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Meditation Breath Attention Scores (MBAS): Test–Retest Reliability and Sensitivity to Repeated Practice

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Abstract The sensitivity of an experience-sampling measure of meditators' ability to maintain attention to their breathing during 15-min practices of mindful breath awareness meditation, referred to as "Meditation Breath Attention Scores" (MBAS), was previously shown to vary with other meditative experiences and mindfulness-related traits. The objectives of the present study were to assess: (1) the test–retest reliability of MBAS and (2) the sensitivity to practice-related effects of MBAS. Participants completed as many as four meditation sessions held on average 8–10 days apart. Ninety-five participants took part in session 1, with 77 (81 %) completing all four sessions. Test–retest reliability of MBAS was established (mean r between sessions = 0.50) and MBAS were sensitive to practice effects (η^2=0.20) consistent with their interpretation as a performance measure. Individual differences in MBAS thus appear to be reliable over time but improve with the repeated practice of meditation. Future research directions are discussed.

Keywords Mindfulness · Meditation · Breath attention · Decentering

Introduction

Although a number of surveys of mindfulness-related traits have been validated (e.g., Baer et al. 2004, 2006, 2008), few standardized methods exist for measuring experiences related to the practice of a particular mindfulness meditation sitting (i.e., state mindfulness). This is problematic because mindfulness, as currently defined, represents a state rather than trait variable, specifically, a state of attention, awareness, and being that is open and non-judgmental (Bishop et al. 2004; Kabat-Zinn 2005).

Measures of the *subjective*, *experiential* aspects of response to meditation include the *Toronto Mindfulness Scale* (TMS; Lau et al. 2006) which assesses the degree to which participants' experience mindful *curiosity* (e.g., "*I was curious to see what my mind was up to from moment to moment*") and mindful *decentering* (e.g., "*I experienced myself as separate from my changing thoughts and feelings*") during a meditation sitting. However, whereas meditation instructions commonly support individuals orienting toward their present-moment experiences with curiosity and decentering, perhaps more straightforwardly, mindfulness meditation practice typically involves paying attention to one's breath and, upon becoming distracted from such focus, gently and nonjudgmentally letting go of the source of the distraction and returning one's attention toward experiencing the process of breathing. It is therefore of interest to examine whether the repeated practice of meditation actually enhances a person's ability to sustain their attention toward the breathing process. Although a recent meta-analysis found that improvements on experimental tests of attentional functioning (both of executive processes and orienting) were among the most robust post-intervention outcomes for meditation training (mean r=0.30; Eberth and Sedlmeier 2012), few studies have examined attentional functioning *during* the practice of meditation (e.g., Mrazek et al. 2012).

Meditation Breath Attention Scores (MBAS) operationalize mindfulness as a *performance* variable having to do with meditative concentration (Frewen et al. 2008, 2010). In particular, MBAS have been interpreted as indexing participants' ability to sustain their attention toward the breathing

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process during meditation practice, and accordingly their capacity to disengage from mind wandering. MBAS are calculated as the sum of the self-reported frequency with which persons are able to maintain their attention toward their breathing as queried approximately every 3-min during the practice of a meditation sitting of at least 10-min duration. Supporting the construct validity of MBAS, Frewen et al. (2010) demonstrated that, particularly during a 15-min (as opposed to 10-min meditation sitting), variability in MBAS were associated with less distracting thoughts having to do with "reviewing a mental 'to-do' list", increased feelings of relaxation and calmness, less self-reported "difficulties maintaining attention on breathing due to mind-wandering", less fatigue, greater interest in and awareness of the process of breathing, and greater use of a mantra to focus attention (e.g., breath counting). MBAS also correlated positively with trait mindful "*Acting with Awareness*", a reverse-scored subscale of the *Five-Factor Mindfulness Questionnaire* (FFMQ) that assesses the tendency of persons to focus their attention and be consciously aware of their thoughts, feelings, and behavior, as opposed to running on "automatic pilot", having one's attention frequently divided, and/or being distractible (e.g., "*When I do things, my mind wanders off and I'm easily distracted*", "*It seems I am 'running on automatic' without much awareness of what I'm doing*", Baer et al. 2006). In comparison, MBAS were independent of TMS mindful-curiosity and mindful-decentering and other FFMQ subscales in previous studies (Frewen et al. 2010). Consistent with the approach of MBAS, Mrazek et al. (2012) also examined the degree to which participants could focus their attention on the sensations of breathing during a 10-min breath–attention meditation in which participants' eyes were open in fixed gaze; the degree to which participants were "on-task" in doing so, as measured at six quasi-random intervals, was correlated with reaction time on a go/no-go task and trait mindfulness as assessed by questionnaire.

MBAS may have promise as a performance-based measure associated with the attentional state of mindfulness that improves with the repeated practice of mindfulness meditation, particularly in the case of mindfulness meditations that involve focusing awareness toward the breathing process. However, a critical limitation remaining in the establishment of the construct validity of MBAS is that their test–retest reliability and their sensitivity to practice effects (i.e., the repeated practice of mindfulness meditation that includes measurement of MBAS) have, to our knowledge, not yet been evaluated. We therefore investigated the test–retest reliability and change of MBAS over the course of four meditation sittings in novice meditators. The questions of interest to us, whether a priori hypotheses or exploratory questions as indicated, were as follows:

1. Being a *state* variable, we hypothesized that MBAS would exhibit test–retest reliability of at least modest effect size ($r \geq 0.30$). We further explored:
   (a) Whether the test–retest reliability of MBAS would vary across the number of meditation sessions practiced (i.e., differing between sessions 1–2 vs 2–3 vs 3–4).
2. We hypothesized that MBAS would improve (i.e., increase) with repeated practice (i.e., across testing sessions). We further explored:
   (a) Whether the effect size of such (predicted) improvements of MBAS with practice would vary across the number of meditation sessions completed (i.e., differing between sessions 1–2 vs 2–3 vs 3–4) and
   (b) Whether the amount of (predicted) improvements of MBAS across testing sessions would increase with the number of times participants' practiced meditation on their own time between testing sessions.
3. As a replication of previous findings (Frewen et al. 2010), we predicted the following associations between MBAS and other reported experiences during the first session of meditation practice, while exploring the replicability of associations across subsequent testing sessions:
   (a) MBAS will correlate positively with feelings of relaxation and calmness, interest in and awareness of the process of breathing, and frequency of use of a mantra to focus attention (e.g., breath counting) during the meditation, with effect sizes ranging between $0.20 \leq r \leq 0.40$.
   (b) MBAS will correlate negatively with distracting thoughts having to do with "reviewing a mental 'to-do' list", self-reported "difficulties maintaining attention on breathing due to mind-wandering", and experienced fatigue, again with effect sizes ranging between $0.20 \leq r \leq 0.40$.
4. As a further replication of previous findings (Frewen et al. 2010), we predicted that MBAS would correlate positively with the FFMQ "*Acting with Awareness*" subscale as the trait measure of mindfulness most directly measuring traits associated with attentional functioning (e.g., "*When I do things, my mind wanders off and I'm easily distracted*"); whether such correlations varied across testing sessions was also assessed. In comparison, MBAS were not expected to correlate with other FFMQ subscales that measure traits less obviously having to do with attention, such as those seemingly having much to do with neuroticism and negative affect regulation (e.g., nonjudging [e.g., "*I think some of my*

emotions are bad or inappropriate and I shouldn't feel them"], non-reactivity [e.g., "*When I have distressing thoughts or images, I 'step back' and am aware of the thought or image without getting taken over by it*"]).

5. In the previous study of Frewen et al. (2010), MBAS failed to correlate positively with TMS mindful-curiosity and mindful-decentering. We therefore did not expect to find such associations in the present study, but further explored whether those who were more able to decenter from experiences during the meditation might exhibit higher MBAS in the present study.

Method

Participants

Ninety-five undergraduate students participated in the first testing session. Participants were evenly distributed between females (n=48 [51 %]) and males (n=47 [49 %]) and ranged in age from 16 to 23, with 95 % (n=90) being aged 18–20 (overall M=18.63, SD=1.00). Most participants were of Caucasian descent (n=64 [67 %]), a sizable minority were of Asian descent (n=10 [11 %]), and the remaining participants were equally distributed amongst other ancestries. Participants were recruited from an introductory psychology course and received partial course credit for participating. In contrast with the previous study of Frewen et al. (2010), a probable self-selection bias toward over-recruitment of individuals interested in learning meditation must be acknowledged in the present study providing that the study advertisement was titled "Learning Meditation Study".

Of the 95 participants who took part in an initial session, 78 (82 %) were considered "completers" as having taken part in all four testing sessions. Of the noncompleters, five completed only the first session, two took part in only two testing sessions, and the remaining 10 completed three testing sessions. Completers vs. noncompleters did not differ significantly with respect to female-to-male ratio, $\chi^2(1)$= 0.00, p=0.96, mean age, $t(93)$=0.88, p=0.38, or ethnicity (Caucasian to non-Caucasian ratio), $\chi^2(1)$=1.10, p=0.30. Completers scored somewhat higher than noncompleters in FFMQ nonreactivity (average difference in means = 1.75, SD=0.86, t[93]=2.04, p=0.04 [two-tailed], d=0.53). Completers vs. noncompleters did not differ on any other dependent variable, including first-session MBAS, $t(93)$=0.14, p=0.91. One completer had missing data for the FFMQ at session 2 and was removed from subsequent analyses accordingly. For simplicity of interpretation, we present subsequent results only for the remaining completers (n=77).

Measures

Meditation Breath Attention Scores MBAS were developed in previous studies as a self-report performance-based measure of individual differences in meditative concentration toward the breath in response to a breath–attention meditation (Frewen et al. 2008, 2010). During the practice of an eyes-closed meditation during which participants are instructed to attend toward the experience of breathing, a meditation bell is rung approximately every 3 min (e.g., three times during a 10-min meditation or five times during a 15-min meditation, the latter as was conducted in the present study). While keeping their eyes closed, participants are instructed to indicate at each time the bell is rung whether their attention is directed toward their breathing (as instructed) or whether instead their minds have wandered to other things such as "thoughts, emotions, plans, memories, etc". In the present study, participants did so by placing a "tick mark" on a sheet of paper in front of them to indicate an affirmative answer, leaving the sheet blank in order to answer "no". Calculation of MBAS involved summing the number of times participants' indicated having been attending toward their breathing at the time of the bell chimes. Participants were instructed that it would be natural for them to find that their attention sometimes wanders away from their breath over the course of the meditation but that, should they become aware that their minds had wandered, they should "gently and non-judgmentally let-go of the object of their attention, bringing it back to the process of their breathing". Such instructions are standard in guided mindfulness meditation practice. They were instructed, however, that the placing of tick marks on their sheets only applies at the time of the bell soundings. After logging whether their attention was directed toward their breathing at the time a particular bell is rung, participants are again reminded of the instruction to attend toward their breathing until the next bell, letting go of other objects of attention should they find that their mind wanders in the meantime. As noted in the introduction, preliminary support for the construct validity of MBAS include moderate positive correlations with concurrently measured trait measures of mindfulness, including the FFMQ subscale "*Acting with Awareness*" (Frewen et al. 2010) and the *Mindful Attention Awareness Scale* (Frewen et al. 2008), as well as other measures of state meditative experience (e.g., Likert scale ratings of frequency with which persons were "interested in and aware of the process of their breathing during the meditation" (Frewen et al. 2010)).

Meditation-Related Experiences List (Frewen et al. 2010) Participants completed a survey of the extent to which they experienced 13 different phenomenological

experiences during the meditation sitting that had occurred with relatively high frequency in open-ended comments to the following instruction in a previous study (Frewen et al. 2010, study 1): "Please comment on what you experienced during the meditation session. Please note anything you noticed, regardless of how trivial you might think it is (e.g., 'I thought about…,' 'I noticed…')." (Frewen et al. 2010, p. 258). The survey completed is identical to that contained in the appendix of Frewen et al. (2010, study 2) and asked participants: "During the meditation exercise, how often did you go through each of the following types of experiences?" from "Never" (scored 1) to "Almost constantly" (scored 5). The item content of this survey is varied, with examples including "reviewing a mental 'to-do' list (what I have to do)", "unpleasant or upsetting thoughts or memories" and "feeling relaxed and calm".

Toronto Mindfulness Questionnaire (State Version; Lau et al. 2006) The TMS is a 13-item self-report questionnaire that assesses participants' experiences of mindful *decentering* (seven items; e.g., "*I experienced myself as separate from my changing thoughts and feelings*", "*I was aware of my thoughts and feelings without over-identifying with them*") and mindful *curiosity* (six items; e.g., "*I was curious to see what my mind was up to from moment to moment*", "*I was curious about each of the thoughts and feelings that I was having*") during the practice of mindfulness meditation. The TMQ is administered immediately following the practice of meditation. Psychometric support is provided by Lau et al. (2006). Coefficient alpha as evaluated at the first testing session for the present sample was α=0.60 for the decentering subscale and α=0.80 for the curiosity subscale.

Five-Factor Mindfulness Questionnaire The FFMQ (Baer et al. 2006, 2008) is a 39-item self-report survey of the mindfulness-related traits: *observing, acting with awareness, describing, accepting without judgment*, and *nonreactivity*. The subscales were derived from the results of factor analyses of items from a number of measures of trait mindfulness (Baer et al. 2006). The *observing* subscale (eight items) measures the degree to which an individual pays attention to both his/her external (e.g., "*I notice visual elements in art or nature, such as colors, shapes, textures, or patterns of light and shadow*") and internal (i.e., bodily; e.g., "*When I'm walking, I deliberately notice the sensations of my body moving*") environment. The *acting with awareness* subscale (eight items, all reverse coded) measures the extent to which a person engages in activities with undivided attention and present awareness, consequently avoiding "*automatic pilot*" (e.g., "*When I do things, my mind wanders off and I'm easily distracted*"). The *describing* subscale (eight items) measures a person's self-reported skill with regard to labeling his/her experiences, especially those involving emotion (e.g., "*I'm good at finding the words to describe my feelings*"). The *Nonjudging* subscale (eight items, all reverse-scored) measures the degree to which an individual negatively evaluates his/her response to events (e.g., "*I think some of my emotions are bad or inappropriate and I shouldn't feel them*"). Finally, the *nonreactivity* subscale (seven items) includes items that survey one's capacity to cope during periods of distress via "decentering" (e.g., "*When I have distressing thoughts or images, I 'step back' and am aware of the thought or image without getting taken over by it*", "*When I have distressing thoughts or images, I just notice them and let them go*"). The alpha coefficients observed for the FFMQ subscales in the present sample, as evaluated at the first testing session, were as follows: observing, α=0.74, describing, α=0.85, acting with awareness, α=0.85, accepting without judgment, α=0.90, and non-reactivity, α=0.57.

Meditation Practice Following Feldman et al. (2010), at the first testing session, participants indicated the approximate frequency with which they practiced meditation over the previous month as either "not regularly" vs. "once per month" vs. "once a week" vs. "once a day". At each subsequent session, participants also indicated approximately how often they had practiced meditation (i.e., number of meditation sittings), and for approximately how long in minutes, on average, per meditation sitting. The answers to the latter questions were then multiplied as the approximate number of minutes of meditation practice participants took part in between sessions.

Procedure

The study received institutional ethics approval and participants gave their written informed consent to participate at the first session. Participants were tested in groups of up to 20 within university classrooms or academic hospital offices. At each of up to four sessions, participants completed a standardized 15-min mindfulness meditation exercise based on that used in previous studies (Frewen et al. 2008, 2010). A limitation of the study was that the number of days that occurred between testing sessions varied considerably between participants. The number of days that elapsed between testing sessions ranged between 1 and 47 between testing sessions 1 and 2 (M=10.18, SD=10.24), ranged between 1 and 26 between testing sessions 2 and 3 (M=7.99, SD=7.56), and ranged between 1 and 42 between testing sessions 3 and 4 (M=9.92, SD=11.58). To address this concern, covariate analyses examined the effects of number of days elapsing between testing sessions; results were not found to vary with the number of days elapsing between testing sessions (see below).

In brief, before beginning participants had approximately 3 min to adjust to the experimental setting as encouraged by instructions to relax and focus their attention toward their

breathing. Then they completed a 15-min eyes-closed sitting meditation in which they monitored the process of their breathing. Participants were instructed that, upon becoming aware of the expected wandering of their attention away from the breathing process, they should attempt to "gently and non-judgmentally *let go* of" the source of the distraction and return their attention to their breathing.

A meditation bell was rang via computer sound file every 3 min (i.e., at 3, 6, 9, and 12 min into the meditation, and again at the end of the meditation [15 min]). At each of these time points, participants were instructed, while keeping their eyes closed, to place a "tick" mark on a paper sheet with their pen (held in the dominant hand throughout the meditation) if their attention was focused on their breathing at the sounding of the bell. After this, participants were encouraged to continue to attend to their breathing until the next bell ringing. Upon completion of the meditation, participants tallied the number of "tick" marks they had written as their MBAS. The score thus indicates the frequency with which their attention had been focused on their breathing during the meditation exercise, scores potentially ranging between 0 and 5. After the meditation, participants completed the *meditation-related experiences list* and TMS in random order. They then completed the FFMQ. Participants were encouraged to practice meditation regularly between the four testing sessions, but received no objective reinforcement for doing so (e.g., via increased course credit) beyond the potential of realizing some personal psychological benefit.

Results

Test–Retest Reliability of MBAS and TMS

Table 1 reports the correlation matrix between MBAS collected across testing sessions. Consistent with predictions, referring to MBAS, all associations were statistically significant ($p \leq 0.001$) and ranged between $r=0.37$ (referring to testing sessions 3 vs 4) to $r=0.69$ (referring to testing sessions 1 vs 2) with mean $r=0.50$ (SD=0.12). There was no obvious linear trend for increasing or decreasing correlations between testing sessions. The reliability of MBAS between sessions 1 and 2 ($r=0.69$) was not significantly greater than that between sessions 2 and 3 ($r=0.55$), $Z=1.54$, $p=0.12$, while the reliability of MBAS between sessions 2 and 3 ($r=0.55$) was not significantly greater than that between sessions 3 and 4 ($r=0.39$), $Z=1.59$, $p=0.11$. Reliability decreased with time since testing, however, such that the correlation of MBAS between sessions 1 and 4 ($r=0.37$) was significantly lower than that between sessions 1 and 2 ($r=0.69$), $Z=3.43$, $p<0.001$ and marginally lower than that between sessions 1 and 3 ($r=0.54$), $Z=1.67$, $p<0.09$. The correlation of MBAS between sessions 2 and 3 ($r=0.55$), however, was not significantly lower than that between sessions 2 and 4 ($r=0.48$), $Z=0.67$, $p=0.51$. In all cases, the number of days that occurred between testing sessions failed to correlate with MBAS measured at a particular session, whereas previous MBAS incrementally predicted future MBAS after the number of days that occurred between testing sessions was accounted for.

To afford comparison with the effect sizes observed for MBAS, the test–retest reliability of TMS scores are also reported in Table 1. The correlation matrix observed for both TMS-curiosity (mean $r=0.54$ [SD=0.07]) and TMS-decentering (mean $r=0.53$ [SD=0.06]) also indicated good test–retest reliability.

Correlations between MBAS, TMS, and FFMQ across Testing Sessions

Table 2 reports associations between the MBAS and both TMS and FFMQ across testing sessions. Consistent with previous findings (Frewen et al. 2010) and predictions, MBAS were positively correlated with FFMQ trait "*act with awareness*" scores at testing session 1, $r=0.27$, $p=0.01$, and this association was replicated and did not vary appreciably in strength across subsequent testing sessions with correlations ranging between $r=0.21$ (referring to testing session 2) to $r=0.39$ (referring to testing session 3) with mean $r=0.27$ (SD=0.08); none of the individual correlations varied significantly from each other ($Zs \leq 0.1.60$, $ps \geq 0.11$).

MBAS were also positively correlated with FFMQ "*non-reactivity*" during the first three sessions. In contrast, MBAS were not systematically associated with other FFMQ subscales across repeated testing sessions.

Consistent with previous findings (Frewen et al. 2010), at the first testing session MBAS were not significantly

Table 1 Test–retest reliability of MBAS and TMS

	MBAS			TMS-decentering			TMS-curiosity		
	Test 1	Test 2	Test 3	Test 1	Test 2	Test 3	Test 1	Test 2	Test 3
Test 2	0.69	–	–	0.59	–	–	0.51	–	–
Test 3	0.54	0.55	–	0.47	0.61	–	0.66	0.57	–
Test 4	0.37	0.48	0.39	0.48	0.53	0.50	0.50	0.56	0.45

Results refer to completers only ($n=77$). All correlations have $ps<0.01$, uncorrected, one-tailed

Table 2 Associations between MBAS and both TMS and FFMQ across testing sessions

	TMS-decenter	TMS-curiosity	FFMQ-observe	FFMQ-describe	FFMQ-act aware	FFMQ-nonjudging	FFMQ-nonreact
MBAS-T1	0.17	0.23*	0.12	0.05	0.27[a]*	0.35*	0.24*
MBAS-T2	0.21*	0.17	0.25*	0.13	0.21[a]*	0.13	0.26*
MBAS-T3	0.38*	0.11	0.03	0.28*	0.39[a]*	0.16	0.23*
MBAS-T4	0.21*	0.08	−0.01	0.11	0.22[a]*	0.12	0.16

Results refer to completers only (n=77)

[a] Hypothesized correlation based on previous results of Frewen et al. (2010)

*p<0.05, uncorrected, one-tailed

correlated with TMS-Decentering, although a trend was observed, r=0.17, p=0.07. Contrary to previous findings (Frewen et al. 2010), however, the association between MBAS and TMS-decentering was statistically significant across all subsequent testing sessions. MBAS were also significantly correlated with TMS-curiosity at the first testing session, although not at any subsequent sessions.

Associations between MBAS and other Experiences of the Meditation

Table 3 reports associations between MBAS and self-reported experiences of the mindfulness meditation across testing sessions. Referring to MBAS, the following associations previously observed by Frewen et al. (2010) were replicated concerning the first testing session: increased relaxation (r=0.36) and breath awareness (r=0.34), and lower frequency of unpleasant thoughts (r=−0.26) and less difficulty maintaining attention toward breathing (r=−0.49). Moreover, in each case, the associations were replicated across all subsequent testing sessions excepting the negative correlation with frequency of unpleasant thoughts which became null by the final testing session (r=−0.15, *ns*). Previously observed associations between MBAS and greater use of a mantra to aid sustained attention, and less frequent thoughts of a "to-do-list", were observed only for certain testing sessions, whereas a previously observed negative correlation between MBAS and fatigue was not replicated at any testing session (Frewen et al. 2010). Finally, associations that were not previously observed by Frewen et al. (2010) were noted in later testing sessions within the present study. Specifically, negative associations with exteroception (e.g., hearing sounds in room) and awareness of the presence of others in the testing room were observed in sessions two and four only, and a negative association with frequency of "thoughts about planning or memories concerning recent social/leisure activities" was observed in sessions 2, 3, and 4 but not during the first testing session.

Changes in MBAS, TMS, and FFMQ across Testing Sessions

The sample descriptive and inferential statistics referring to the MBAS, TMS, and FFMQ, as varying by testing sessions 1 through 4, are reported in Table 4. The repeated measure "*testing session*" explained 57 % of the variance in the multivariate effect, F(24,53)=2.87, p=0.001, $\eta 2$=0.57. A subsequent covariate analysis showed that the number of days occurring between testing sessions was not significantly related with any dependent measure.

Follow-up univariate effects were highly statistically significant for MBAS, with 20 % of the variance in MBAS explained by testing session, F(3,219)=19.10, p<0.001, $\eta 2$=0.20. The linear effect of MBAS as improving with testing sessions was also highly significant, explaining fully one third of the variance in MBAS, F(1,73)=38.31, p<0.001, $\eta 2$=0.34. Comparing individual sessions, MBAS increased most between sessions 1 and 2, t(76)=5.09, p<0.001, d'=0.58, failed to increase significantly between sessions 2 and 3, t(76)=0.19, p=0.85, d'=0.02, but increased further between sessions 3 and 4, t(76)=3.03, p=0.003, d'=0.35.

By comparison, the only other statistically significant effect was observed for FFMQ "*non-judging*", although only 5 % of the variance was explained by testing session, F(3,219)=4.05, p=0.01, $\eta 2$=0.05. Results were also marginally significant for FFMQ "*act with awareness*", F(3,219)=2.34, p=0.07, $\eta 2$=0.03. Effects were such that FFMQ "*non-judging*" and "*act with awareness*" also increased over testing sessions, as would be expected with improvements in trait mindfulness occurring with meditation practice.

Meditation Practice

All but three participants indicated that they practiced meditation less than once in the month preceding the first testing session, thus these data were not analyzed further. In comparison, Table 5 indicates that participants varied considerably with respect to how often and for how long that they practiced meditation between the subsequent testing

Table 3 Associations between MBAS and experiences reported during mindfulness meditation across testing sessions

	1. To do list	2. Unpleasant thought	3. Pleasant thought	4. Relax	5. Difficulty in breath	6. Others' presen.	7. Exter-ocept	8. Interocept	9. Body discom	10. Planning	11. Fatigue	12. Aware Breath	13. Use of mantra
MBAS-T1	−0.20[a]	−0.26[a]*	−0.01	0.36[a]*	−0.49[a]*	0.06	−0.04	−0.14	−0.16	−0.18	−0.18[a]	0.34[a]*	0.17[a]
MBAS-T2	−0.11[a]	−0.31[a]*	−0.06	0.46[a]*	−0.29[a]*	−0.21*	−0.26*	0.06	−0.08	−0.27*	−0.08[a]	0.48[a]*	0.34[a]*
MBAS-T3	−0.37[a]*	−0.26[a]*	0.06	0.41[a]*	−0.34[a]*	−0.03	−0.16	−0.07	−0.18	−0.28*	0.06[a]	0.30[a]*	0.21[a]
MBAS-T4	−0.34[a]*	−0.15[a]	−0.15	0.31[a]*	−0.46[a]*	−0.30*	−0.25*	−0.13	−0.25*	−0.30*	0.08[a]	0.34[a]*	0.10[a]

Across the top row, numbers indicate item number in the questionnaire included as appendix to Frewen et al. (2010). Results refer to completers only ($n=77$)

[a] Hypothesized correlation based on previous results of Frewen et al. (2010)

*$p<0.05$, uncorrected, two-tailed

sessions. Practice time increased with the number of days occurring between sessions 1 and 2, $r=0.22$, $p=0.03$, and between testing sessions 3 and 4, $r=0.33$, $p=0.002$, but not between testing sessions 2 and 3, $r=-0.17$, *ns*, thus paralleling the results reported earlier regarding increases in MBAS.

The approximate number of minutes participants indicated that they had practiced meditation between sessions 1 and 2 predicted MBAS at sessions 2 ($r=0.22$), 3 ($r=0.25$), and 4 ($r=0.23$; $ps<0.05$, one tailed). Part correlations controlling for the effect of number of days elapsed between testing sessions were largely unchanged from the simple correlations, giving the following corresponding results: MBAS at sessions 2 ($r=0.21$), 3 ($r=0.22$), and 4($r=0.26$; $ps<0.05$, one tailed).

The number of minutes participants practiced between sessions 2 and 3 failed to predict MBAS at session 3, $r=0.11$, but predicted MBAS at session 4, $r=0.24$, $p<0.05$. The corresponding part correlation for the latter association, controlling for number of days elapsed in between sessions, was $r=0.23$, $p<0.05$. Finally, the number of minutes participants practiced between sessions 3 and 4 failed to predict MBAS at session 4, $r=0.02$.

Discussion

The present results provide additional support for the construct validity of MBAS as a measure of participants' ability to sustain their attention toward the breathing process during the practice of breathing-focused mindfulness meditation, and accordingly their ability to disengage from mind wandering during the meditation. MBAS exhibited good test–retest reliability for a state measure, on par with that observed for the TMS. MBAS were also much more sensitive than both the TMS and FFMQ to the effects of repeated practice of meditation across the four testing sessions. The obtained improvements in MBAS across testing sessions are consistent with interpreting MBAS as a performance-based measure of sustained attentive focus during the practice of mindfulness meditation. Further consistent with this interpretation, the cumulative number of minutes participants practiced meditation between sessions prospectively predicted MBAS assessed at a later date; in four of six associations that were evaluated the result was significant, most especially emphasizing the amount with which participants' practiced during the days between the first and second testing sessions. Finally, most of the associations between MBAS and other self-reported meditation-related experiences that were previously identified by Frewen et al. (2010) were replicated in the present study, but were sometimes found to vary across testing sessions. The reasons why associations between certain meditative experiences and

Table 4 Change in MBAS, TMS, and FFMQ scores over four sessions of meditation practice

Scale	T1 *M* (*SD*)	T2 *M* (*SD*)	T3 *M* (*SD*)	T4 *M* (*SD*)	*F*(3,219)	*p*	η^2
MBAS	2.18 (1.36)	2.79 (1.30)	2.82 (1.21)	3.32 (1.42)	19.10	<0.001	0.20
TMS-decenter	19.53 (4.18)	19.77 (4.11)	20.01 (4.60)	20.43 (4.88)	1.21	0.31	0.02
TMS-Cur	16.36 (4.71)	15.14 (4.93)	15.87 (5.43)	15.45 (5.49)	1.76	0.16	0.02
FFMQ-Obs.	24.94 (5.14)	25.36 (4.75)	25.53(5.05)	25.73 (5.34)	1.19	0.32	0.02
FFMQ-Descr.	16.19 (3.96)	16.58 (4.40)	16.52 (4.28)	16.38 (4.11)	0.73	0.54	0.01
FFMQ-AWA	24.84 (5.15)	24.92 (5.32)	24.95 (5.49)	25.77 (5.28)	2.34	0.07	0.03
FFMQ-NonJg.	27.08 (6.35)	28.13 (6.76)	28.14 (7.23)	29.29 (7.11)	4.05	0.01	0.05
FFMQ-NonRc.	21.03 (3.27)	21.14 (3.71)	21.68 (3.52)	21.42 (4.53)	1.22	0.30	0.02

Results refer to completers only (n=77). The multivariate effect of testing session was statistically significant $F(24,53)=2.87$, $p=0.001$. Univariate statistical significance is reported after correction for sphericity (Greenhouse–Geisser)

MBAS should vary across repeated practices of meditation await further clarification. Additionally, in contrast with previous results (Frewen et al. 2010), MBAS correlated positively with TMS-decentering in the present sample, most strongly at later sessions. The basis for such mixed results across studies is not presently known; additional studies are needed to clarify the replicability of findings and how they may be moderated by individual differences that were not measured in the studies conducted to date.

We note as a potential limitation that the improvement in MBAS observed prospectively in the present study may have something to do with measurement reactivity, that is, be contingent not only on repeated meditation practice but on the meditations having included measurement of MBAS. In other words, had we similarly conducted four meditation sessions, but only measured MBAS at sessions 1 and 4, for example, with sessions 2 and 3 thus involving meditation practice but without measurement of MBAS, improvement might not have been as striking; the actual implementation of MBAS assessment during meditation practice may have something to do with the acceleration of participants' improvement in MBAS above and beyond meditation practice per se. A future study might tease this apart. Nevertheless, the practical significance of this point is somewhat weakened in considering that the ringing of bells during silent breath–attention meditations, as means of calling participants' wandering attention back to their breathing (or some other intended anchor for attention), is already frequently conducted at mindfulness meditation centers and retreats. Nevertheless, demand characteristics may motivate participants to report increasing MBAS over time (i.e., positive impression management effect), a concern that should be addressed in future research. Further limitations include that the number of days that elapsed between testing sessions was variable, even if such variability was not found to influence mean changes or correlations between variables. Finally, generalizability of results may be limited due to our reliance on a young-adult student sample of convenience who may well have self-selected to participate based on their interest in learning meditation, a motivation less likely to characterize as significant a proportion of the participants who took part in our earlier studies (Frewen et al. 2010). Replication and extension of the present study to community and clinical samples would therefore be important.

Table 5 Self-reported amount of participant meditation practice between sessions

Testing sessions	Scale	*M*	SD	Max
T1–T2	~# of Meditation Sessions between	2.29	1.88	10
	~# of Minutes per Session	9.96	6.94	44
T2–T3	~# of Meditation Sessions between	1.97	1.31	6
	~# of Minutes per Session	9.15	7.86	60
T3–T4	~# of Meditation Sessions between	2.21	2.27	15
	~# of Minutes per Session	8.42	5.32	30

Results refer to completers only (n=77). In all cases, the minimum self-reported amount of participant meditation practice between sessions was zero

Future studies should investigate the sensitivity of MBAS to repeated practice of meditation within therapeutic settings. In addition, studies should examine the degree to which changes in mindful concentration, relative to other state changes associated with mindfulness practice (decentering, curiosity), mediate the clinical benefits of mindfulness meditation-based clinical interventions on mindfulness-related traits and clinical symptoms including those associated with affective disorders. We wonder, for example, whether MBAS might provide an index of change associated with mindfulness practice that is more specific than other state and trait mindfulness measures that are also strongly associated with affective disposition. In other words, the latter measures may be more susceptible to change as a result of components of mindfulness-based clinical interventions other than meditation practice per se (e.g., psychoeducation; Frewen et al. 2008, 2010), as well as even with psychological

interventions that do not include meditation practice at all and/or do not explicitly teach mindfulness-related principles or ethics (e.g., as in traditional cognitive–behavior therapy for affective disorders). Finally, construct validity for MBAS would be further supported if objective neurophysiological markers associated with mind-wandering, such as metabolic activity within the so-called "default-mode network", distinguished states preceding MBAS scores associated with attention directed toward breathing (as instructed) versus mind wandering (e.g., Andrews-Hanna et al. 2010).

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