindful awareness; Latency to MA = latency to reengagement in mindful awareness.
[a] Spearman–Brown prophecy-corrected. [b] One-way random effects intraclass correlation coefficients (ICC) testing for absolute agreement for a single measurement (Koo & Li, 2016; McGraw & Wong, 1996). Interrater reliabilities were computed on 60 participants (42% of sample) that were coded by two coders (see Supplemental Materials). [c] Computed on Log10 transformation of score because nontransformed values were skewed (see Supplemental Materials).

Experience samples of mindful awareness of body, mind, pleasant, and unpleasant experience were tested as measures of mindfulness in a previous study (Hadash et al., 2016).

## Transparency and Openness

All reported data are deposited in the Open Science Framework (https://osf.io/a679v). This study was not preregistered.

# Results

## Reliability of MAT Scores

See Table 1, for reliability coefficients of MAT scores. Split-half reliabilities of most MAT scores were good (>.80) or excellent (>.90). Interrater reliabilities of the objects of mindful awareness scores were all excellent (>.90; see Supplemental Materials, for additional findings on interrater reliabilities).

## Aim 1: Empirically Characterizing Attention and Awareness During Mindfulness Meditation

See Table 1, for descriptive statistics of MAT scores for the total sample, and Table 2 for descriptive statistics for participants with and without previous mindfulness meditation practice. MAT scores indicated that participants were meta-aware—noticed a *present moment experience* other than the breath—$M(SD) = 23.38(19.29)$ times during the 20-min meditation. Furthermore, a comparison of MAT scores indicated that frequencies of mindful awareness differed between experiential objects. Specifically, participants demonstrated a slightly higher frequency of mindful awareness of their body than their mind[2], $t(142) = 2.31$, $p = .02$, Cohens' $d = 0.19$; and a much higher frequency of mindful awareness of unpleasant than pleasant experience, $t(142) = 14.14$, $p < .001$, Cohens' $d = 1.18$ (see Supplemental Materials, for these analyses among participants with previous mindfulness meditation practice).

MAT scores also indicated that participants engaged in mindful awareness $M(SD) = 47.04\%$ (25.58%) of the time, sustained mindful awareness for $M(SD) = 42.92$ (51.45) s, and reengaged in mindful awareness $M(SD) = 11.97(7.41)$ s following the onset of mindless states. Notably, a comparison of MAT scores indicated that sequences of sustained mindful awareness were significantly longer on average duration than sequences of mindless states, $t(142) = 14.70$, $p < .001$, Cohens' $d = 1.23$ (see Supplemental Materials, for this analyses among participants with previous mindfulness meditation practice). Finally, coefficients of variation of MAT scores indicated that participants demonstrated high levels of individual differences on all objects and temporal dynamics of mindful awareness $\left(\frac{SD_{range}}{M_{range}} = .54 \text{ to } 1.53\right)$. However, some of the MAT scores displayed evidence for floor effects, and none of the MAT scores displayed evidence for ceiling effects (see Supplemental Materials, for tests of floor and ceiling effects).

## Aim 2: Whether and How Previous Meditation Practice Predicts Attention and Awareness During Mindfulness Meditation

We used multivariate analysis of variance and follow-up *t* tests, to examine the differences between participants with ($n = 33$) and without ($n = 110$) previous mindfulness meditation practice on mindfulness processes during meditation measured by the MAT. As expected, participants with previous mindfulness meditation practice were more frequently aware of most experiential objects and engaged in mindful awareness for a larger proportion of time; model $F(9, 133) = 2.56$, $p = .010$, $\eta_p^2 = 0.15$ (see Table 2 for follow up *t* tests). Importantly, these differences were specific to *mindfulness* meditation practice. Participants with previous practice of meditation styles that *do not* emphasize the cultivation of mindfulness (e.g., transcendental meditation) did not display greater mindful awareness during meditation compared to participants with no meditation practice at all (see Supplemental Materials). We furthermore tested whether the amount of previous mindfulness meditation practice (number of months) predicts greater mindful awareness during meditation as

[2] All MAT scores except for total mindful awareness time were positively skewed ($\text{skewness}_{\text{range}} = 1.43$ to 5.13; see Table S5 in Supplemental Materials). Skewed scores were transformed using a Log10 transformation (Log10 transformed $\text{skewness}_{\text{range}} = -0.85$ to 1.16) and all statistical analyses were performed on transformed scores to protect against violating normality assumptions of statistical tests.

**Table 2**
*T Tests and Descriptive Statistics for Mindfulness Processes Measured via the MAT by Previous Mindfulness Meditation Practice*

| | Participants with previous mindfulness meditation practice ($n$ = 33) | Participants without previous mindfulness meditation practice ($n$ = 110) | | | | |
|---|---|---|---|---|---|---|
| MAT score | $M$ ($SD$) | $M$ ($SD$) | $t$ | $df$ | $P$ | Hedges' $g$ |
| Meta-awareness | 33.24 (19.94) | 20.42 (18.17) | 4.80[a]*** | 82.23[a] | <.001[a] | 0.75[a] |
| MA of body | 16.09 (13.61) | 10.37 (12.56) | 4.02[a]*** | 76.94[a] | <.001[a] | 0.65[a] |
| MA of mind | 12.21 (7.70) | 6.78 (6.97) | 3.99[a]*** | 141[a] | <.001[a] | 0.79[a] |
| MA of thoughts | 9.09 (6.63) | 4.52 (6.34) | 4.38[a]*** | 141[a] | <.001[a] | 0.87[a] |
| MA of pleasant | 1.76 (2.33) | 1.25 (2.01) | 1.26[a] | 141[a] | .21[a] | 0.25[a] |
| MA of unpleasant | 10.91 (9.28) | 6.56 (7.49) | 3.02[a]** | 141[a] | .003[a] | 0.60[a] |
| MA time | 57.82% (24.25%) | 43.80% (25.18%) | 2.83** | 141 | .005 | 0.56 |
| Sustained MA | 60.43 (91.21) | 37.67 (29.77) | 0.86[a] | 39.65[a] | .40[a] | 0.22[a] |
| Latency to MA | 11.19 (4.34) | 12.20 (8.10) | −0.18[a] | 141[a] | .86[a] | −0.04[a] |

*Note*. See the Participants subsection for descriptive statistics of previous mindfulness meditation practice. MAT = mindful awareness task; MA = mindful awareness; Latency to MA = latency to reengagement in mindful awareness.
[a] Computed on Log10 transformation of score because nontransformed values were skewed (see Supplemental Materials).
** $p < .01$. *** $p < .001$.

measured by the MAT, among participants that have/had a regular mindfulness meditation practice (i.e., at least once a week; $n$ = 16). As expected, number of months of regular mindfulness meditation practice strongly and positively predicted greater meta-awareness ($r$ = .51, $p$ = .04), mindful awareness of body ($r$ = .52, $p$ = .04), mindful awareness time ($r$ = .70, $p$ = .003), and sustained mindful awareness ($r$ = .87, $p < .001$, see Table S7 in Supplemental Materials).

## Aim 3: Whether and How Attention and Awareness During Mindfulness Meditation Are Associated With Attitudinal Qualities of Mindfulness, Attention Regulation, and Mental Health

We used stepwise regression models to test whether and which specific mindfulness processes during meditation measured by the MAT are uniquely associated with attitudinal qualities of mindfulness, attention (dys)regulation, and mental health (see Table 3 and Table S8 in Supplemental Materials). Generally, mindfulness processes during meditation were associated with attention (dys)regulation, mental health, and some attitudinal qualities of mindfulness ($R_{range}$ = .21 to .34). Moreover, the majority of stepwise regression models retained at least one object of mindful awareness and at least one type of temporal dynamic, indicating that in many cases both objects *and* temporal dynamics of mindful awareness were related to these processes.

## Aim 4: Psychometric Performance of the MAT Relative to Self-Report Measures and Cognitive-Experimental Tasks in Measuring Mindful Awareness

### *Aim 4a: Are Behavioral and Self-Reported Mindful Awareness Related?*

We tested whether behavioral mindfulness processes (i.e., measured via the MAT) were correlated with *state* self-report measures assessing the same mindfulness processes during the MAT mindfulness meditation (i.e., experience samples and scales); as well as with *trait* self-report scales of mindfulness facets theoretically related to these mindfulness processes. While, as predicted, all correlations between MAT scores and self-reported *state* mindfulness were significant and ranged from small to large in magnitude ($r_{range}$ = .19 to .52; see Table 4), only half of the correlations between MAT scores and self-reported trait mindfulness were significant, and correlations were small in magnitude ($r_{range}$ = .22 to .27; see Table 4).

### *Aim 4b: Is the Accuracy of Self-Reported Mindful Awareness Dependent on Levels of Behavioral Mindful Awareness?*

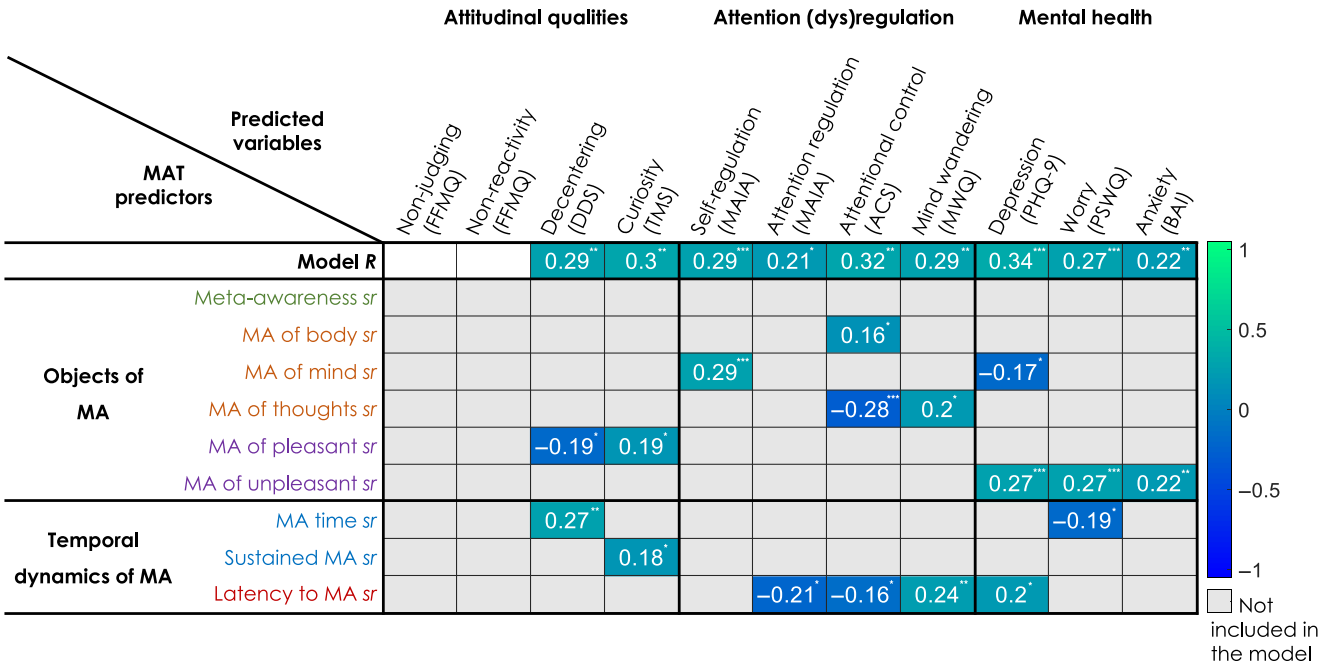
We used Breusch–Pagan tests of heteroscedasticity to examine whether participants with higher behavioral mindful awareness demonstrated greater correspondence (i.e., reduced prediction errors/residuals) between their self-reported and behavioral levels of mindful awareness. Analyses indicated significant heteroscedasticity in most associations between MAT scores and their corresponding state self-report measure (see Table S9 in Supplemental Materials). As predicted, participants with high behavioral mindful awareness demonstrated significantly greater correspondence between their self-reported and behavioral mindful awareness. In contrast, participants with low behavioral mindful awareness reported a broader range of mindful awareness ratings (i.e., very high to very low levels) and demonstrated lower correspondence between their self-reported and behavioral mindful awareness (see Figure 3). This pattern of heteroscedasticity suggests that participants with high behavioral mindful awareness may provide relatively more accurate and valid self-reports on their levels of state mindfulness than participants with low behavioral mindful awareness.

### *Aim 4c: Are Attentional Processes Measured via Cognitive-Experimental Tasks Related to Attention and Awareness During Mindfulness Meditation?*

First, we tested whether levels of sustained visual attention (SART) were related to behavioral sustained mindful awareness during meditation (MAT). Second, we tested whether levels of interference between competing tasks (ARTS) were related to increased interference of mind-wandering during meditation, measured as longer latencies to disengage from mind-wandering and reengage in mindful awareness (MAT). Sustained mindful awareness during meditation was negatively but weakly correlated with an index of transient

**Table 3**

*Stepwise Regressions Testing Associations Between Mindfulness Processes Measured via the MAT and Attitudinal Qualities of Mindfulness, Attention (Dys)Regulation, and Mental Health*




*Note.* The table presents semipartial correlations (*sr*) and coefficients of multiple correlation (*R*) in stepwise regression models. Each column represents one stepwise regression model predicting indices of attitudinal qualities of mindfulness, attention (dys)regulation, or mental health. Semipartial correlation values are reported only for MAT predictors retained in each stepwise model. Models for FFMQ nonjudging and FFMQ-nonreactivity subscales were not created because no predictors were significantly associated with predicted values. See Table S8 in Supplemental Materials for all stepwise regression models' parameters. $N = 143$. MAT = mindful awareness task; MA = mindful awareness; *sr* = semipartial correlation; Latency to MA = latency to reengagement in mindful awareness; FFMQ = Five Facet Mindfulness Questionnaire; DDS = Drexel Defusion Scale; TMS = Toronto Mindfulness Scale; MAIA = Multidimensional Assessment of Interoceptive Awareness; ACS = Attentional Control Scale; MWQ = Mind-Wandering Questionnaire; PHQ-9 = Patient Health Questionnaire–9; PSWQ = Penn State Worry Questionnaire; BAI = Beck Anxiety Inventory. See the online article for the color version of this table.
$^{*}p < .05$. $^{**}p < .01$. $^{***}p < .001$.

disengagement of attention from the dynamic features of a visual task (SART-reaction time variability $r = -.18$, $p = .03$) but was not correlated with an index of inattention to visual information and motor behavior (SART-commission errors $r = .02$, $p = .85$). Latency to disengage from mind-wandering and reengage in mindful awareness during meditation was positively but weakly correlated to an index of impaired task set competition management (ARTS-mixing cost $r = .18$, $p = .03$) but not correlated with an index of impaired task set reconfiguration (ARTS-switching cost $r = .09$, $p = .31$).

### *Aim 4d: Is Previous Mindfulness Meditation Practice Related to Self-Reported Mindfulness and to Attentional Processes Measured via Cognitive-Experimental Tasks?*

We tested whether, participants *with*, relative to participants *without* previous mindfulness meditation practice, demonstrated greater self-reported mindfulness (measured via mindfulness scales) and greater capacities for sustained visual attention and task switching (measured via cognitive-experimental tasks). In contrast to behavioral mindful awareness (see Aim 2), the associations between previous mindfulness meditation practice and self-reported mindfulness were null or in the direction opposite to prediction (see Table S10 in Supplemental Materials). Likewise, previous mindfulness meditation practice was not related to sustained visual attention or task switching (see Supplemental Materials).

## Discussion

Buddhist and contemporary psychological theories suggest that training attention and awareness during mindfulness meditation is fundamental to the practice, cultivation, and salutary functions of mindfulness (Dahl et al., 2015; Goldstein, 2013; Hölzel et al., 2011; Thera, 2014). Yet, despite its theoretical significance, the empirical foundation of this central premise in contemporary mindfulness science is surprisingly limited (Im et al., 2021; Lao et al., 2016; Treves et al., 2019). These critical gaps in contemporary science of mindfulness are, in large part, a byproduct of the field's limited capacity to measure attention and awareness during mindfulness meditation (Davidson & Kaszniak, 2015; Garland & Gaylord, 2009; Van Dam et al., 2018). Accordingly, we set out to measure and study attention and awareness during mindfulness meditation in a laboratory study ($N = 143$, 76.92% female) by means a novel behavioral paradigm—the MAT. We used the MAT to empirically characterize attention and awareness during mindfulness meditation, their

**Table 4**

*Associations Between Behavioral Mindful Awareness and Self-Reported State and Trait Mindful Awareness*

| MAT score and self-report score | Pearson/weighted least squared correlation | *p* |
|---|---|---|
| Behavioral mindfulness and self-reported *state* mindfulness | | |
| MAT meta-awareness and ES meta-awareness | .34[a,b***] | <.001 |
| MAT MA of body and ES MA of body | .43[a,b***] | <.001 |
| MAT MA of mind and ES MA of mind | .19[a,b*] | .03 |
| MAT MA of pleasant and ES MA of pleasant | .52[a,b,c***] | <.001 |
| MAT MA of unpleasant and ES MA of unpleasant | .44[a,b,d***] | <.001 |
| MAT sustained MA and ES sustained MA | .23[b**] | .006 |
| MAT latency to MA and ES latency to MA | .24[b**] | .004 |
| MAT MA time and SMS-total | .26[a**] | .002 |
| MAT MA of body and SMS-body | .33[a,b***] | <.001 |
| MAT MA of mind and SMS-mind | .21[a,b*] | .01 |
| MAT MA of thoughts and SMS-mind | .22[b**] | .008 |
| Behavioral mindfulness and self-reported *trait* mindfulness | | |
| MAT MA of body and MAIA-noticing | .15[b] | .06 |
| MAT MA of body and FFMQ-observing | .22[b**] | .008 |
| MAT MA of mind and MAIA-emotional awareness | .27[b***] | <.001 |
| MAT MA of mind and FFMQ-describing | −.09[b] | .288 |
| MAT sustained MA and FFMQ-acting with awareness | −.01[b] | .922 |
| MAT latency to MA and FFMQ-acting with awareness | −.23[b**] | .005 |

*Note.* $N = 143$ unless otherwise specified. MAT = mindful awareness task; ES = experience sampled; MA = mindful awareness; Latency to MA = latency to reengagement in mindful awareness; SMS = State Mindfulness Scale; MAIA = Multidimensional Assessment of Interoceptive Awareness; FFMQ = Five Facet Mindfulness Questionnaire.

[a] Weighted least squares due to heteroscedasticity (see Table S9 in Supplemental Material). [b] Computed on Log10 transformation of MAT score because nontransformed values were skewed (see Supplemental Materials). [c] $N = 126$ (see Table S3 note in Supplemental Material). [d] $N = 140$ (see Table S3 note in Supplemental Material).

$^{*}p < .05$. $^{**}p < .01$. $^{***}p < .001$.

associations with previous meditation practice, and their salutary correlates; and to investigate the psychometric performance of this novel behavioral paradigm relative to self-report measures and cognitive-experimental tasks in measuring mindful awareness.

## Empirically Characterizing Attention and Awareness During Mindfulness Meditation

First, we found that during mindfulness meditation, participants demonstrated a much higher frequency of mindful awareness of unpleasant relative to pleasant experience, as well as a slightly higher frequency of mindful awareness of bodily experiences (e.g., bodily sensations) relative to mental experiences (e.g., emotions, thoughts). These novel behavioral findings suggest that the well-documented negativity bias phenomenon (Baumeister et al., 2001; Rozin & Royzman, 2001) may also be expressed during mindfulness meditation as a tendency to notice unpleasant experience to a much greater extent than pleasant experience. Second, we found that, on average, participants engaged in mindful awareness approximately half (47%) of the time meditating, and that states of sustained mindful awareness were longer in duration than states without mindful awareness (i.e., mindless states) during meditation. Interestingly, these novel behavioral findings parallel estimates of mindful awareness and mind-wandering during meditation derived from brain decoding of neuroimaging data (Weng et al., 2020).

## Associations of Previous Meditation Practice With Attention and Awareness During Mindfulness Meditation

We found that previous mindfulness meditation practice was moderately to strongly associated with greater mindful awareness of most experiential objects, mindful awareness time, and sustained mindful awareness during meditation. Furthermore, these associations were specific to *mindfulness* meditation practice, such that previous practice of meditation styles that do not emphasize the cultivation of mindfulness (e.g., transcendental meditation) was not similarly related to attention and awareness during mindfulness meditation. These findings are important because, to date, findings regarding the associations between mindfulness practice and conventional measures of attention (e.g., Continuous Performance Task) and interoceptive awareness (e.g., Heartbeat Detection Tasks) are, at best, mixed (Im et al., 2021; Lao et al., 2016; Treves et al., 2019). Thus, in line with theory and neuroimaging findings (Brefczynski-Lewis et al., 2007; Brewer et al., 2011; Hölzel et al., 2007; Lutz et al., 2004, 2008), these findings provide novel and much-needed behavioral evidence that *previous* mindfulness meditation practice may have a substantial effect on attention and awareness *during* mindfulness meditation.

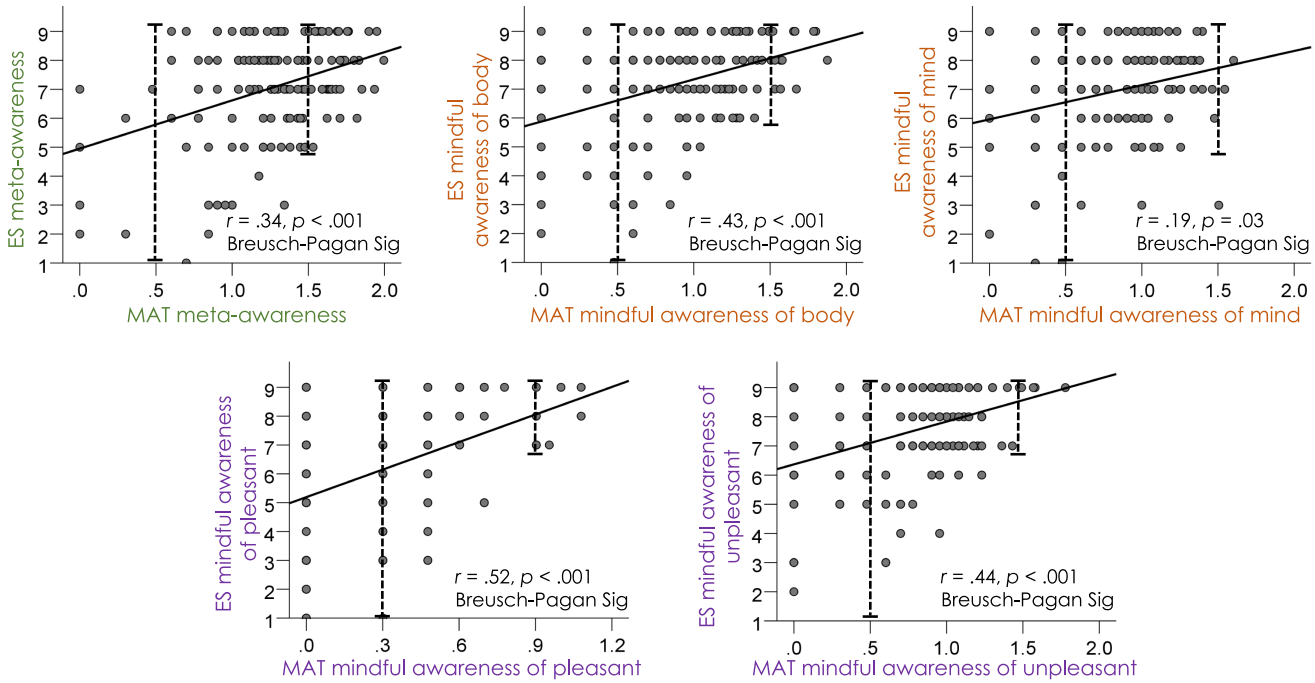
## Associations Between Attention and Awareness During Mindfulness Meditation and Attitudinal Qualities of Mindfulness, Attention (Dys)Regulation, and Mental Health

We found novel behavioral findings indicating that people with greater attentional control tended to notice less thoughts, and that people with greater mental health symptoms tended to notice more unpleasant experiences during mindfulness meditation. First, in line with previous findings (Mrazek et al., 2012), greater attentional control and reduced mind-wandering were related to reduced awareness of thoughts during meditation. Second, in line with findings indicating mental health symptoms are linked to biases in attentional selection of negative stimuli (Amir et al., 2021; Mennen et al., 2019), greater depression and anxiety symptoms and greater worry were related to greater awareness of unpleasant experience during meditation.

We also found novel and important evidence indicating that greater mindful awareness of mental events and pleasant experience during mindfulness meditation were related to putative salutary correlates of mindfulness. First, in line with the theorized roles of mindful awareness of mental events in emotion regulation and depression relapse prevention (Crane, 2017; Segal et al., 2013; Vago & Silbersweig, 2012), increased mindful awareness of mental events during meditation was related to greater self-regulation and reduced depression symptoms. Second, in line with the theorized bidirectional effects of mindful awareness of pleasant experience on

**Figure 3**

*Examples of Heteroscedastic Associations Between Mindfulness Processes Measured by the MAT and Their Corresponding State Self-Report Scores*




*Note*. Participants with higher behavioral mindful awareness (MAT scores) demonstrated significantly better correspondence between their self-reported and behavioral levels of mindful awareness, as indicated by significantly reduced residuals. All correlations were computed using weighted least squares due to heteroscedasticity, and all MAT scores were Log10 transformed because nontransformed values were skewed (see Tables S5 and S9 in Supplemental Materials). ES = experience sampled; MAT = mindful awareness task. See the online article for the color version of this figure.

upward spirals of positive emotions including curiosity and interest (Garland & Fredrickson, 2019; Garland et al., 2010, 2015), greater mindful awareness of pleasant experience during meditation was related to increased curiosity toward experience.

Finally, we found theoretically important behavioral evidence indicating that specific temporal dynamics of mindful awareness were related to distinct putative salutary correlates of mindfulness. First, in line with theory and research in contemplative, cognitive, and clinical sciences (Smallwood & Schooler, 2015; Vago & Silbersweig, 2012; Wielgosz et al., 2019), shorter latencies to reengagement in mindful awareness following the onset of mindless states were related to greater attention regulation and control, lower mind-wandering, and reduced depression symptoms. Second, in line with theory (Bernstein et al., 2015; Segal et al., 2013), increased mindful awareness time during meditation was related to greater decentering and reduced worry. Third, in line with theory implicating bidirectional effects of sustained mindful awareness on attitudinal qualities like curiosity and vice versa (Anālayo, 2003; Brewer et al., 2013), sustained mindful awareness was related to increased curiosity toward experience.

Collectively, these findings provide novel and important behavioral evidence that, in line with theory, the objects and temporal dynamics of mindful awareness during meditation are related to attitudinal qualities of mindfulness, attention (dys)regulation in daily living, and mental health. Recent evidence indicates that self-reported mindfulness meditation practice quality mediates the effects of mindfulness meditation practice on salutary outcomes (Del Re et al., 2013; Goldberg et al., 2014, 2020). Accordingly, mindfulness processes expressed in the objects and temporal dynamics of mindful awareness may reflect important dimensions of mindfulness meditation practice quality, and therefore may function as mechanisms that mediate the effects of mindfulness meditation practice on salutary outcomes (Anālayo, 2003; Hölzel et al., 2011; Vago & Silbersweig, 2012).

## Psychometric Performance of the MAT Relative to Self-Report Measures and Cognitive-Experimental Tasks in Measuring Mindful Awareness

We found that the MAT displayed sound psychometric performance as a measure of mindful awareness and, specifically, of attention and awareness during mindfulness meditation. First, MAT scores displayed good to excellent split-half and interrater reliabilities. Second, in contrast to self-report methods and cognitive-experimental tasks, most MAT scores were associated with previous mindfulness meditation practice—evidence of known-groups validity and incremental validity. Third, MAT scores were not associated with previous practice of meditation styles that do not emphasize the cultivation of mindfulness—evidence of discriminant validity. Fourth, each MAT score was associated with its corresponding state self-report measure assessing the same object or temporal dynamic of mindful awareness during meditation—evidence of convergent validity. Finally,

MAT scores predicted the accuracy of self-reported state mindful awareness and were associated with attitudinal qualities of mindfulness, attention (dys)regulation, and mental health—evidence of criterion validity.

In contrast, we found that self-report methods for measuring mindful awareness, including extensively used trait and state self-report scales and experience sampling, may be limited in measuring mindfulness processes trained and expressed in mindfulness meditation. First, in contrast to the MAT, and partially in line with previous findings (Falkenström, 2010; Manuel et al., 2017), most mindfulness self-report scales were *not* related to previous practice of mindfulness meditation; and participants *with* previous mindfulness meditation practice demonstrated significantly *lower mindfulness* scores than participants *without* previous practice on two (sub) scales. Second, in line with previous findings (Frewen et al., 2011, 2016; Levinson et al., 2014), half of the associations between self-report scales of trait mindfulness and behaviorally measured mindfulness processes during meditation were null, and the remaining correlations were small in magnitude ($r_{range}$ = .22 to .27). Third, in line with theory (Davidson & Kaszniak, 2015; Van Dam et al., 2018), participants with high behavioral mindful awareness demonstrated good correspondence between their self-reported and behavioral mindful awareness, while participants with low behavioral mindful awareness demonstrated low correspondence. Thus, people with high (behavioral) mindful awareness capacities may provide relatively accurate and valid self-reports on their levels of mindfulness, whereas people with low mindful awareness capacities may not be able to provide accurate and valid self-reports on their levels of mindfulness. Notably, this finding may have broad implications for mindfulness research, as self-report methods are the most commonly used approach to measure mindfulness, and are often used among people with putatively low mindful awareness capacities (e.g., meditation novices; Baer, 2019; Van Dam et al., 2018). If replicated, self-report measurement of mindfulness among such people may need to be reexamined and interpreted with caution.

Furthermore, we found novel behavioral evidence indicating that cognitive-experimental tasks thought to measure key cognitive capacities subserving mindful awareness (Bishop et al., 2004; Chiesa et al., 2011; Lutz et al., 2008; Malinowski, 2013) may, in fact, not be good cognitive proxies of attentional processes trained and expressed in mindfulness meditation. First, in contrast to the MAT, levels of sustained visual attention (SART) and of interference between competing tasks (ARTS; i.e., executive function) were *not* related to previous practice of mindfulness meditation. These null findings align with mixed findings regarding the effects of mindfulness practice on cognitive-experimental tasks measuring attention and executive functions (Gallant, 2016; Im et al., 2021; Lao et al., 2016; Vago et al., 2019). Second, the associations between levels of sustained visual attention and of interference between competing tasks and behaviorally measured attention and awareness during meditation were either null or weak ($r$ = .18). Collectively, these findings may suggest that attention and awareness in mindfulness meditation may be largely determined by domain-specific capacities (e.g., subserving internally directed cognition) that are distinguished from those involved in sensory-perceptual cognitive-experimental tasks (e.g., measuring externally directed cognition; Chun et al., 2011; Dixon et al., 2014; Levinson et al., 2014).

## Limitations and Future Directions

First, the MAT was designed to measure attention and awareness during mindfulness meditation, but not attitudinal qualities of mindfulness. Future studies using the MAT may also use behavioral measures of attitudinal qualities of mindfulness for a more comprehensive behavioral assessment of mindfulness processes (Hadash & Bernstein, 2019; Hadash et al., 2016). Second, the present study did not examine whether the MAT also demonstrates robust psychometrics among advanced meditators. For example, some advanced meditators could, potentially, enter altered meditative states of consciousness during the MAT (e.g., absorptions and formless attainments; Anālayo, 2003; Thanissaro, 2012) which may interrupt button presses and/or verbal labeling. Future studies focused on advanced meditators are needed to examine the MAT score's reliability and validity, as well as rule out potential ceiling effects, among advanced meditators. Importantly, in this sample, we did not find any ceiling effects in MAT scores, indicating higher scores may be obtained by advanced meditators. Third, the present sample included mostly young, predominantly female, educated adults from Israel. Future studies may test whether findings replicate among populations from additional and diverse demographic backgrounds, as well as among clinical or selected populations.

Fourth, by design, additional behavioral measures of mindfulness were not included in this single-session study due to potential carryover, training, and task switching effects that are expected to alter the psychometric performance of these measures, particularly among meditation naïve participants. Future studies may test the incremental validity of the MAT relative to other behavioral measures of mindfulness by administering tasks over separate sessions. Fifth, during the MAT, participants are instructed to provide behavioral reports of their mindful awareness during meditation (i.e., verbal labels and button presses). Accordingly, like many other behavioral measures of mindfulness, providing behavioral reports during meditation may alter the experience of meditation and therefore, the measure may not function as a purely naturalistic observation of mindful awareness during meditation.

Sixth, stepwise regression models were used in some of the analyses (Aim 3 analyses) to address multicollinearity between MAT scores. However, stepwise regression models may capitalize on sample-specific properties, and thus, future studies are needed to replicate these findings in independent samples. Seventh, to retain statistical power and limit Type II errors in this first study of the MAT, we did not control for multiple comparisons. Future studies are needed to test whether these findings replicate in independent samples. Finally, the present study entailed a cross-sectional correlational design. Future randomized controlled study designs could test the effects of mindfulness training on attention and awareness during mindfulness meditation using the MAT, as well as to test whether such effects prospectively mediate the salutary outcomes of mindfulness training.

In addition to using the MAT to study mindfulness, the MAT may also have implications for mindfulness training that may be tested in future studies. For example, based on an assessment of each participants' objects and temporal dynamics of mindful awareness via the MAT, meditation instructions may be personalized to train mindful awareness of specific experiential objects (e.g., pleasant experience) and/or specific processes reflected in the temporal dynamics of mindful awareness (e.g., sustained mindful

awareness). Thus, this type of mindfulness training personalization, often conducted by meditation instructors through the process of inquiry (Crane, 2017; Segal et al., 2013), may now be digitally guided, as well as systematically studied through the MAT.

## Conclusions

Using the MAT, a novel behavioral measurement paradigm of mindful awareness, we empirically characterized attention and awareness during mindfulness meditation and provided important evidence that attention and awareness during mindfulness meditation may indeed be fundamental to the practice, cultivation, and salutary functions of mindfulness. Furthermore, we presented novel evidence suggesting that whereas self-report measures and cognitive-experimental tasks may be limited in measuring mindful awareness capacities and attentional processes trained and expressed during mindfulness meditation; the MAT may overcome these limitations and perform as a reliable and valid measure of mindful awareness during meditation. Accordingly, it may provide a valuable measurement paradigm for the field to look inside the "black box" of mindfulness meditation, and thereby explore a variety of questions about attention and awareness in mindfulness meditation and practice.

## References


Amir, I., Ruimi, L., & Bernstein, A. (2021). Simulating thoughts to measure and study internal attention in mental health. *Scientific Reports*, *11*(1), Article 2251. https://doi.org/10.1038/s41598-021-81756-w

Anālayo, B. (2003). *Satipaṭṭhāna: The direct path to realization*. Windhorse Publications.

Baer, R. (2019). Assessment of mindfulness by self-report. *Current Opinion in Psychology*, *28*, 42–48. https://doi.org/10.1016/j.copsyc.2018.10.015

Baer, R. A., Smith, G. T., Hopkins, J., Krietemeyer, J., & Toney, L. (2006). Using self-report assessment methods to explore facets of mindfulness. *Assessment*, *13*(1), 27–45. https://doi.org/10.1177/1073191105283504

Batchelor, M. (2019). Mindfulness theory: Feeling tones (vedanās) as a useful framework for research. *Current Opinion in Psychology*, *28*, 20–22. https://doi.org/10.1016/j.copsyc.2018.10.002

Baumeister, R. F., Bratslavsky, E., Finkenauer, C., & Vohs, K. D. (2001). Bad is stronger than good. *Review of General Psychology*, *5*(4), 323–370. https://doi.org/10.1037/1089-2680.5.4.323

Beck, A. T., Epstein, N., Brown, G., & Steer, R. A. (1988). An inventory for measuring clinical anxiety: Psychometric properties. *Journal of Consulting and Clinical Psychology*, *56*(6), 893–897. https://doi.org/10.1037/0022-006X.56.6.893

Bernstein, A., Hadash, Y., Lichtash, Y., Tanay, G., Shepherd, K., & Fresco, D. M. D. M. (2015). Decentering and related constructs: A critical review and metacognitive processes model. *Perspectives on Psychological Science*, *10*(5), 599–617. https://doi.org/10.1177/1745691615594577

Bernstein, A., Vago, D. R., & Barnhofer, T. (2019). Understanding mindfulness, one moment at a time: An introduction to the special issue. *Current Opinion in Psychology*, *28*, vi–x. https://doi.org/10.1016/j.copsyc.2019.08.001

Bishop, S. R., Lau, M., Shapiro, S., Carlson, L., Anderson, N. D., Carmody, J., Segal, Z. V., Abbey, S., Speca, M., Velting, D., & Devins, G. (2004). Mindfulness: A proposed operational definition. *Clinical Psychology: Science and Practice*, *11*(3), 230–241. https://doi.org/10.1093/clipsy.bph077

Brefczynski-Lewis, J. A., Lutz, A., Schaefer, H. S., Levinson, D. B., & Davidson, R. J. (2007). Neural correlates of attentional expertise in long-term meditation practitioners. *Proceedings of the National Academy of Sciences of the United States of America*, *104*(27), 11483–11488. https://doi.org/10.1073/pnas.0606552104

Brewer, J. A., Davis, J. H., & Goldstein, J. (2013). Why is it so hard to pay attention, or is it? Mindfulness, the factors of awakening and reward-based learning. *Mindfulness*, *4*(1), 75–80. https://doi.org/10.1007/s12671-012-0164-8

Brewer, J. A., Worhunsky, P. D., Gray, J. R., Tang, Y.-Y., Weber, J., & Kober, H. (2011). Meditation experience is associated with differences in default mode network activity and connectivity. *Proceedings of the National Academy of Sciences of the United States of America*, *108*(50), 20254–20259. https://doi.org/10.1073/pnas.1112029108

Brown, K. W., & Ryan, R. M. (2003). The benefits of being present: Mindfulness and its role in psychological well-being. *Journal of Personality and Social Psychology*, *84*(4), 822–848. https://doi.org/10.1037/0022-3514.84.4.822

Brown, K. W., Ryan, R. M., & Creswell, J. D. (2007). Mindfulness: Theoretical foundations and evidence for its salutary effects. *Psychological Inquiry*, *18*(4), 211–237. https://doi.org/10.1080/10478400701598298

Burg, J. M., & Michalak, J. (2011). The healthy quality of mindful breathing: Associations with rumination and depression. *Cognitive Therapy and Research*, *35*(2), 179–185. https://doi.org/10.1007/s10608-010-9343-x

Chiesa, A., Calati, R., & Serretti, A. (2011). Does mindfulness training improve cognitive abilities? A systematic review of neuropsychological findings. *Clinical Psychology Review*, *31*(3), 449–464. https://doi.org/10.1016/j.cpr.2010.11.003

Chun, M. M., Golomb, J. D., & Turk-Browne, N. B. (2011). A taxonomy of external and internal attention. *Annual Review of Psychology*, *62*(1), 73–101. https://doi.org/10.1146/annurev.psych.093008.100427

Crane, R. (2017). *Mindfulness-based cognitive therapy: Distinctice features* (2nd ed.). Routledge. https://doi.org/10.4324/9781315627229

Dahl, C. J., Lutz, A., & Davidson, R. J. (2015). Reconstructing and deconstructing the self: Cognitive mechanisms in meditation practice. *Trends in Cognitive Sciences*, *19*(9), 515–523. https://doi.org/10.1016/j.tics.2015.07.001

Davidson, R. J., & Kaszniak, A. W. (2015). Conceptual and methodological issues in research on mindfulness and meditation. *American Psychologist*, *70*(7), 581–592. https://doi.org/10.1037/a0039512

Del Re, A. C., Flückiger, C., Goldberg, S. B., & Hoyt, W. T. (2013). Monitoring mindfulness practice quality: An important consideration in mindfulness practice. *Psychotherapy Research*, *23*(1), 54–66. https://doi.org/10.1080/10503307.2012.729275

Derryberry, D., & Reed, M. A. (2002). Anxiety-related attentional biases and their regulation by attentional control. *Journal of Abnormal Psychology*, *111*(2), 225–236. https://doi.org/10.1037/0021-843X.111.2.225

Dixon, M. L., Fox, K. C. R., & Christoff, K. (2014). A framework for understanding the relationship between externally and internally directed cognition. *Neuropsychologia*, *62*, 321–330. https://doi.org/10.1016/j.neuropsychologia.2014.05.024

Dunne, J. D., Thompson, E., & Schooler, J. (2019). Mindful meta-awareness: Sustained and non-propositional. *Current Opinion in Psychology*, *28*, 307–311. https://doi.org/10.1016/j.copsyc.2019.07.003

Falkenström, F. (2010). Studying mindfulness in experienced meditators: A quasi-experimental approach. *Personality and Individual Differences*, *48*(3), 305–310. https://doi.org/10.1016/j.paid.2009.10.022

Forman, E. M., Herbert, J. D., Juarascio, A. S., Yeomans, P. D., Zebell, J. A., Goetter, E. M., & Moitra, E. (2012). The Drexel Defusion Scale: A new measure of experiential distancing. *Journal of Contextual Behavioral Science*, *1*(1–2), 55–65. https://doi.org/10.1016/j.jcbs.2012.09.001

Frewen, P., Evans, E. M., Maraj, N., Dozois, D. J. A., & Partridge, K. (2008). Letting go: Mindfulness and negative automatic thinking. *Cognitive Therapy and Research*, *32*(6), 758–774. https://doi.org/10.1007/s10608-007-9142-1

Frewen, P., Hargraves, H., DePierro, J., D'Andrea, W., & Flodrowski, L. (2016). Meditation Breath Attention Scores (MBAS): Development and

investigation of an internet-based assessment of focused attention during meditation practice. *Psychological Assessment*, *28*(7), 830–840. https://doi.org/10.1037/pas0000283

Frewen, P., Lundberg, E., MacKinley, J., & Wrath, A. (2011). Assessment of response to mindfulness meditation: Meditation breath attention scores in association with subjective measures of state and trait mindfulness and difficulty letting go of depressive cognition. *Mindfulness*, *2*(4), 254–269. https://doi.org/10.1007/s12671-011-0069-y

Gallant, S. N. (2016). Mindfulness meditation practice and executive functioning: Breaking down the benefit. *Consciousness and Cognition*, *40*, 116–130. https://doi.org/10.1016/j.concog.2016.01.005

Garland, E. L., Farb, N. A. R., Goldin, P., & Fredrickson, B. L. (2015). Mindfulness broadens awareness and builds eudaimonic meaning: A process model of mindful positive emotion regulation. *Psychological Inquiry*, *26*(4), 293–314. https://doi.org/10.1080/1047840X.2015.1064294

Garland, E. L., Fredrickson, B., Kring, A. M., Johnson, D. P., Meyer, P. S., & Penn, D. L. (2010). Upward spirals of positive emotions counter downward spirals of negativity: Insights from the broaden-and-build theory and affective neuroscience on the treatment of emotion dysfunctions and deficits in psychopathology. *Clinical Psychology Review*, *30*(7), 849–864. https://doi.org/10.1016/j.cpr.2010.03.002

Garland, E., & Gaylord, S. (2009). Envisioning a future contemplative science of mindfulness: Fruitful methods and new content for the next wave of research. *Complementary Health Practice Review*, *14*(1), 3–9. https://doi.org/10.1177/1533210109333718

Garland, E. L., & Fredrickson, B. L. (2019). Positive psychological states in the arc from mindfulness to self-transcendence: Extensions of the mindfulness-to-meaning theory and applications to addiction and chronic pain treatment. *Current Opinion in Psychology*, *28*, 184–191. https://doi.org/10.1016/j.copsyc.2019.01.004

Geisinger, K. F. (1994). Cross-cultural normative assessment: Translation and adaptation issues influencing the normative interpretation of assessment instruments. *Psychological Assessment*, *6*(4), 304–312. https://doi.org/10.1037/1040-3590.6.4.304

Goldberg, S. B., Del Re, A. C., Hoyt, W. T., & Davis, J. M. (2014). The secret ingredient in mindfulness interventions? A case for practice quality over quantity. *Journal of Counseling Psychology*, *61*(3), 491–497. https://doi.org/10.1037/cou0000032

Goldberg, S. B., Knoeppel, C., Davidson, R. J., & Flook, L. (2020). Does practice quality mediate the relationship between practice time and outcome in mindfulness-based stress reduction?. *Journal of Counseling Psychology*, *67*(1), 115–122. https://doi.org/10.1037/cou0000369

Goldberg, S. B., Riordan, K. M., Sun, S., & Davidson, R. J. (2022). The empirical status of mindfulness-based interventions: A systematic review of 44 meta-analyses of randomized controlled trials. *Perspectives on Psychological Science*, *17*(1), 108–130. https://doi.org/10.1177/1745691620968771

Goldberg, S. B., Tucker, R. P., Greene, P. A., Simpson, T. L., Hoyt, W. T., Kearney, D. J., & Davidson, R. J. (2019). What can we learn from randomized clinical trials about the construct validity of self-report measures of mindfulness? A meta-analysis. *Mindfulness*, *10*(5), 775–785. https://doi.org/10.1007/s12671-018-1032-y

Goldberg, S. B., Wielgosz, J., Dahl, C., Schuyler, B., MacCoon, D. S., Rosenkranz, M., Lutz, A., Sebranek, C. A., & Davidson, R. J. (2016). Does the Five Facet Mindfulness Questionnaire measure what we think it does? Construct validity evidence from an active controlled randomized clinical trial. *Psychological Assessment*, *28*(8), 1009–1014. https://doi.org/10.1037/pas0000233

Goldstein, J. (2013). *Mindfulness: A practical guide to awakening*. Sounds True.

Grossman, P. (2008). On measuring mindfulness in psychosomatic and psychological research. *Journal of Psychosomatic Research*, *64*(4), 405–408. https://doi.org/10.1016/j.jpsychores.2008.02.001

Hadash, Y., & Bernstein, A. (2019). Behavioral assessment of mindfulness: Defining features, organizing framework, and review of emerging methods. *Current Opinion in Psychology*, *28*, 229–237. https://doi.org/10.1016/j.copsyc.2019.01.008

Hadash, Y., Lichtash, Y., & Bernstein, A. (2017). Measuring decentering and related constructs: Capacity and limitations of Extant Assessment Scales. *Mindfulness*, *8*(6), 1674–1688. https://doi.org/10.1007/s12671-017-0743-9

Hadash, Y., Plonsker, R., Vago, D. R., & Bernstein, A. (2016). Experiential self-referential and selfless processing in mindfulness and mental health: Conceptual model and implicit measurement methodology. *Psychological Assessment*, *28*(7), 856–869. https://doi.org/10.1037/pas0000300

Hasenkamp, W., Wilson-Mendenhall, C. D., Duncan, E., & Barsalou, L. W. (2012). Mind wandering and attention during focused meditation: A fine-grained temporal analysis of fluctuating cognitive states. *NeuroImage*, *59*(1), 750–760. https://doi.org/10.1016/j.neuroimage.2011.07.008

Hölzel, B. K., Lazar, S. W., Gard, T., Schuman-Olivier, Z., Vago, D. R., & Ott, U. (2011). How does mindfulness meditation work? Proposing mechanisms of action from a conceptual and neural perspective. *Perspectives on Psychological Science*, *6*(6), 537–559. https://doi.org/10.1177/1745691611419671

Hölzel, B. K., Ott, U., Hempel, H., Hackl, A., Wolf, K., Stark, R., & Vaitl, D. (2007). Differential engagement of anterior cingulate and adjacent medial frontal cortex in adept meditators and non-meditators. *Neuroscience Letters*, *421*(1), 16–21. https://doi.org/10.1016/j.neulet.2007.04.074

Im, S., Stavas, J., Lee, J., Mir, Z., Hazlett-Stevens, H., & Caplovitz, G. (2021). Does mindfulness-based intervention improve cognitive function? A meta-analysis of controlled studies. *Clinical Psychology Review*, *84*, Article 101972. https://doi.org/10.1016/j.cpr.2021.101972

Kabat-Zinn, J. (2013). *Full catastrophe living: Using the wisdom of your body and mind to face stress, pain, and illness*. Bantam Books.

Kiesel, A., Steinhauser, M., Wendt, M., Falkenstein, M., Jost, K., Philipp, A. M., & Koch, I. (2010). Control and interference in task switching—A review, *Psychological Bulletin*, *136*(5), 849–874. https://doi.org/10.1037/a0019842

Koo, T. K., & Li, M. Y. (2016). A guideline of selecting and reporting intraclass correlation coefficients for reliability research. *Journal of Chiropractic Medicine*, *15*(2), 155–163. https://doi.org/10.1016/j.jcm.2016.02.012

Kroenke, K., Spitzer, R. L., & Williams, J. B. W. (2001). The PHQ-9: Validity of a brief depression severity measure. *Journal of General Internal Medicine*, *16*(9), 606–613. https://doi.org/10.1046/j.1525-1497.2001.016009606.x

Lao, S.-A., Kissane, D., & Meadows, G. (2016). Cognitive effects of MBSR/MBCT: A systematic review of neuropsychological outcomes. *Consciousness and Cognition*, *45*, 109–123. https://doi.org/10.1016/j.concog.2016.08.017

Lau, M. A., Bishop, S. R., Segal, Z. V., Buis, T., Anderson, N. D., Carlson, L., Shapiro, S., Carmody, J., Abbey, S., & Devins, G. (2006). The Toronto Mindfulness Scale: Development and validation. *Journal of Clinical Psychology*, *62*(12), 1445–1467. https://doi.org/10.1002/jclp.20326

Levinson, D. B., Stoll, E. L., Kindy, S. D., Merry, H. L., & Davidson, R. J. (2014). A mind you can count on: Validating breath counting as a behavioral measure of mindfulness. *Frontiers in Psychology*, *5*, Article 1202. https://doi.org/10.3389/fpsyg.2014.01202

Lindsay, E. K., & Creswell, J. D. (2017). Mechanisms of mindfulness training: Monitor and Acceptance Theory (MAT). *Clinical Psychology Review*, *51*, 48–59. https://doi.org/10.1016/j.cpr.2016.10.011

Lutz, A., Dunne, J. D., & Davidson, R. J. (2007). Meditation and the neuroscience of consciousness: An introduction. In P. D. Zelazo, M. Moscovitch, & E. Thompson (Eds.), *Cambridge handbook of consciousness* (Vol. 19, pp. 499–554). Cambridge University Press. https://doi.org/10.1017/CBO9780511816789.020

Lutz, A., Greischar, L. L., Rawlings, N. B., Ricard, M., & Davidson, R. J. (2004). Long-term meditators self-induce high-amplitude gamma synchrony during mental practice. *Proceedings of the National Academy of Sciences of the United States of America*, *101*(46), 16369–16373. https://doi.org/10.1073/pnas.0407401101

Lutz, A., Jha, A. P., Dunne, J. D., & Saron, C. D. (2015). Investigating the phenomenological matrix of mindfulness-related practices from a neurocognitive perspective. *American Psychologist*, *70*(7), 632–658. https://doi.org/10.1037/a0039585

Lutz, A., Slagter, H. A., Dunne, J. D., & Davidson, R. J. (2008). Attention regulation and monitoring in meditation. *Trends in Cognitive Sciences*, *12*(4), 163–169. https://doi.org/10.1016/j.tics.2008.01.005

Mahasi, S. (1978). *Practical Vipassanā meditational exercises*. Buddhasāsanānuggaha Association.

Malinowski, P. (2013). Neural mechanisms of attentional control in mindfulness meditation. *Frontiers in Neuroscience*, *7*, Article 8. https://doi.org/10.3389/fnins.2013.00008

Manuel, J. A., Somohano, V. C., & Bowen, S. (2017). Mindfulness practice and its relationship to the Five-Facet Mindfulness Questionnaire. *Mindfulness*, *8*(2), 361–367. https://doi.org/10.1007/s12671-016-0605-x

McGraw, K. O., & Wong, S. P. (1996). Forming inferences about some intraclass correlation coefficients. *Psychological Methods*, *1*(1), 30–46. https://doi.org/10.1037/1082-989X.1.1.30

Mehling, W. E., Price, C., Daubenmier, J. J., Acree, M., Bartmess, E., & Stewart, A. (2012). The Multidimensional Assessment of Interoceptive Awareness (MAIA). *PLOS ONE*, *7*(11), Article e48230. https://doi.org/10.1371/journal.pone.0048230

Mennen, A. C., Norman, K. A., & Turk-Browne, N. B. (2019). Attentional bias in depression: Understanding mechanisms to improve training and treatment. *Current Opinion in Psychology*, *29*, 266–273. https://doi.org/10.1016/j.copsyc.2019.07.036

Meyer, T. J., Miller, M. L., Metzger, R. L., & Borkovec, T. D. (1990). Development and validation of the Penn State Worry Questionnaire. *Behaviour Research and Therapy*, *28*(6), 487–495. https://doi.org/10.1016/0005-7967(90)90135-6

Mrazek, M. D., Phillips, D., Franklin, M., Broadway, J., & Schooler, J. (2013). Young and restless: Validation of the Mind-Wandering Questionnaire (MWQ) reveals disruptive impact of mind-wandering for youth, *Frontiers in Psychology*, *4*, Article 560. https://doi.org/10.3389/fpsyg.2013.00560

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

Robertson, I. H., Manly, T., Andrade, J., Baddeley, B. T., & Yiend, J. (1997). 'Oops!': Performance correlates of everyday attentional failures in traumatic brain injured and normal subjects. *Neuropsychologia*, *35*(6), 747–758. https://doi.org/10.1016/S0028-3932(97)00015-8

Rozin, P., & Royzman, E. B. (2001). Negativity bias, negativity dominance, and contagion. *Personality and Social Psychology Review*, *5*(4), 296–320. https://doi.org/10.1207/S15327957PSPR0504_2

Sauer, S., Walach, H., Schmidt, S., Hinterberger, T., Lynch, S., Büssing, A., & Kohls, N. (2013). Assessment of mindfulness: Review on state of the art. *Mindfulness*, *4*(1), 3–17. https://doi.org/10.1007/s12671-012-0122-5

Segal, Z. V., Williams, J. M., & Teasdale, J. D. (2013). *Mindfulness-based cognitive therapy for depression* (2nd ed.). Guilford Press.

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

Tanay, G., & Bernstein, A. (2013). State Mindfulness Scale (SMS): Development and initial validation. *Psychological Assessment*, *25*(4), 1286–1299. https://doi.org/10.1037/a0034044

Thanissaro, B. (2012). *With each and every breath: A guide to meditation*. Metta Forest Monastery.

Thera, N. (2014). *The heart of Buddhist meditation: The Buddha's way of mindfulness*. Weiser Books.

Treves, I. N., Tello, L. Y., Davidson, R. J., & Goldberg, S. B. (2019). The relationship between mindfulness and objective measures of body awareness: A meta-analysis. *Scientific Reports*, *9*(1), Article 17386. https://doi.org/10.1038/s41598-019-53978-6

Vago, D. R., Gupta, R. S., & Lazar, S. W. (2019). Measuring cognitive outcomes in mindfulness-based intervention research: A reflection on confounding factors and methodological limitations. *Current Opinion in Psychology*, *28*, 143–150. https://doi.org/10.1016/j.copsyc.2018.12.015

Vago, D. R., & Silbersweig, D. A. (2012). Self-awareness, self-regulation, and self-transcendence (S-ART): A framework for understanding the neurobiological mechanisms of mindfulness. *Frontiers in Human Neuroscience*, *6*, Article 296. https://doi.org/10.3389/fnhum.2012.00296

Van Dam, N. T., van Vugt, M. K., Vago, D. R., Schmalzl, L., Saron, C. D., Olendzki, A., Meissner, T., Lazar, S. W., Kerr, C. E., Gorchov, J., Fox, K. C. R., Field, B. A., Britton, W. B., Brefczynski-Lewis, J. A., & Meyer, D. E. (2018). Mind the hype: A critical evaluation and prescriptive agenda for research on mindfulness and meditation. *Perspectives on Psychological Science*, *13*(1), 36–61. https://doi.org/10.1177/1745691617709589

Weng, H. Y., Lewis-Peacock, J. A., Hecht, F. M., Uncapher, M. R., Ziegler, D. A., Farb, N. A. S., Goldman, V., Skinner, S., Duncan, L. G., Chao, M. T., & Gazzaley, A. (2020). Focus on the breath: Brain decoding reveals internal states of attention during meditation. *Frontiers in Human Neuroscience*, *14*, Article 336. https://doi.org/10.3389/fnhum.2020.00336

Wielgosz, J., Goldberg, S. B., Kral, T. R. A., Dunne, J. D., & Davidson, R. J. (2019). Mindfulness meditation and psychopathology. *Annual Review of Clinical Psychology*, *15*(1), 285–316. https://doi.org/10.1146/annurev-clinpsy-021815-093423

Wong, K. F., Massar, S. A. A., Chee, M. W. L., & Lim, J. (2018). Towards an objective measure of mindfulness: Replicating and extending the features of the breath-counting task. *Mindfulness*, *9*(5), 1402–1410. https://doi.org/10.1007/s12671-017-0880-1

Received February 25, 2022
Revision received August 14, 2022
Accepted September 29, 2022 ■