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Advances in contemplative science

Edited by
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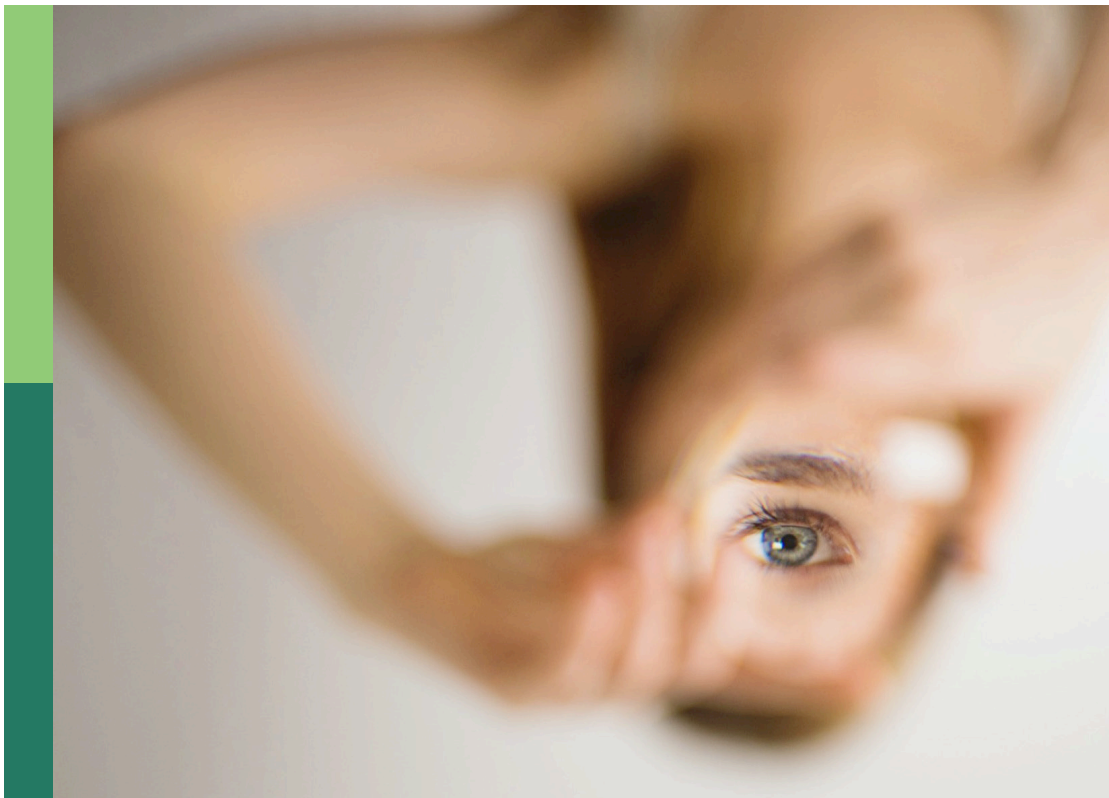

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Advances in contemplative science

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Table of contents

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Editorial: Advances in contemplative sciences

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Editorial on the Research Topic
Advances in contemplative sciences

In his 1930 book "Civilization and Its Discontents," Freud advocated a new and secular science of psychotherapy as a pragmatic alternative to the traditional healing techniques offered by religions. Since then, Western psychology/psychiatry has operated separately from religion (Neeleman and Persaud, 1995). However, in recent years, robust research has confirmed the potential of qualities such as love, compassion, and altruism for therapeutic use and wellbeing (Lutz et al., 2008; Amihai and Kozhevnikov, 2014). For this reason, conventional psychology is moving toward contemplative science, which has always been considered nonscientific knowledge.

Davidson and Begley (2013) coined the term "contemplative neuroscience," which describes the emerging field arising at the intersection of meditation research and neuroscience. It includes any kind of meditation, yoga, mantra recitation, intensive breathing, and healing movement (Loizzo, 2009). This new science fulfills the dream of visionary pioneers in psychiatry and psychology, such as Carl Gustav Jung and Ken Wilber, and is connected to some aspects of transpersonal psychology. Several universities across the world have developed courses on or departments of contemplative sciences or similar disciplines, examples of which include Brown University (Providence, Rhode Island), the University of San Diego (San Diego, California), Naropa University (Boulder, Colorado) and the University of Mary Washington (Fredericksburg, Virginia), in the United States, and the University of Ottawa, in Canada.

In recognition of this Research Topic, we have edited a dedicated Research Topic on Frontiers in Psychology. It comprises nine papers, seven clinical or experimental, and two theoretical ones that tackle different aspects of meditation. With regard to clinical studies, the study by Buric et al. compares three groups of participants (sensory priming, semantic priming, and control group). The intervention was administered prior to a guided self-compassion meditation, and three variables were assessed: state self-compassion, self-criticism, and positive and negative affect. Despite being underpowered, the study suggests that neither semantic nor sensory priming improves any of the outcomes.

The study by McDonald et al. assesses the efficacy of online mindfulness in reducing suspiciousness/paranoia in individuals with high positive schizotypy. A 40-day mindfulness-based intervention was compared to an active control condition using reflective journaling. The feasibility criteria were excellent in the intervention group: 100% retention, a completion rate of 91%, and high acceptance. Mindfulness produced no effect on trait paranoia but reduced state paranoia with a medium-to-large effect.

The study by Neri et al. assesses the neural correlates of concentrative and analytical meditation, the two most important forms of Tibetan meditation. At the Tibetan University of Sera-Jey in India, 23 meditators underwent an ecological EEG acquisition. Concentrative meditation elicited more numerous and marked changes than analytical meditation, consisting of an increase in the theta, alpha, and beta frequency ranges.

The paper by Borghi et al. analyzes the relationship between daily perceived stress and mindfulness, specifically, and the four facets of mindfulness: observing, describing, nonjudging, and nonreacting. Bidirectional cross-lagged associations were investigated using the random-intercept cross-lagged panel model. The results challenge prior results regarding mindfulness as a protective factor against daily stress. With the exception of nonreacting, mindfulness was either positively associated with perceived stress, or else perceived stress appeared to interfere with the ability to stay mindful in daily life.

The study by McGee et al. paper assesses collective labyrinth walking as an integrative contemplative practice, particularly at times of distress, such as during pandemics. The study was developed at the height of the COVID-19 pandemic by 416 participants from 19 countries. Three predominant themes emerged in the qualitative study: (1) A sense of connectedness between the participants, (2) Qualities associated with "transcendent" experiences (boundless, ultimacy, transcendence), and (3) Compassionate action.

The paper by Price et al. studies the effect of a mindfulness-based protocol whose aim was to improve mind wandering by reviewing five longitudinal studies conducted in different organizational settings. A meta-analysis confirmed differences between the mindfulness and control groups between baseline and 4-month follow-up in mind wandering and meta-awareness, with low-to-intermediate effects.

The study by Smith et al. reports on the efficacy of mindfulness and yoga compared to usual training in health, pain, and injury on a sample of US Army trainees. The objective outcomes were injury-related medical encounters and the number of diagnoses. After the intervention, the trainees showed better health, sleep, and mood, less stress and impact of pain on training, and fewer diagnoses. Differences arose at 3 weeks.

In addition, the following two theoretical studies are included. The first is an introspective paper by Sparby et al. on six individuals performing different attentional tasks over a month. The authors discuss whether our inability to sustain attention implies we are not free. It also reflects on the role of introspection as a method in contemplative sciences. Finally, the paper by Garcia-Campayo et al. discusses the need for personalized meditation according to meditators' characteristics. It reviews several personality classifications—two from the Buddhist tradition and the Enneagram—that could be useful to predict which meditation better fits specific personality traits or characteristics.

In summary, this Research Topic aims to present some of the new research areas currently in progress within the domain of contemplative sciences.

Author contributions

JG-C: Writing – original draft, Writing – review & editing. JM-M: Writing – original draft, Writing – review & editing. RA: Writing – original draft, Writing – review & editing.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Impact of mindfulness training and yoga on injury and pain-related impairment: a group randomized trial in basic combat training

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Introduction: Service members are at risk for pain-related difficulties in functioning and physical injury. Previous studies suggest that mindfulness training (MT) and yoga may prevent these outcomes. The present study was designed to determine the impact of MT and yoga on the health, pain, and injury of Army trainees completing 10 weeks of basic combat training (BCT).

Methods: Platoons (≈40 trainees per platoon) were randomized to MT and yoga or training-as-usual in October to December 2020 at a large installation in the US. Self-reported outcomes were health, pain level, and pain impact on training, sleep, mood, and stress. Objective outcomes were injury-related medical encounters and number of diagnoses. The trial was registered at ClinicalTrials.Gov (NCT05550610).

Results: Intervention trainees reported significantly better health (OR = 1.05, 95% CI [1.00, 1.10]) and less impact of pain on training (OR = 0.81, 95% CI [0.74, 0.90]), sleep (OR = 0.88, 95% CI [0.81, 0.95]), mood (OR = 0.86, 95% CI [0.78, 0.96]), and stress (OR = 0.88, 95% CI [0.79, 0.98]). There was no significant difference in injury-related medical encounters (AOR = 0.70, 95% CI [0.48, 1.03]), but intervention trainees had fewer diagnoses (OR = 0.67, 95% CI [0.47, 0.95]) and were 30% less likely to have a first medical encounter at any time during BCT. This difference emerged 3 weeks into BCT.

Discussion: A combined MT and yoga intervention resulted in better trainee health. The US Army and other organizations requiring resilience under extreme stress should consider implementing MT and yoga to offset risks to employee health.

KEYWORDS

military, mindfulness, yoga, injuries, pain

1. Introduction

The military places significant demands on service members to ensure their physical readiness for completing operational missions; however, sustained, intense physical activity can lead to injury and pain. In 2020, 49% of active-duty soldiers experienced a new injury, with most categorized as musculoskeletal injuries (MSKIs) (U.S. Army Public Health Center, 2022). Physical injuries are estimated to result in nearly 2 million medical encounters at treatment facilities and 10 million limited military duty days annually (U.S. Army Public Health Center, 2022). Furthermore, over 80% of service members with physical injuries have reported clinically significant levels of pain (Hauret et al., 2010; McGeary et al., 2016).

The substantial prevalence of injury and pain-related impairment in the military exerts a toll on service members and presents a profound risk to organizational readiness. Given that a history of physical injury increases risk for future injury (Sammito et al., 2021), preventing injury and effectively managing pain are critical to sustaining service member health. To this end, the U.S. Army has utilized a broad range of physical and behavioral protocols designed to monitor and reduce injuries, including implementing injury surveillance programs, improving training regimens, and testing the efficacy of orthotics (Jones et al., 2018; Molloy et al., 2020). In addition to injury prevention, programs designed to address the significant number of service members experiencing chronic pain from these injuries requires a resource-intensive interdisciplinary approach from medical, behavioral, and community providers (Vallerand et al., 2015). Despite some success with these interventions, injuries and injury-related pain remain common, underscoring the need for innovative and scalable approaches within the Department of Defense.

Mindfulness and yoga-based programs offer a novel means of mitigating the risk of injury and pain. Mindfulness, defined as "attending to relevant aspects of experience in a nonjudgmental manner" (Ludwig and Kabat-Zinn, 2008) may benefit musculoskeletal health and reduce pain through greater awareness of the body and attention to proper physical alignment. Although the direct relationship between mindfulness training (MT) and pain severity is not consistently observed (Hilton et al., 2017), research suggests that MT enables individuals to function even in the presence of pain (Reiner et al., 2013; Hilton et al., 2017). MT may also prevent injury by improving an individual's focus on their physical movement and reducing distractibility (Birrer et al., 2012; Petterson and Olson, 2017). To date, research on MT in the military has predominantly examined attention, working memory, emotion regulation, and performance (Nassif et al., 2021; Hepner et al., 2022); however, little is known about the effects of MT on injury and pain among service members.

Yoga may also reduce the risk of injury and pain (Tran et al., 2001). Broadly, yoga includes a range of practices that often integrate physical postures, meditative practices, and spiritual concepts (Tran et al., 2001), For the present purposes, we use the term "yoga" to refer to modern postural yoga programs that focus on physical postures, breathing techniques, and mindfulness components (Tran et al., 2001). Yoga interventions can improve strength, endurance, and flexibility in healthy practicing participants (Tran et al., 2001; Raj et al., 2021). Randomized controlled trials have also found that yoga reduces pain in a variety of populations (Nambi et al., 2014; Kim, 2020), including veterans (Miller et al., 2017), but research has not examined the impact of yoga on injury and pain among service members. Additionally, most previous trials have relied on small cohorts (Kim, 2020).

Given their complementarity of approach, offering MT and yoga during the same interval may support holistic mind–body health by bolstering body awareness, reducing distractibility, enhancing flexibility, and attenuating the effects of pain. Such salutary effects may prevent injury and help service members maintain functioning. To investigate this possibility, we selected a venue for program implementation that ensured structured program delivery. Specifically, MT and yoga were delivered in tandem during basic combat training (BCT), a 10-week period of enculturation for newcomers to the military. We predicted that trainees receiving MT and yoga, compared to those receiving training-as-usual, would report better health, lower levels of pain, less frequent pain, less pain-related impact on training, sleep, mood, and stress, and would result in fewer medical encounters and injury diagnoses. This study is the first to examine the impact of MT and yoga on the physical health of service members in an intense military training environment. Identifying such benefits can directly inform training recommendations in the military and other physically demanding occupations where risk of injury is higher.

2. Materials and methods

2.1. Design

Trainees ($N = 1{,}896$) entering U.S. Army BCT between October and December 2020 were assigned to platoons (~40 persons), and platoons were randomized to two conditions. Twenty platoons received MT and yoga, and 20 platoons received training-as-usual. Initially, small groups (i.e., residential bays), rather than platoons, were used as an organizing element in BCT to minimize the risk of infecting larger numbers of trainees with COVID-19 during the pandemic. Randomization occurred after trainees were assigned to a residential bay when they first arrived at BCT. After 3 weeks, these small groups were reconfigured into larger platoons, keeping assignment to training condition intact. All participants were briefed prior to study enrollment. The CONSORT diagram is presented in Figure 1. Trainees attending BCT at one military installation in the southeastern United States were eligible for inclusion. Data were excluded from 312 (16.5%) of the 1,896 trainees who participated in the evaluation: 81 did not provide consent for their data to be used for research purposes, 177 could not be matched to condition or had inconsistent identification data, and 54 had COVID-19 and were relegated to a separate platoon, leaving a final sample of 1,584 for analysis.

Four surveys were administered over the 10-week BCT period. The first survey (T1) was administered in the first week of BCT before MT and yoga began; the second (T2), third (T3), and fourth (T4) surveys were administered during weeks 4, 6, and 9, respectively. Survey completion was voluntary; there was no financial compensation for study participation. The evaluation was approved by the Walter Reed Army Institute of Research Human Research Protection Branch, and registered at ClinicalTrials. Gov, Identifier: NCT05550610. Non-physical health outcomes assessed through this evaluation are reported elsewhere.

2.2. Intervention

The mindfulness training component was delivered via a 4-week, 8-h intervention developed for military personnel referred to as Mindfulness-Based Attention Training (MBAT) (Jha et al., 2020).

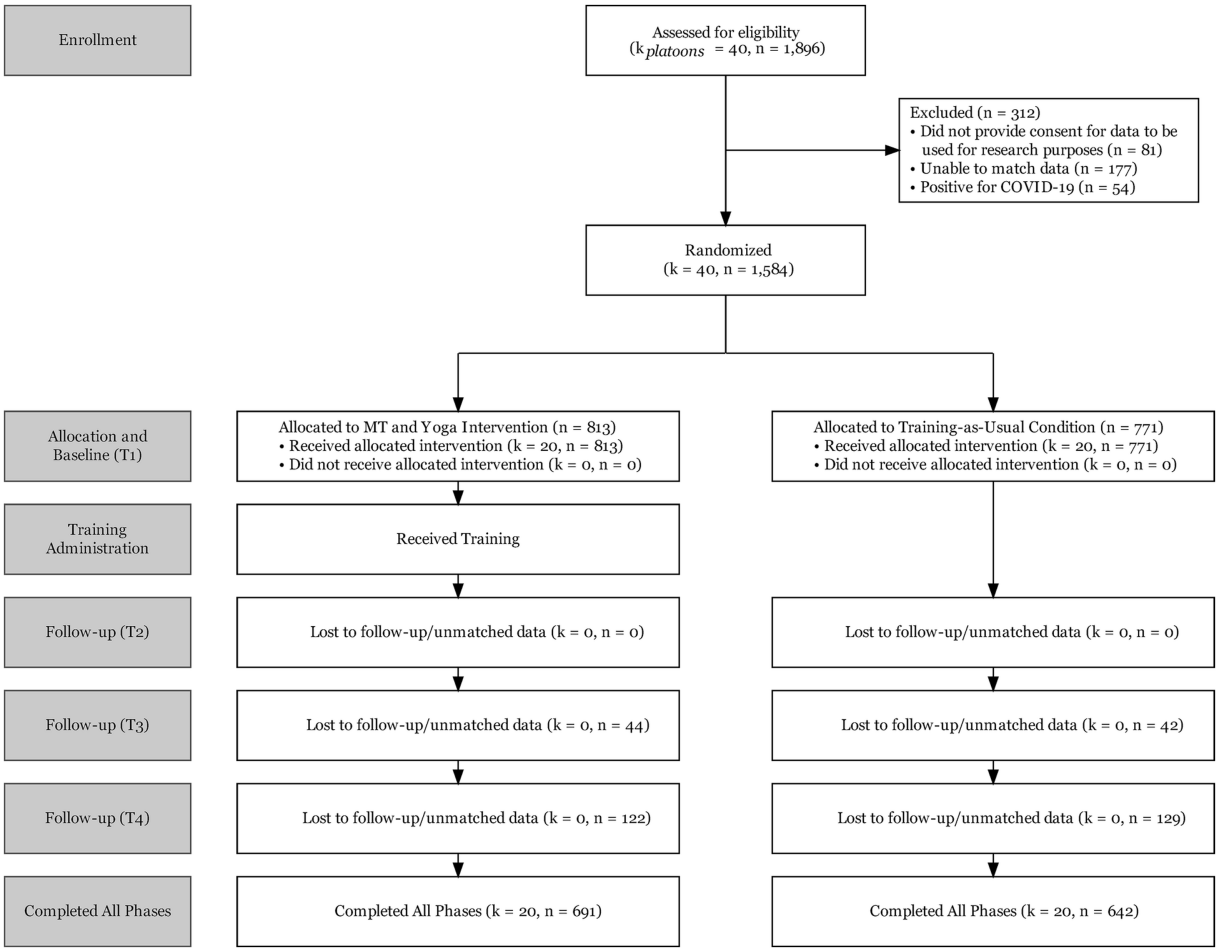

FIGURE 1
CONSORT diagram.

Participants received weekly 2-h MBAT sessions during the first 4 weeks of BCT. There was a new topic each week: breath awareness and focused attention skills, body awareness, open monitoring, and interpersonal connection. The MBAT course material encouraged participants to engage in impromptu mindfulness practice throughout the day. Six days a week throughout BCT, participants also listened together as a platoon to a 15-min audio recording as part of an evening mindfulness practice. MBAT was delivered by 10 civilians with graduate degrees in the field of performance psychology. They were trained to deliver MBAT by completing 26 h of training over the course of 12 weeks (Jha et al., 2020). There were two MBAT instructors assigned to each platoon. When the intervention platoons were engaging in MBAT-related activities, trainees in the training-as-usual platoons were directed to study their BCT materials.

The yoga component of the intervention consisted of hatha yoga postures (Tran et al., 2001). The program was based on conventional hatha yoga postural sequences selected by a yoga expert. These postures were taught prior to and immediately after daily physical training every morning, 6 days a week, for a total of 3 h per week. This process was provided in place of the Army's traditional preparatory and recovery drills and required the same amount of training time. In preparatory drills, yoga postures such as sun salutations, crescent lunge and eagle pose were selected to engage major muscle groups. In recovery drills, yoga postures such as gate pose, reverse plank, and bridge pose were selected to release tension in major muscle groups. Yoga training sessions were taught by one yoga instructor per platoon. Drill Sergeants who had received familiarization training circulated to offer postural corrections. In all, there were 21 yoga instructors, all of whom were registered yoga teachers with at least 200 h and 2 years of teaching practice. The yoga instructors completed 8 h of training specific to the study curriculum and had to demonstrate their competency with the material. When the intervention platoons were engaging in yoga, trainees in the training-as-usual platoons were engaging in traditional preparatory and recovery drills, which include calisthenics for warming up and stretching for cooling down.

2.3. Measures

2.3.1. Overall health

Self-reported overall health was measured with a single item from the SF-8 Health Survey (Ware et al., 2001) "Overall, in the past 2 weeks, how would you rate your health?" using response options from poor (0) to excellent (5) (Jones et al., 2018). The SF-8

is a widely used and validated self-report measure for overall health.

2.3.2. Pain level

Pain level was assessed with a single item assessed using 11 response options adapted from existing measures (Hjermstad et al., 2011): "In the past 2 weeks, what has been your level of physical pain?" using responses options from no pain (0) to severe pain (10) (Reiner et al., 2013). Studies demonstrate that 11-point numeric rating scales are reliable and valid methods for measuring pain in a variety of settings (Hjermstad et al., 2011).

2.3.3. Pain frequency

Pain frequency was measured with a single item developed by Toblin et al. (2014). The item, "In the past 2 weeks, how often have you experienced physical pain?" was rated on a 5-point scale from not at all/a few days (1) to constantly (5) (Jones et al., 2018). This approach to measuring pain frequency is consistent with similar measures validated in previous research (dela Cruz et al., 2014).

2.3.4. Pain-related impact

Trainees were asked the degree to which their pain has impacted training, sleep, mood and stress using four items from the validated Defense and Veterans Pain Rating Scale (DVPRS) (Buckenmaier et al., 2013). Trainees rated how much pain interfered with their training and sleep with response options from does not interfere (0) to completely interferes (10) (Reiner et al., 2013), how much pain affected their mood with response options from does not affect (0) to completely affects (10) (Reiner et al., 2013), and how much pain contributed to their stress with response options from does not contribute (0) and contributes a great deal (10) (Reiner et al., 2013).

2.3.5. Injury-related medical encounters and diagnoses

Medical encounter and diagnostic data were obtained through the Army's Soldier Performance, Health, and Readiness (SPHERE) data repository. The SPHERE contains Army medical encounter data and has been used extensively in previous research (Amoroso et al., 2000; Bulzacchelli et al., 2014). Medical encounters were documented when trainees sought help from medical providers at a military treatment facility or other facility where they used their military medical insurance. Encounters during the trainee's time in BCT were defined using International Classification of Diseases (ICD)-10 diagnoses related to injury. SPHERE data included date of the encounter and ICD-10 diagnoses, which were used to categorize injuries by type and location (Roy et al., 2022).

2.4. Statistical analysis

We used linear mixed models to examine how condition, time, and time-by-condition interactions explained variance in outcomes while accounting for systematic variance attributable to platoon. Binomial generalized linear mixed models were conducted to estimate adjusted odds ratios (AORs) for condition-wise differences in injury, injury type, and injury region. Poisson generalized linear mixed models were used to examine condition-wise differences in the frequency of injury-related medical encounters and number of injury diagnoses. Multilevel models were estimated using restricted maximum likelihood with bound optimization by quadratic approximation, and nested time within trainee, and trainees within platoons. Finally, a Cox proportional-hazards model was used to examine time to first injury-related medical encounter by condition.

Across conditions and time points, missing data ranged from 7.0% (overall health), to 8.0% (pain level). Missing observations were handled using listwise deletion for each model. Analyses were conducted in R v.4.1.0 (R Core Team, 2021). Multilevel models were estimated using the "lme4" package (Bates et al., 2015).

3. Results

3.1. Participants

Participants reflected a typical cohort of BCT trainees: 1,189 (75.1%) were between the ages of 18 and 24, and 1,142 (72.2%) were male. No significant baseline differences were found between conditions by age group, $\chi^2(3) = 0.32$, $p = 0.956$, or by gender, $\chi^2(1) = <0.01$, $p = >0.999$.

3.2. Self-reported health and pain

Summary statistics for measures of self-reported overall health, pain level, pain frequency, the perceived relationship between pain and training, sleep, mood, and stress are presented in Table 1 by time and condition. Table 1 also reports regression coefficients, p values, and odds ratios for multilevel time-by-condition interactions for each outcome.

3.2.1. Overall health

Across time and condition, trainees reported a mean score between 3 and 4, indicating "good" to "very good" health. Whereas mean overall health scores remained stable in the MT and yoga condition, changing by just 0.01 from Time 1 to Time 4, there was a mean decrease of 0.17 in the training-as-usual condition. The significant time-by-condition interaction for overall health scores indicated a difference in slopes by condition, such that self-reported overall health worsened in the training-as-usual condition relative to the MT and yoga condition.

3.2.2. Pain level and frequency

Self-reported pain levels ranged between 2 and 4 among trainees, indicating a low to moderate level of pain. Pain increased by a mean of 0.28 in the MT and yoga condition and a mean of 0.60 in the training-as-usual condition. The time-by-condition interaction demonstrated that pain increased more in the training-as-usual condition compared to the MT and yoga condition; however, the condition-wise difference was not significant (see Table 1). Similarly, mean scores for self-reported frequency of pain hovered around 2, indicating that most trainees experienced pain several days per week across time and condition. Mean scores for pain frequency increased by 0.24 in the MT and yoga condition and by 0.34 in the training-as-usual condition from Time 1 to Time 4. The time-by-condition interaction indicated no significant difference in pain frequency over time by condition.

TABLE 1 Overall health, pain level, pain frequency, and pain interference by time and condition.

	Condition										
	MT and yoga				Training-as-usual						
	Time 1	Time 2	Time 3	Time 4	Time 1	Time 2	Time 3	Time 4	Multilevel time-by-condition interaction		
Variable	*M* (SD)	*M* (SD)	*M* (SD)	*M* (SD)	*M* (SD)	*M* (SD)	*M* (SD)	*M* (SD)	*b*	*p*	OR [95% CI]
Overall health	3.58 (1.04)	3.47 (1.03)	3.51 (1.00)	3.59 (1.07)	3.55 (1.01)	3.34 (1.00)	3.37 (1.00)	3.38 (1.08)	0.05	0.034	1.05 [1.00, 1.10]
Pain level	2.59 (2.36)	3.64 (2.24)	3.03 (2.30)	2.87 (2.38)	2.38 (2.17)	3.55 (2.20)	3.11 (2.31)	2.98 (2.57)	−0.12	0.078	0.88 [0.77, 1.01]
Pain frequency	1.77 (1.20)	2.39 (1.37)	2.11 (1.32)	2.01 (1.24)	1.69 (1.13)	2.38 (1.35)	2.19 (1.30)	2.03 (1.25)	−0.03	0.268	0.97 [0.92, 1.02]
Pain interfering with training	1.83 (2.45)	2.18 (2.44)	1.70 (2.30)	1.45 (2.13)	1.57 (2.25)	2.12 (2.38)	2.00 (2.38)	1.77 (2.33)	−0.21	<0.001	0.81 [0.74, 0.90]
Pain interfering with sleep	0.95 (1.95)	1.41 (2.28)	1.28 (2.16)	1.24 (2.07)	0.81 (1.79)	1.26 (2.15)	1.46 (2.24)	1.45 (2.29)	−0.13	0.002	0.88 [0.81, 0.95]
Pain affecting mood	1.66 (2.49)	2.09 (2.57)	1.81 (2.46)	1.61 (2.31)	1.41 (2.29)	2.04 (2.58)	1.93 (2.52)	1.80 (2.51)	−0.15	0.010	0.86 [0.78, 0.96]
Pain contributing to stress	2.14 (2.86)	2.35 (2.93)	1.96 (2.73)	1.69 (2.52)	1.87 (2.67)	2.30 (2.85)	2.09 (2.71)	1.78 (2.59)	−0.13	0.029	0.88 [0.79, 0.98]

Regression coefficients and odds ratios derived from three-level multilevel linear regression models predicting each outcome from time, condition, time-by-condition interaction, and random effects terms for uncorrelated intercepts and slopes with time nested within soldier, and soldier nested within platoon.

3.2.3. Pain-related impact

Means for self-reported pain-related impact on training, sleep, mood, and stress ranged from around 1 to 2 across measures, time points, and conditions, indicating that pain had a low level of impact on each of these outcomes. Mean pain-related interference in training decreased by 0.38 in the MT and yoga condition from Time 1 to Time 4, but increased by 0.20 in the training-as-usual condition. Mean pain-related interference with sleep increased by 0.29 in the MT and yoga condition over the course of BCT, and by 0.64 in the training-as-usual condition. Mean pain-related effect on mood decreased by 0.05 in the MT and yoga condition from Time 1 to Time 4, but increased by 0.39 in the training-as-usual condition. Lastly, mean pain-related contribution to stress decreased by 0.45 in the MT and yoga condition from Time 1 to Time 4, but only by 0.09 in the training-as-usual condition. There was a significant time by condition interaction for each of the pain-related variables.

3.3. Injury-related outcomes

3.3.1. Injury-related medical encounters

Frequencies of injury types and injury regions by condition are presented in Table 2. Across conditions, 38.6% of trainees ($n = 612$), or more than one in three trainees, had at least one injury-related medical encounter over the course of BCT. Trainees in MT and yoga were 18.4% less likely to have had at least one injury-related medical encounter compared to training-as-usual, $\chi^2(1) = 9.99$, $p = 0.002$. After accounting for clustering by platoon with binomial generalized multilevel modeling, MT and yoga trainees did not significantly differ in the number of injury-related medical encounters compared to training-as-usual; $b = -0.35$, SE = 20, $p = 0.073$, CI [95%] = 0.70 [0.48, 1.03]. Additionally, Poisson generalized multilevel modeling found that there was no significant difference in the frequency of injury-related medical encounters between conditions; $b = -0.28$, SE = 0.15, $p = 0.055$, CI [95%] = 0.75 [0.56, 1.01].

3.3.2. Injury-related diagnoses

In terms of injury diagnoses, most injury diagnoses made across all trainees were pain diagnoses ($n = 1{,}167$, 76.4%) and located in the lower extremities ($n = 1{,}268$, 83.0%); injury type and injury region did not differ as a function of condition (Table 2). After accounting for clustering by platoon, Poisson generalized multilevel modeling demonstrated that trainees in MT and yoga had significantly fewer diagnoses compared to training-as-usual, $b = -0.40$, SE = 0.18, $p = 0.026$, CI [95%] = 0.67 [0.47, 0.95].

3.3.3. Time to first medical encounter

The conditional Cox proportional-hazards model examined whether trainees differed in their likelihood of a medical encounter as a function of time. Findings from this model revealed a significant difference by condition, $b = 0.26$, SE = 0.08, $p \leq 0.001$. The hazard ratio for condition was 1.30 (95% CI = 1.11, 1.52), indicating that trainees in the training-as-usual condition were 30% more likely than trainees in MT and yoga to have had at least one injury-related medical encounter at any time over the course of BCT. A visual assessment of the inverted Kaplan–Meier survival curve (Figure 2) shows that the

TABLE 2 Injury-related medical encounters, injury type, and injury region by condition.

		Condition		
	Total (n = 1,584)	MT and yoga (n = 813)	Training-as-usual (n = 771)	
Variable	*N* (percent)	*N* (percent)	*N* (percent)	AOR [95% CI]
One or more injury-related medical encounters[a]	612 (38.6%)	283 (34.8%)	329 (42.7%)	0.70 [0.48, 1.03]
Number of injury-related medical encounters per trainee[b]				0.75 [0.56, 1.01]
0	972 (61.4%)	530 (65.2%)	442 (57.3%)	
1	361 (22.8%)	181 (22.3%)	180 (23.3%)	
2	157 (9.9%)	59 (7.3%)	98 (12.7%)	
3	61 (3.9%)	28 (3.4%)	33 (4.3%)	
4 or more	33 (2.1%)	15 (1.8%)	18 (2.3%)	
Number of injury-related diagnoses per trainee[b]				0.67 [0.47, 0.95]
0	972 (61.4%)	530 (65.2%)	442 (57.3%)	
1	229 (14.5%)	131 (16.1%)	98 (12.7%)	
2	163 (10.3%)	71 (8.7%)	92 (11.9%)	
3	72 (4.5%)	27 (3.3%)	45 (5.8%)	
4	73 (4.6%)	22 (2.7%)	51 (6.6%)	
5 or more	75 (4.7%)	32 (3.9%)	43 (5.6%)	
Injury type[a]				
Pain	1,167 (76.4%)	500 (77.2%)	667 (75.9%)	1.03 [0.73, 1.45]
Tendonitis/bursitis	41 (2.7%)	14 (2.2%)	27 (3.1%)	0.67 [0.31, 1.46]
Strain	41 (2.7%)	21 (3.2%)	20 (2.3%)	1.44 [0.76, 2.73]
Fracture	31 (2.0%)	13 (2.0%)	18 (2.0%)	1.18 [0.44, 3.16]
Sprain	26 (1.7%)	11 (1.7%)	15 (1.7%)	1.03 [0.44, 2.40]
Open wound	5 (0.3%)	1 (0.2%)	4 (0.5%)	0.34, [0.04, 3.03]
Dislocation	3 (0.2%)	1 (0.2%)	2 (0.2%)	1.10 [<0.01, 551.0]
Cold weather-related	3 (0.2%)	1 (0.2%)	2 (0.2%)	0.68 [0.06, 7.49]
Traumatic brain injury	2 (0.1%)	1 (0.2%)	1 (0.1%)	1.36 [0.08, 21.74]
Other/not specified	208 (13.6%)	85 (13.1%)	123 (14.0%)	1.00 [0.63, 1.57]
Injury region[a]				
Lower extremity	1,268 (83.0%)	523 (80.7%)	745 (84.8%)	0.75 [0.49, 1.15]
Spine	99 (6.5%)	47 (7.3%)	52 (5.9%)	1.28 [0.75, 2.17]
Upper extremity	94 (6.2%)	44 (6.8%)	50 (5.7%)	1.14 [0.57, 2.30]
Torso	19 (1.2%)	11 (1.7%)	8 (0.9%)	1.92 [0.70, 5.32]
Head and neck	7 (0.5%)	2 (0.3%)	5 (0.6%)	0.52 [0.07, 4.08]
Unspecified	25 (1.6%)	12 (1.9%)	13 (1.5%)	1.26 [0.57, 2.77]
Other/not specified	15 (1.0%)	9 (1.4%)	6 (0.7%)	2.17 [0.51, 9.32]

Percentages reported as a total of valid responses. Higher AORs across outcomes reflect greater likelihood of medical encounter or injury in the training-as-usual condition.

[a]AORs for one or more medical encounters (dichotomized), injury type, and injury region derived from binomial generalized multilevel model predicting dichotomized outcomes with soldiers nested by platoon.

[b]AORs for number of injury-related medical encounters and number of injury diagnoses derived from Poisson generalized multilevel models predicting dichotomized outcomes with soldiers nested by platoon.

proportion of trainees who had a first medical encounter began to diverge by condition between weeks 3 and 4 of BCT. Moreover, the proportion of trainees who had a medical encounter were significantly different by condition at the end of week 5, and remained so through the end of BCT.

4. Discussion

This study is the first to examine the effects of MT and yoga on the physical health of military service members. Results demonstrated that MT and yoga prevented a decline in self-reported overall health,

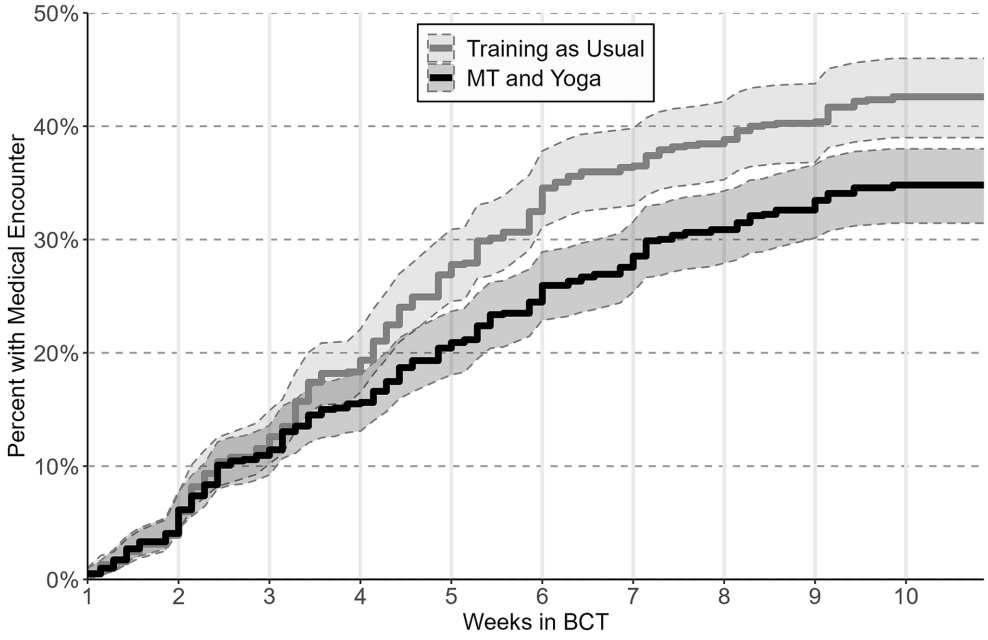

FIGURE 2
Inverted Kaplan-Meier survival curve depicting time to first medical encounter by condition with 95% confidence intervals.

attenuated the impact of pain on training, sleep, mood and stress, and reduced the likelihood of having an injury-related medical encounter for trainees at BCT, compared to training-as-usual. These findings align with previous reports that MT and yoga can benefit physical health (Tran et al., 2001; Birrer et al., 2012; Petterson and Olson, 2017; Raj et al., 2021).

In the case of pain, our findings demonstrated that while there were no significant differences in pain intensity levels over time by condition, military trainees appeared to benefit from MT and yoga in terms of how pain impacted them, a potentially relevant benefit given that the average pain rating was mild to moderate throughout BCT. These findings are consistent with previous studies that have suggested MT and yoga may reduce the degree to which pain interferes with functioning (Reiner et al., 2013; Nambi et al., 2014; Hilton et al., 2017; Kim, 2020). Given the emphasis on present-centered sensory awareness in mindfulness and yoga practices, the intervention may have helped trainees observe their discomfort without emotional reactivity, have greater awareness of their body in ways that helped them avoid injury, and use mindfulness practices and yoga postures that alleviated discomfort so that pain did not distract them from training, interfere with their sleep, disrupt their mood, or compound their stress.

Study results regarding medical encounters offer a nuanced pattern of findings. The most conservative statistical models demonstrated no overall significant difference between conditions with respect to the likelihood and frequency of injury-related medical encounters during BCT. However, trainees in the training-as-usual condition had significantly more injury diagnoses than trainees receiving MT and yoga, possibly suggesting the injuries may have been more complex. These results are consistent with previous studies demonstrating the impact of MT and yoga on injury prevention and physical well-being (Birrer et al., 2012; Petterson and Olson, 2017). Potential mechanisms of action underlying the observed injury results could include both physical and psychosomatic elements. For example, yoga is known to improve flexibility (Tran et al., 2001; Raj et al., 2021) and balance (Polsgrove et al., 2016), which may have prepared trainees in the intervention condition for the physical demands of BCT more than those receiving training-as-usual. Additionally, trainees receiving MT and yoga may have had fewer injury diagnoses because they were impacted less by pain than trainees in the training-as-usual condition, and thus, did not formally report as many medical concerns.

An analysis of the first injury-related medical encounter over time found that there was a 30% greater hazard of injury among MT and yoga relative to training-as-usual. Furthermore, the inverted Kaplan–Meier curves illustrate that the two conditions diverged at approximately 3 weeks, and this divergence was maintained through the remainder of BCT. The timing of this divergence is useful to consider. Previous research has indicated that physical health benefits require more than 2 weeks of MT (Cruze and Games, 2021) and several weeks of yoga practice (Park et al., 2020), suggesting that the benefits from the MT and yoga intervention also required weeks of practice.

Study strengths include a real-world occupational setting with subjective and objective outcomes. It is notable that results for subjective outcomes (self-reported health and pain-related impact) were corroborated by objective data that showed a meaningful condition-wise difference in injury-related medical encounters over the 10 weeks of BCT and a significant difference in the number of injury-related diagnoses between conditions. Study constraints include not being able to disentangle selective or additive effects of the two components of the intervention condition and not being able to determine mechanisms of effect. While this study did not examine causal mechanisms, future research may benefit from a multi-armed evaluation of intervention components and assessment of mitigating mechanisms. Such mechanisms could include the degree to which MT

and yoga interventions contribute to strength, flexibility, body awareness, and emotion regulation (Tran et al., 2001; Busch et al., 2012; Veehof et al., 2016; Schmid et al., 2019; Raj et al., 2021).

Future research should also assess the effects of a MT and yoga intervention beyond BCT and identify ways to support the continuation of mindfulness and yoga practice once trainees have joined their first unit of assignment where group schedules may be less explicitly structured. Building on studies demonstrating the impact of practice on study outcomes, future research should consider optimizing practice engagement in an occupational setting (Blanck et al., 2018; Denkova et al., 2020, 2021; Nassif et al., 2021). Such studies can also examine the scope of effort required to sustain the benefits of MT and yoga in these settings. Given the potential resources that would be involved in a larger roll out of this kind of program, it would be important to evaluate methods for streamlining implementation, optimizing effects over time, and determining the cost–benefit of the investment.

Data availability statement

The datasets presented in this article are not readily available because of institutional regulations related to human participant protection requirements but can be made available from the corresponding author upon reasonable request (may require data use agreements to be developed). Requests to access the datasets should be directed to CS, carl.d.smith179.mil@health.mil.

Ethics statement

The studies involving humans were approved by Walter Reed Army Institute Human Subjects Protections Branch. The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study.

Author contributions

CS led the article writing, with substantial contributions and edits from TN, IG, AJ, and AA. IG conducted statistical analyses. KJ and KT provided support regarding data collection and analysis. All authors provided feedback on the final draft of the manuscript.

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Conflict of interest

AJ is co-author and a copyright holder of the Mindfulness-Based Attention Training (MBAT) Program.

The remaining authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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A sense of connectedness, transcendent experiences, and insights for compassionate action emerge through an international collective labyrinth walk with a shared intention during the COVID-19 pandemic

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Introduction: Labyrinth walking is an integrative contemplative practice that aims to engage the body, heart, mind, and spirit. In this article, qualitative findings from the first year of a mixed methods study on collective labyrinth walking with a shared intention are described. This form of labyrinth walking is distinct in that it is a social contemplative practice. It expands upon most of the labyrinth walking research to date which has been focused upon the individual. More specifically, practitioners walk labyrinths together in solidarity with the same intention in mind during collective labyrinth walking. This practice can be used locally (i.e. practitioners walk the same labyrinth together for the same reason) or non-locally (i.e. practitioners walk different labyrinths for the same reason together in different locations). The study is unique in that it took place at the height of the COVID-19 pandemic which was a time in recent history that evoked fear, uncertainty, grief, isolation, and disconnectedness for many persons around the world.

Methods: This sample in this study was comprised of 461 participants from 19 countries who collectively walked labyrinths together with a shared intention on World Labyrinth Day 2021. Most participants were women in middle to later life from the United States. Data was collected through an anonymous online survey and analyzed using the qualitative methodology of interpretive phenomenological analysis.

Results: Three predominant themes emerged from practitioners' narrative accounts of their lived experiences: (1) multiple forms of connectedness (i.e., intrapersonal, interpersonal, transpersonal, labyrinth connection) were cultivated through collective labyrinth walking with a shared intention; (2)

practitioners reported qualities associated with "transcendent" experiences during this experience (i.e., boundlessness, ultimacy, transcendence, connectedness, positive emotions); and (3) practitioners had insights for compassionate action.

Discussion: Findings suggest that collective labyrinth walking with a shared intention can contribute to individual and group flourishing during times of distress. Quasi-experimental and experimental research designs are needed to build on this exploratory developmental research and are described in this article.

KEYWORDS

labyrinth walking, contemplative practices, flourishing, wellbeing, connectedness, transcendence, spirituality, consciousness

> "There is so much fear being perpetuated during these COVID times. So, the question of how to make this change and let go was revealed as I stepped out of my mind and into my heart. I felt others doing the same collectively. Compassion for others, self-compassion and some humor from the Universe presented itself as I walked the labyrinth."
>
> –Participant

Introduction

Qualitative findings from the first year of a 3-year long mixed methods study on collective labyrinth walking with a shared intention are described in this article. This form of labyrinth walking is distinct in that it involves a shared social experience, either locally or non-locally, in which practitioners walk at the same time in solidarity for the same reason. The study is significant in that it is the first to examine the experience of collective labyrinth walking with a shared intention as compared to prior research on labyrinth walking which has been predominantly focused upon individual labyrinth walking. The study is unique in that it took place at the height of the COVID-19 pandemic which was a period that evoked fear, uncertainty, grief, and isolation for many persons around the world. The study is innovative in its community-engaged field-based design which was aimed at better understanding a real-world scenario in which a contemplative practice was implemented as compared to a lab-based study. The purpose of the study was to learn about labyrinth walking practitioners' thoughts, feelings and insights while collectively walking labyrinths, in multiple locations, at the same time, a little over a year after the COVID-19 pandemic began on World Labyrinth Day 2021. The impetus for the study was the labyrinth community's dedication to walking labyrinths together as an expression of solidarity during an international crisis as well as dedication to research on learning more about this contemplative practice. By way of background, the psychosocial impacts of the first year of the COVID-19 pandemic are discussed to provide context for the study followed by an introduction to the field of contemplative science and practice. A summary of prior research on labyrinth walking is provided as well as a description of the distinct practice of collective labyrinth walking with a shared intention.

Background

Psychosocial impacts of the COVID-19

The first year of the COVID-19 pandemic was a challenging time for many in the recent history of the world. The prevalence of disease and death on a global scale was unprecedented as the virus spread. In addition, a major toll was taken on the financial, social, and emotional health of many (Brooks et al., 2020). Rates of depression and anxiety in the USA tripled as compared to pre-pandemic levels (Czeisler et al., 2020). Similarly, international researchers reported high levels of anxiety, depression, sleep disturbance, stress, and emotional trauma in the community leading to a call for increased mental health resources as a public health response (Bao et al., 2020; Jia et al., 2020; Li et al., 2020; Rajkumar, 2020; Giel et al., 2021; Lee Y. et al., 2021; Panda et al., 2021; Taquet et al., 2021; Matsumoto et al., 2022).

Individuals, families, and communities sought ways to protect their health and to maintain their wellness during the COVID-19 pandemic in the context of distress and social isolation. Wellness, according to the World Health Organization (2023), is a "state of physical, mental and social wellbeing and not merely the absence of disease or infirmity." It is a "conscious, self-directed, and evolving process of achieving full potential" (National Wellness Institute, 2023). As such, some persons engaged in various forms of contemplative practice for comfort and guidance as they learned to navigate the unique challenges of the pandemic (Achepohl et al., 2022; Lekhak et al., 2022). Labyrinth walking practitioners turned to this unique contemplative practice as a means of coping, maintaining wellness, and cultivating flourishing.

Contemplative science

A goal of the interdisciplinary field of contemplative science, according to Dorjee (2016), is to gain a better understanding of "the core capacities, processes and states of mind modified

by contemplative practice" (p. 9). As such, this interdisciplinary field seeks to understand the capacity of the human mind for self-regulation through metacognitive processes which can be influenced by a person's existential awareness, motivations, and intentions—as well as the contextual factors associated with the practice they are engaging with (Dorjee, 2016).

Contemplative scientists are interested in learning how various contemplative practices serve to cultivate a range of desirable outcomes. For example, some practices are aimed at increasing a person's capacity for loving kindness and compassion (e.g., Hofmann et al., 2011), joy and equanimity (Wallace, 1999), and acceptance and non-reactivity (Bishop et al., 2004; Baer et al., 2008). Other practices seek to generate a sense of meaning and purpose and to cultivate specific strengths and virtues (Dreyfus, 2002; Dahlsgaard et al., 2005; Dorjee, 2016).

Contemplative scientists are also interested in studying the shifts and modes of existential awareness that may be induced by a contemplative practice. A practitioner's level of awareness, when first learning how to engage in a specific practice, may be more consistent with their typical or habitual thought patterns. With practice, however, an increased openness to insights into the nature of the self and reality may occur (Gampopa, 1998; Dorjee, 2016). Best practices for contemplative science research utilize first- and second-person methodologies as well as third person measurements of behavioral and physiological data (Varela et al., 1991; Varela, 1996; Davidson and Kaszniak, 2015; Lutz et al., 2015).

Contemplative practice

The term contemplative practice encompasses a broad-array of mind-body integrative practices each having unique roots within cultural-spiritual and historical contexts. An overarching goal of contemplative practices is to enhance wellbeing through cultivating the recognition of the connections people have to each other (Komjathy, 2015). Inherent in this goal is the desire for cultivating compassionate responses toward the self, others, and the world.

Perhaps the most notable development within the broader field of contemplative practice is the growth and interest in mindfulness meditation. This area of research has been highly influenced by Kabat-Zinn (2003) among other researchers (Lee J. et al., 2021). Mindfulness meditation has shown promising results in a myriad of arenas, including clinical, social, and industrial-organizational psychology as well as education, social work, healthcare, and related disciplines. Centering prayer, Lectio Divina, and labyrinth walking are a few other forms of contemplative practices, although there is less research on these practices as compared to mindfulness meditation.

One classification system for the variety of forms of contemplative practice is depicted in the Tree of Contemplative Practice (Center for Contemplative Mind in Society, 2021a,b). In this model, the roots of the tree symbolize two foundational purposes of contemplative practice: (1) increasing personal awareness; and (2) cultivating a sense of connection with the divine (e.g., God, a higher power, the universe, the earth, etc.). The branches on the Tree of Contemplative Practice are a way to categorize the forms of contemplative practice. For example, there are branches that depict practices involving movement (e.g., labyrinth walking, dancing, walking meditation, etc.), stillness (e.g., meditation, centering, etc.), and creativity branches (e.g., singing, journaling, improvisation, etc.). There is notably overlap between the forms and desired outcomes of contemplative practices. The focus of the current study, collective labyrinth walking with a shared intention, could be placed on the ritual/cyclical, generative, movement, meditative, and even activist (e.g., social justice related) branches.

Labyrinth walking

Labyrinths beckon practitioners to step onto a meandering, often unicursal path, patterned after sacred geometry, to embark on a metaphorical spiritual journey. Historians discovered that labyrinths have been used in many cultures for the last 2,000 years (although there is some evidence of the labyrinth symbol being used as long as 4,000 years ago), beginning in Crete and spreading to most continents. According to historians, such as Jeff Saward, the earliest reliably dated labyrinths have been found in Southern Europe. These labyrinths were typical of a classical style with a series of seven concentric pathways surrounding a central goal.

In the last 30 years, the ancient practice of labyrinth walking has been revived through the work of Artress (1995, 2006, 2020) among others. Since then, this practice has grown in popularity as an adjunctive process to various types of psychotherapy and as a spiritual practice (Hong and Jacinto, 2012). There is evidence that individual labyrinth walking serves to quiet/focus the mind, foster peace, reduce stress, and improve physical, emotional, and spiritual health (Yang, 2003; Zucker, 2016; Behman et al., 2018; Weaver et al., 2018; Butcher, 2023). Little is known, however, about how these benefits translate to community or social outcomes which is one of the significant aspects of the current study.

Modern labyrinths are found in religious and secular settings such as churches of all faiths, universities, hospitals, prisons, community centers, and backyards, among other locations (Abdallah-Baran, 2003; Peel, 2004; Weigal et al., 2007; Gersbach, 2008; Hong and Jacinto, 2012; Johnson, 2013; Heard et al., 2015; Zucker et al., 2016; Lizier et al., 2018). Although modern labyrinths come in many forms and designs, one of the most familiar is the 11-circuit Chartres style labyrinth, named for the medieval pavement labyrinth found in the nave of the Chartres Cathedral in France. Another well-known modern labyrinth was constructed in the nave of Grace Cathedral in the United States and is a replica of the Labyrinth at Chartres. A third notable labyrinth is a "green rooftop labyrinth" at the American Psychological Association (APA) headquarters in Washington, DC, USA.[1] This labyrinth was designed to provide a place for employees and visitors to reflect and as a means for reducing pollution in local waterways.

Other forms and designs of modern labyrinths include physical labyrinths in the ground, virtual labyrinths, finger labyrinths, paper labyrinths, and more. There are no financial costs for walking a labyrinth which make it a potentially scalable contemplative practice. Labyrinth walking reaches the far corners of the technological spectrum from low-tech to high-tech. An example of

1 https://naturesacred.org/sacred_place/american-psychological-association/

a low-tech labyrinth is when a person draws a labyrinth design in the dirt (or sand) with a stick, then walks it. Another example of a low-tech labyrinth is a paper handout with a labyrinth printed on it whereby a person can "walk" it by using their finger to trace the pattern. An example of a high-tech labyrinth would be the vision of Sandra Wasko-Flood in Angel Fire, New Mexico. Her prototype for a PEACE labyrinth is projected onto the floor by liquid crystal display (LCD) and can be modified based on desired labyrinth design, color, size, and music. Examples of other options for labyrinth walking are using a finger type labyrinth on an app for a smartphone, carved finger labyrinths in wood, and labyrinths illuminated by solar power for walking at night. There are also labyrinths made from recyclable materials (i.e., crushed computer discs (CDs), recycled bottle glass, old pottery, used shoes, tires) and natural materials (i.e., dried flowers from bouquets no longer being used) which allows for the production of eco-friendly labyrinths. The Labyrinth Society[2] has curated a useful downloadable resource on research and presentations on this contemplative practice.

Collective labyrinth walking with a shared intention

Most of the research on labyrinth walking to date, has examined this practice from an individual or more Western perspective. In the current study, we have focused on collective labyrinth walking with a shared intention which involves 3 or more people walking a labyrinth or labyrinths in solidarity for an agreed upon purpose or reason. This form of labyrinth walking can occur locally (i.e., all walkers are in the same place) or non-locally (i.e., walkers are located in different places even though they are walking at the same time with a shared purpose or intention). Shared intentions must be of a prosocial nature and about improving circumstances for an identified people group that the collective is concerned about.

A short meditation is usually conducted before beginning a collective labyrinth walk. This meditation is aimed at unifying the hearts and minds of the practitioners who are walking. Practitioners are instructed to state the shared intention silently or out loud before they step onto a labyrinth to walk the path toward the center or "heart," also called the rosette. Upon arriving at the center of the labyrinth, practitioners are encouraged to repeat the shared intention again verbally or silently to themselves. In the center, practitioners are asked to begin to feel the emotion of the intention as if it was already completed and to release it. The practitioner remains in the center as long as they want to and walks the path out of the labyrinth when ready. At this point, the practitioner is advised to be present to what is being received in their mind or heart and receptive to any ideas, feelings, and/or sensations that emerge without analyzing or judging.

After the walk, it is recommended that a journal be used to write about what happened during the walk. The practitioner should be encouraged to recall their experience, noting any changes in their thoughts, feelings, and sensations. Possible reflections include how they felt after "releasing" the intention in the center of the labyrinth, as compared to before releasing it, and new insights or ideas they had stemming from their collective labyrinth walking experience. Individual journaling is for personal reference and for sharing when a collective comes together to discuss what came up for each member during the walk whether in-person or online.

Materials and methods

The project was reviewed by the Institutional Review Board (IRB) of Baylor University (Reference Number 1711129). The data was collected through an anonymous online questionnaire. No personally identifiable Research Health Information or Personal Health Information was collected.

Research design and sampling strategy

A convenience sampling strategy was employed in this study and data collection occurred on World Labyrinth Day (WLD) which was held on 1 May 2021. Inclusion criteria were: (1) participated in a labyrinth walk on World Labyrinth Day 2021; (2) signed up for the research study before WLD to receive instructions; (3) age 18 or older; (4) English reader; and (5) willingness to complete an anonymous questionnaire online. Exclusion criteria were no internet or cellular access to complete the questionnaire associated with the study.

Procedure

Recruitment

The Legacy Labyrinth Project (LLP), a community organization dedicated to the practice of labyrinth walking and sponsor of the study, was responsible for recruitment and worked in close collaboration with the researchers on this study. Information about the study was distributed through social media outlets, email, study flyers, website announcements, word of mouth, and presentations. Other well-known labyrinth organizations supported recruitment efforts such as The Labyrinth Society (2023), Veriditas[3], and The Australian Labyrinth Network.[4] The organizers of World Labyrinth Day were supportive of the research study and provided outlets for recruitment.

Instructional resources

The Legacy Labyrinth Project (LLP) developed two instructional videos for the study which were emailed to participants the day before WLD 2021. The goal of the first video was to teach participants a brief meditation to becoming more calm and more focused before participating in collective labyrinth walking. The goal of the second video was to teach participants how to walk a labyrinth with a shared intention based on the work of McTaggart (2007). Participants also received a video developed by The Labyrinth Society on how to walk a labyrinth safely during the COVID-19 pandemic (based on what was known about transmission at the time).

2 https://labyrinthsociety.org

3 https://veriditas.org

4 https://aln.org.au

Instructions for participating in the study

There were three steps for practitioners to complete in sequential order in this study. First, they were asked to do the brief meditation. Second, they were asked to reflect on the intention below that was developed by a committee of expert practitioners who served in advisory capacity for the study.

> *In this year of suffering and uncertainty around the world, my intention is to walk a labyrinth with others on World Labyrinth Day to receive insights that can influence change.*

Finally, participants were asked to walk a labyrinth of any kind, wherever they were in the world, before completing an online questionnaire within 48 h of doing their labyrinth walk. There were no restrictions on the location of a practitioner's labyrinth walk or the form of labyrinth they utilized (i.e., finger labyrinth, labyrinth on the ground, canvas labyrinth, etc.). However, practitioners were asked to walk labyrinths on the same day around 1:00 PM in their respective countries and regions with the shared intention noted above.

Questionnaire

A link to complete an anonymous questionnaire was sent out to practitioners to complete after their collective labyrinth walk. The questionnaire took approximately 15–30 min to complete. There were no financial or in-kind incentives for participating in the study. No electronic data on location of participants or other electronic identification was tracked.

Data collection

An online data collection tool was utilized to collect qualitative and quantitative data (Qualtrics©, Provo, UT, USA). The measures for this study were: (1) a short investigator-developed demographic questionnaire which included questions about experience walking labyrinths as well as other information about each practitioner's labyrinth walk; (2) three open-ended narrative questions about practitioners' experience collectively walking a labyrinth with a shared intention; and (3) three standardized self-report measures. For the current article, we report only qualitative findings from the three open-ended questions.

Practitioners were invited to complete the questionnaire online within 48 h of collectively walking a labyrinth with a shared intention on World Labyrinth Day 2021. The questionnaire could be taken on a computer or on a smartphone. Responses went directly to the academic research team for analysis. The data was housed on a password protected server.

Measures

Qualitative data was obtained through three open-ended questions. Participants were asked: (1) to share any insights they received during their collective labyrinth walk with a shared intention, if any; (2) what they envisioned as a plan for following up on their insights, if at all; and (3) their general experience participating in a collective labyrinth walk with a shared intention.

Data analysis

To gain a deeper understanding of the themes emerging from the narratives of practitioners, interpretative phenomenological analysis (Alase, 2017) was utilized. This qualitative research methodology is advantageous for fostering examination of a person's inner-most deliberations while making interpretations of the meaning of their lived experiences (Alase, 2017; Smith et al., 2022). It is particularly well-suited for learning about complex emotional and spiritual experiences (Pietkiewicz and Smith, 2014).

The narrative data from this study were uploaded to NVivo (QSR International Pty Ltd, 2022) for analysis. Three members of the research team gained insight into the data by individually reading participants' narratives multiple times, making notes, and then developing initial codes that represented common words or sentences derived from the data. The team discussed the merits of each code and whether to retain, refine, merge, or eliminate codes over four team meetings. The agreed upon codes were grouped into "meaning units" that captured the essence of participants' lived experiences. These codes and their definitions served as the basis for forming themes. To reduce bias, two members of the team, without personal experience with labyrinth walking, independently conducted line-by-line coding of the narratives for analysis. A third team member, who had experience walking labyrinths, served as an arbiter in case there was disagreement between the two primary coders.

The team conducted four additional meetings to process insights from individual analyses and to triangulate the data (Alase, 2017; Nowell et al., 2017). Next, the team interpreted the data around the themes which gave meaning to what practitioners shared about this collective labyrinth walk. This iterative process of text-to-code and code-to-code revision was conducted to increase the trustworthiness of the findings (Merriam, 2002; Creswell, 2013). Finally, a committee of expert labyrinth walking practitioners provided input on the interpretation of the themes.

Demographic characteristics of participants

A total of 461 practitioners completed the online questionnaire. Although most were from the United States, practitioners from 19 countries were represented. Most practitioners were experienced labyrinth walkers with 96.3% having previously walked a labyrinth. The average age was 63 (SD = 10.726). Most practitioners self-identified as "Caucasian or White" (86.6%) although a small percentage considered themselves to be a "person of color" (e.g., "Black," "Latinx or Hispanic," "Indigenous," "Asian," "mixed racial identity") or did not identify with any of these categories. Most practitioners self-identified as "female" (87.3%), with fewer who identified as "male" (11.9%), and the remainder preferring not to answer this question. There were people from all the world religions, persons who considered themselves spiritual and not religious, and persons who considered themselves as agnostic.

Findings

Three predominant themes emerged from practitioners' narrative accounts of collectively walking labyrinths with a shared intention: (1) a sense of connectedness (intrapersonal, interpersonal, transpersonal, and connectedness with the labyrinth they were walking); (2) qualities associated with a "transcendent" experience; and (3) insights into ways to cultivate social and communal flourishing. The themes are presented below in order of prevalence in this sample of practitioners.

Theme 1: A sense of connectedness

Practitioners reported experiencing multiple forms of connectedness. Subthemes for connectedness were: (1) intrapersonal connectedness (i.e., within oneself); (2) interpersonal connectedness (i.e., with others); (3) transpersonal connectedness (i.e., with the divine, God, the Earth, nature); and (4) connectedness with the labyrinth they were walking.

Intrapersonal connectedness

For some practitioners, collective labyrinth walking with a shared intention led to a sense of feeling more integrated as a person. For example, a practitioner shared, "This experience brought (me) to the (realization) that I had to put my wellbeing first in my life." Another example from a practitioner was, "I felt my heart open more and had a sense that my soul had purpose. My best days are in front of me. The Universe has my back." This theme was important given that most practitioners in the study had reported feeling distressed and disconnected from themselves because of the COVID-19 pandemic and quarantine initiatives.

Interpersonal connectedness

A heightened sense of interpersonal connectedness was shared by practitioners during their labyrinth walk. The forms of interpersonal connectedness reported in this study were to family, friends, deceased loved ones and ancestors as well as fellow labyrinth walkers who were participating in this experience, practitioners' local communities, and people around the world who were experiencing suffering as a consequence of the pandemic.

Friends and family

Interconnectedness to friends was demonstrated in the following quote by a practitioner, "I felt a greater connection with the many friends and other people to whom I sent love and good wishes to even though we were not together (physically)." Another example was, "As I rounded the final bend (of the labyrinth) and I noticed other walkers already in the center of the labyrinth, I was overcome with a rush of emotion. I felt joyful and grateful. Somehow, I KNEW that what I was experiencing was shared by others." Still another shared, "I was filled with joy and gratitude at being reunited on the labyrinth with four dear friends. It energized me to think that we, along with hundreds around the globe, were united in a common experience, many of us holding the same intention." This level of perceived connection with others was notable given that many practitioners reported feeling physically and socially isolated and disconnected from family, friends, and other persons prior to their labyrinth walk.

Deceased loved ones and ancestors

Connectedness with deceased loved ones and ancestors were often reported by practitioners. For example, a practitioner expressed, "I had a sense of anticipation and deep connection with my deceased parents." Another practitioner shared, "Yesterday was my late Father's 105th birthday. My heart was deeply moved when I became aware of his presence." Another expressed having a sense of connection with deceased members of their church, "As the pastor here. . .I don't know many of those buried in our memorial garden, but I certainly know their heirs. It was moving to connect with those folks (deceased parishioners) while walking and recall the stories that I've heard and offered prayers for their eternal rest and peace for their descendants."

The community, other labyrinth walkers, and the world

For some practitioners, a sense of connectedness to their communities and the world was experienced. For example, a practitioner shared, "The wisdom I received is how to deal graciously and constructively with the tension among people in the community where I live about the safety measures that are required for the pandemic." Another practitioner shared, "I immediately felt attuned with all of the other labyrinth walkers today even though we were not in the same place." Still another participant wrote, "I felt connected to everyone (around the world) during these challenging times."

Transpersonal connectedness

In this study, we defined transpersonal connectedness as feeling connected to something larger than oneself. Transpersonal connectedness most often had to do with feeling connected to the divine or a higher power (e.g., God, gods, spirit, universe, etc.) or something metaphysical (e.g., energy, consciousness, etc.). Close to two-thirds of the practitioners' narrative responses suggested that they experienced a transpersonal connection. For instance, a practitioner shared, "I felt peace, connected to God and encouraged that people all over the world were walking the labyrinth as one." Another shared, "The connection with Spirit is strong, even in these seemingly difficult times." Another shared, "I felt such a connection. . .to the 'fierce and tender' love of the Divine moving through me. . . (during the collective labyrinth walk)."

Another form of transpersonal connectedness reported by practitioners was to the Earth or Nature. For example, a practitioner shared, "Each inward breath (while walking the labyrinth) brought me a sense of peacefulness that came directly from the Earth itself." Another practitioner shared, "I was filled with gratitude and connection to the Earth and others walking that day." Another wrote: "I felt a deep love and forgiveness for all of Creation." Nature or earth-based connections were experienced viscerally by some participants. For example, a practitioner explained: "My feet

and legs were vibrating with Earth energy. . .it was incredible. . .the connectedness." Another participant shared: "I liked very much the connection with the Earth. I could feel my own roots going down in the earth as I walked this geometric figure (labyrinth)."

Connection with the labyrinth

A sense of being connected to the labyrinth was reported by most practitioners. A poignant example of a labyrinth connection was shared by a participant, "I experienced a deep connection to the Now and the incredible power of being within (hugged by) the center (of the labyrinth) where I felt others across the world standing." Another participant shared, "I had a dream last night. . .that connected to the last petal (of the labyrinth) today. That last petal is often very quiet for me, even today but it was also very strong."

Labyrinth connections were imbued with meaning and healing for some as expressed in this quote, "The experience today, connecting with a complete stranger on a mainly empty shoreline, reaffirmed my love and commitment and connection with the labyrinth as a power and place and source of healing." Another shared,

> *No matter the type of labyrinth or the form of the labyrinth, they all connect to the energy of the labyrinth. I really sensed this today.*

Theme 2: Collective labyrinth walking as a transcendent experience

There are several qualities that may present when a person believes they have had a transcendent experience. These qualities are a sense of transcendence, ultimacy, boundlessness, connectedness (previously discussed), and positive emotions (Pargament et al., 2014; Magyar-Russell et al., 2022). Any of these qualities can emerge singularly or simultaneously during a transcendent experience. Below we describe practitioners' experiences during collective labyrinth walking with a shared intention.

Transcendence

Transcendence, may be described as the perception of having been a part of something bigger than the self that goes beyond one's ordinary day-to-day existence. A sense of transcendence may occur when a person believes they have encountered a deity or deities (i.e., God, gods, etc.), although transcendence occurs outside of religious connotations. An example of transcendence from a practitioner's narrative was, "I felt very expanded and truly connected to something bigger than myself." Another was, "My experience was a transmutation of energy that sent ripples out from me. . .into the cosmos. . .it was much bigger than me."

Ultimacy

Ultimacy may be described as the perception that an experience was "really, real" or revelatory of a deeper truth (Geertz, 1966). An example from a practitioner narrative was, "I felt the sky, a glorious azure. . .I was aware of all the labyrinth walkers around the world. I felt the connection, even though we were walking in different time zones. . .I felt privileged to be able to participate. I felt fully alive and present (in this moment)."

Boundlessness

Boundlessness may be described as involving the perception of moving beyond the limits of ordinary time and space. It is a perceptual shift away from Chronos time (ordinary time and space) to Cairo's time (a more expansive experience of time and space). An example of boundlessness from a practitioner narrative was, "I lost track of time and space and had a deep sense of calm walking (the labyrinth)." Another practitioner shared, "Upon entering the labyrinth, it felt like time wasn't important. . .I had stepped out of the normal confines of time and space." A third example from a practitioner's narrative was, "This (experience) felt like an open day. . .there were no barriers, if only for a moment, between that which was, that which is, and that which will be."

Positive emotions

A person may experience a range of positive emotions during a contemplative practice. For example, emotions such as uplift, awe, humility, mystery, gratitude, joy, peace, and compassion, among others, may be classified in this way. In this sample, the most frequently endorsed emotion was gratitude, "I found myself a bit weepy with a deep sense of gratitude (during collective labyrinth walking)." The emotion of uplift is reflected in this practitioner's quote, ". . .I felt lifted up out of my body with dignity and determination and out of the sadness I had been experiencing because of COVID." Peace was another frequently endorsed emotion as shared by a practitioner, ". . .I had an overpowering sense of peace envelope me." Joy and a sense of release was experienced by a practitioner, "I stopped and looked down to see the labyrinth shimmering in dappled light. . .I could almost feel the heat emanating from the surface. It only lasted a few minutes, but oh. . .the joy and release and relief I experienced." Multiple positive emotions were experienced simultaneously during collective labyrinth walking with a shared intention as reported by a practitioner, "I felt a deep sense of gratitude, love, and peace from myself for others."

Theme 3: Compassion for action

Compassion for action was the third theme emerging from practitioners' narratives of their experience in this study. This theme involved an increased level of awareness of the suffering other people might be experiencing as a consequence of the COVID-19 pandemic, a sense of compassion, and a desire for action. Increased awareness of the potential suffering of others is demonstrated in this quote from a practitioner, "I gained insights about addressing the HUGE suffering so many are experiencing." Bettering oneself was regarded as an essential component of compassion for action by some practitioners as expressed in this quote, "I will continue with my efforts to bring healing to myself and others through meditation and mindfulness and labyrinth walking with compassion." Another practitioner echoed a similar sentiment, "Healing the earth needs to start with me."

Several practitioners reported that they were planning in engaging in direct action after receiving insights from collective

labyrinth walking. An example of this sentiment follows, "I work with a group called (deleted for confidentiality). We meet buses coming in from (deleted for confidentiality) to offer a small packet of food and water to asylum seekers. We feel it is important to welcome these seekers with small practical offerings. Today's walk encouraged me to continue with this." Another practitioner shared a desire to translate their insights from their collective labyrinth walking experience into the actions needed for planting a community garden to address food insecurity. This practitioner went on to explain, "I am involved in helping finish this labyrinth garden and caring for it, in a community project. . . I'm hoping to coordinate an event to showcase the gardens on the South side of my town which was historically red-lined." Another practitioner shared, "I am very concerned about the children all over the World who are being deprived of a joyous childhood and receive limited education." This practitioner goes on to say, "I plan to do something about this (social issue) now that I am aware of my heart."

Collective labyrinth walking with a shared intention was viewed as a form of non-traditional or spiritual activism by some practitioners as reflected in the following quote, "I will continue to speak out against injustice, will protest, and walk labyrinths for the good of others." Another practitioner remarked, "As I prepare to retire. . .I will continue to do my justice work and will be able to hold sacred space (through labyrinth walking) to encourage other people who are doing the frontline work." The idea of collective labyrinth walking with a shared intention being a form of prayer was often reported as demonstrated in a practitioner quote, "I will include water in my prayers while I walk labyrinths and share its importance with others."

The subtheme of strengthening relationships among diverse people was expressed by practitioners. For example, a practitioner shared that they had received the insight that they needed to be "working toward creating peace among the people of the World." Another practitioner expressed, "I plan to include greater inclusivity in thought and engage in conversation with a more diverse group of people. . .I am concerned about what happens when societies get too comfortable and complacent. . .when change only incorporates one point of view." Another shared, "There is a need for the ongoing engagement and dialog around the impact of Colonization on First Nation people and movement for reparations. I recognized this during my labyrinth walk today."

Discussion and implications

The current study explored individual responses to the social contemplative practice of collective labyrinth walking with a shared intention within the context of the COVID-19 pandemic. Findings suggested that the practice of collective labyrinth walking with a shared intention can lead to a sense of connectedness through a transcendent or sacred experience that may spur insights and ideas for addressing human suffering with compassionate action.

Practitioners, in the study, reported experiencing various forms of connectedness during their collective labyrinth walking experience (i.e., intrapersonal, interpersonal, transpersonal, connectedness with the labyrinth). This finding is particularly salient in the context of the COVID-19 pandemic which resulted in a sense of isolation and loneliness for many persons around the world. Each form of connectedness could be present on its own or several forms of connectedness could present at the same time in each practitioner's experience. Likewise, the qualities of transcendence, ultimacy, boundlessness, interconnectedness, and positive emotions were cultivated through collective labyrinth walking with a shared intention which expand the work of Pargament et al. (2014).

In a systematic review on labyrinth walking, Davis (2021) reported that four out of seven people experienced positive emotions such as peace when walking a labyrinth individually. The current study expands these findings to the experience of collective labyrinth walking with a shared intention during an international crisis. This collective labyrinth walk cultivated a sense of peace, calm, compassion, relaxation, and increased awareness within a community context. This finding is particularly notable in that the practitioners in our study had been experiencing stress, anxiety, and trauma due to the COVID-19 pandemic and related concerns. The experience of collective labyrinth walking with a shared intention may have served to regulate emotions for the participants in the current study in addition to expanding their awareness.

Although we did not compare people walking with the same intention to those who walk labyrinths with the goal of simply seeing what emerges, we believe that collective labyrinth walking with a shared intention may amplify positive emotions which warrants additional research. This finding provides evidence of the value of labyrinth walking as a social contemplative practice. It suggests that collective labyrinth walking with a shared intention may be a practice that can contribute to emotion regulation during disasters such as the COBID-19 pandemic.

Contemporary contemplative practice may evoke radical shifts in the self and perception of the world, leading to actions that may benefit humanity and the earth. Among the most renowned contemplatives are Thomas Merton, Trappist monk and peace activist; Dorothy Day, social activist and co-founder of the Catholic Worker Movement; Howard Thurman, principal architect of the non-violent civil rights movement and mentor to Martin Luther King, Jr.; Anglican Bishop Desmond Tutu, Anti-Apartheid and human rights activist; and Thich Nhat Hanh, Buddhist monk and peace activist. These are individuals who have taught us that contemplation can foster justice and action (Taylor-Stinson, 2017; Pennington-Russell, 2020). In this study, we verified that this mindset could occur through the practice of collective labyrinth walking with a shared intention.

One branch of The Tree of Contemplative Practices is labeled "activism" and includes practices such as "taking trips to sites of social justice activity, working and volunteering for social causes, attending marches and vigils, and bearing witness" (Kaufman, 2017, p. 5–6). Our findings suggest that collective labyrinth walking with a shared intention can also be a form of contemplative activism where deep insight is cultivated to address the social issues of our time with greater clarity and resolve. Indeed, like other contemplative practices, collective labyrinth walking with a shared intention may serve to cultivate the inner tools for disrupting inner logic system that are based on oppression and bias so that we can see ourselves, others, and the world more clearly (Lee, 2021; Son, 2021). Expanded awareness and vision through this inner work can be transformed into the outer work of supporting social and structural change (Schaarsberg, 2021).

Findings from the current study supported prior work on the use of contemplative practices for social justice concerns (Lee, 2021; Son, 2021). The form of activism present in collective labyrinth walking is more subtle in nature when compared to more well-known or traditional forms of activism such as marching and protesting. Instead, the form of subtle activism we observed in collective labyrinth walking with a shared experience emphasize insight, connection with others and creativity (Hesterman and Hawkey, 2020).

The outer work of social change begins with inner soul work (Lee, 2021). To date, labyrinth walking has primarily focused on inner work (Davis, 2021). The current study expanded this focus to labyrinth walking for communal and cultural flourishing. Further research is needed to explore the ways collective labyrinth walking can be used as a form of contemplative activism.

Limitations

This study was a community based participatory research (CBPR) study. A CBPR approach views all stakeholders as equal. For this project, stakeholders included the sponsor, an expert practitioner advisory board, the labyrinth community, and the research team. Efforts were made to engage stakeholders at every point in the research process to co-create and shape the project by contributing expertise, sharing in decision making, and taking ownership of the project. This form of research is aimed at increasing knowledge and understanding of a given phenomenon for the purpose of integrating that knowledge in a manner that benefits the community. Inherent in this form of research is the potential for bias as compared to a tightly controlled researcher-initiated project. Although there were participants representing 19 countries, most of these participants were from North America, predominately the United States. Thus, it is not known whether our findings are generalizable cross-culturally. There was also a lack of gender and age diversity with most participants being women in mid-life or older. Therefore, additional research is needed with younger cohorts of practitioners and those who identify as male to with different genders fuller understanding of the impact of practitioners. The data in this project was collected at one time and a longitudinal approach is highly recommended.

Future research

Future research on collective labyrinth walking with a shared intention could take several directions. For example, there is a need to understand the differences between collective labyrinth walking with a shared intention as compared to individual labyrinth walking without a shared intention. These are both different ways that labyrinth walking can be utilized as a contemplative practice and it is not yet clear how an individual versus a social form of labyrinth walking differs in regards to practitioner experiences and outcomes. Second, comparative research could be conducted between collective labyrinth walking with a shared intention and other well-known practices such as mindful walking with compassion. Although both contemplative practices involve movement (i.e., walking) and compassionate intentions, they are distinct forms of contemplative practice. It is known that labyrinths were constructed based on what has been referred to as sacred geometry. It would be interesting to determine if labyrinth patterns can amplify practitioners' experiences as compared to other contemplative walking practices which do not hold a similar structure. Quasi-experimental and experimental designs are recommended for further research comparing practices.

Another important area for future directions research is to better understand the mechanisms by which collective labyrinth walking with a shared intention effects individual and social flourishing. For example, the question of possible mediators and moderators by which collective labyrinth walking with a shared intention works is an important step in this line of research. We recommend the use of objective indicators (i.e., psychometric and *in vivo* biomarker measurement) pre- and post-collective labyrinth walking experience to better understand this phenomenon. Ideally, data collection could occur before, during, immediately after, and longitudinally on individual and collective flourishing outcomes.

Finally, research on the effects of walking labyrinths in a collective over time with a shared intention should be examined. For example, what do practitioners report when they participate in collective labyrinth walking with a shared intention over more than one session? Do results change if different intentions are utilized by a collective? Future research should examine not only individual responses but also group responses such as social cohesion between practitioners who are engaging in collective labyrinth walking with a shared intention over time.

Conclusion

In conclusion, practitioners shared that their experience of collective labyrinth walking with a shared intention allowed them to gain a contemplative posture of peace and calm leading to insights and motivations for positive change during an international crisis. A poignant quote from a participant echoes this sentiment, "The (collective) labyrinth walk reflected the life we are in now. . .IN this case the wondering about how to come out of this pandemic. The intention made me feel into all the aspects I need to let go of myself to be able to be the intention. . .of making positive change." This study highlights the relevance and possibilities of this integrative contemplative practice for cultivating a sense of connection, at multiple levels, and compassion which could potentially bring people together for action that may affect positive change.

Data availability statement

The datasets presented in this article are not readily available because the data set is confidential per the Institutional Review Board (IRB). Requests to access the datasets should be directed to JM, jocelyn_mcgee@baylor.edu.

Ethics statement

The studies involving humans were approved by the Baylor University IRB (Reference Number 1711129). The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study.

Author contributions

JM was the Principal Investigator for the study and oversaw all aspects of the study including contributed to conception and design of the study, organized the database, oversaw statistical analysis, wrote the first draft of the manuscript, and the final version of the manuscript. CK contributed to conception and design of the study, oversaw recruitment efforts, wrote a section of the first draft of the manuscript, and reviewed the final version of the manuscript. SB and RM wrote sections of the manuscript and reviewed the first and final draft of the manuscript. SW reviewed all drafts of the manuscript. All authors contributed to manuscript revision, read, and approved the submitted version.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Investigating the protective effects of mindfulness-based attention training on mind wandering in applied settings

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Introduction: Mind wandering, a phenomenon in which attention drifts away from the task-at-hand, is associated with deleterious effects on performance and well-being. As such, efforts to curb mind wandering are warranted. Recently, mindfulness training (MT) has been found to protect against mind wandering. Yet, many MT programs are at risk of falling off the *implementation cliff* due to challenges implementing these programs in applied settings. To mitigate against this, early-stage research in small convenience samples may be necessary to spur stakeholder engagement and collaboration. Herein, the effects of MT on mind wandering were examined via an internal meta-analysis of early-stage studies of a manualized, context-adaptable short-form MT program, referred to as Mindfulness-Based Attention Training (MBAT).

Methods: Five longitudinal studies (N = 304) were conducted in a variety of organizational cohorts. Self-reported mind wandering and meta-awareness, as well as accuracy (A') and response time variability (intra-individual coefficient of variation, ICV) during performance of the sustained attention to response task (SART) were assessed at baseline (T1) and 4 weeks later (T2) in MBAT and no-training participants.

Results: Standardized mean change (SMC) from T1 to T2 significantly differed between MBAT and no-training groups for mind wandering (ΔSMC = −0.387, $p < 0.001$), meta-awareness (ΔSMC = −0.374, $p < 0.001$), and ICV (ΔSMC = −0.376, $p = 0.043$), suggesting potential protective effects in self-reported and performance-based metrics of mind wandering.

Discussion: These results serve as preliminary proof-of-concept support for MBAT's protective effects on mind wandering. Further, they suggest that MBAT is amenable to implementation across a variety of applied and organizational settings and warrants additional research employing larger sample sizes in randomized controlled designs.

KEYWORDS

off-task thoughts, cognition, sustained attention, workplace, mind wandering

Introduction

Mind wandering is a pervasive phenomenon characterized by attentional instability wherein off-task thoughts occur during an ongoing task or activity. Herein, we focus on mind wandering during cognitive task performance. One laboratory-based cognitive task during which mind wandering has been readily assessed is the Sustained Attention to Response Task (SART; Robertson et al., 1997). During this task, self-reported mind wandering is assessed via embedded experience sampling probe questions that aim to capture mind wandering in the moment. Prior research has reliably linked greater subjective mind wandering with poorer task accuracy (e.g., Randall et al., 2014; Kane et al., 2016) and greater response time variability (Zanesco et al., 2020). Beyond laboratory settings, the occurrence of mind wandering has been associated with errors in everyday activities (Baldwin et al., 2017) and may be particularly consequential in applied workplace settings (Li, 2022). Given these detrimental effects, there has been growing interest in effective methods to promote greater attentional control over mind wandering.

One promising approach to reduce mind wandering is mindfulness training (MT; Feruglio et al., 2021; Turkelson and Mano, 2022). From a cognitive perspective, MT and related practices, are suggested to engage attentional skills involved in the regulation of mind wandering. For example, one category of MT practice—focused-attention practice—instructs practitioners to focus their attention on a specific target object (e.g., breath-related sensations), and to notice when their attention drifts away from this object to internal (i.e., thoughts) or external (e.g., a light flickering) distractions. When they catch themselves mind wandering, the practitioner is instructed to disengage from task-unrelated thought or other distractions and reorient attention back to the specific target object (see Lutz et al., 2015; Jha et al., 2019). With repeated engagement in MT and related practices, practitioners may strengthen processes (i.e., selective attention, monitoring, and disengagement) essential for noticing when the mind has wandered and redirecting attention back to the task-at-hand.

Prior studies involving intensive periods of MT, such as month-long retreats requiring full-time, daily mindfulness practice, report reduced mind wandering during performance on the SART (Witkin et al., 2022) and other tasks requiring sustained attention (e.g., Zanesco et al., 2016). In addition, mind wandering has been examined in studies involving mindfulness-based interventions (MBIs) such as 8-week programs frequently offered in healthcare settings (i.e., Mindfulness-Based Stress Reduction, MBSR; Kabat-Zinn, 1990; Giannandrea et al., 2019; and Mindfulness-Based Cognitive Therapy, MBCT; Teasdale et al., 2002; Greenberg et al., 2018), as well as shorter-form programs lasting 2 to 7 weeks (Mrazek et al., 2013; Levinson et al., 2014; Bennike et al., 2017). Across many of these studies, MT is found to be beneficial in reducing rates of mind wandering over the study interval.

Yet, in certain settings and cohorts, attentional control has been proposed to degrade over a few to several weeks, leading to greater mind wandering over the study interval. Recent studies in students tracked over the academic semester (e.g., Morrison et al., 2014), soldiers over pre-deployment training intervals (see Jha et al., 2020), and elite athletes engaged in intensive pre-season physical training (e.g., Rooks et al., 2017) report less mind wandering (e.g., Morrison et al., 2014; Rooks et al., 2017) over time in those receiving MT relative to comparison groups. Thus, in some settings, MT's salutary effects may be to curb putative increases in mind wandering over time.

Protecting against mind wandering is of interest across a variety of applied and organizational settings in which its occurrence may be particularly hazardous for performance. While MT-related benefits have been observed with gold standard programs, there may be barriers for implementation related to program time demands, framing, and trainer competencies. As such, more research evaluating the efficacy of shorter, tailored MT programs in applied workplace settings is warranted (see Grégoire and Lachance, 2015).

A prominent framework that is often used to guide MT program development is the NIH stage model of behavioral intervention research (Onken et al., 2014). This model is typically utilized for clinical intervention development. The stages progress from basic research (i.e., Stage 0) to intervention development (i.e., Stage 1), efficacy (i.e., Stages 2–3), and effectiveness studies (i.e., Stage 4) to then culminate in real-world intervention dissemination (i.e., Stage 5). One challenge in intervention development is that intervention delivery interfaces with real-world settings during *later implementation stages*, which may disadvantage engagement and collaboration with stakeholders, and ultimately limit intervention adoption and uptake (see Loucks et al., 2021). Interventions that suffer from poor translation from research into real-world settings are described as falling off the "implementation cliff." They suffer from low intervention uptake, as well as lower than predicted benefits as the intervention moves from research-controlled and monitored settings to real-world, community settings (Dimidjian and Segal, 2015; Griffith et al., 2021).

Herein, we describe a program of research investigating the effects of a specific MT intervention, Mindfulness-Based Attention Training (MBAT), on attentional performance and mind wandering. The overarching aim was to advantage MT implementation by interfacing with real-world, organizational cohorts in applied settings *earlier* in the stage progression of intervention development. While such an approach allows for greater initial engagement and collaboration with stakeholders to ensure contextual adaptation, there are acknowledged methodological tradeoffs with this emphasis. Sample sizes tend to be smaller in applied studies, and participants may be limited to convenience samples. In addition, experimental controls may be limited.

Mindfulness-based attention training

MBAT has benefitted from prior Stage 0 and Stage 1 research. Stage 0 aims to identify the *targets* for intervention development. From a clinical perspective, the intervention target could be a specific symptom in a patient population (e.g., ruminative thinking in depressed patients). From a cognitive perspective, the target could be specific cognitive vulnerabilities that may have deleterious consequences in specific applied settings (e.g., mind wandering in task contexts or settings that require sustained focus for optimal performance). Stage 1 involves creating and adapting the intervention with these targets in mind, and then conducting preliminary testing of the intervention. In line with this approach, short-form MT programs were developed by our research team to examine their impact on mind wandering and task performance in various cohorts (Morrison et al., 2014; Rooks et al., 2017; Denkova et al., 2018). Informed by these and other prior studies of MT (Jha et al., 2010,

TABLE 1 Overview of included study design and MBAT conditions.

Study	Community context	MBAT format	Study condition assignment
Study 1	Firefighters	One 2-h class per week over 4 weeks	Cluster randomized controlled trial
Study 2	Military spouses	One 2-h class per week over 4 weeks	Non-randomized controlled trial
Study 3	Employees at a large company	Two 1-h classes per week over 4 weeks	Non-randomized controlled trial
Study 4	Community leaders	Two 4-h classes, weekly office hours over 4 weeks	Non-randomized controlled trial
Study 5	Middle and high school teachers	One 2-h class per week over 4 weeks	Cluster randomized controlled trial

2017, 2022), MBAT was developed as a short-form, 4-week MT program that can be readily adapted for implementation in various applied and organizational settings.

Initial studies of MBAT have been conducted in military cohorts (Zanesco et al., 2019; Jha et al., 2020, 2022; Nassif et al., 2023). In addition, several studies of MBAT have been conducted in applied settings in civilian cohorts to date: including in firefighters, military spouses or relationship partners, corporate employees, community leaders, and educators. Studies varied in cohort-specific contextualization, randomization, and trainer type (embedded context-familiar or research affiliated trainers). While these are largely early-stage exploratory studies, they have the advantage of being contextualized and conducted in real-world, applied settings. In the present study, we conducted an internal meta-analysis of this body of research to determine if MBAT benefits attentional performance by taming mind wandering during ongoing task performance. The results of this meta-analysis will help determine whether further research with larger samples and rigorous randomized controlled trials is warranted.

Materials and methods

Five longitudinal studies conducted by our research group are included in this internal meta-analysis (see Goh et al., 2016, for a discussion of internal meta-analyses, and Vosgerau et al., 2019, for a critical perspective). Procedures for all five studies were approved by the Institutional Review Boards at the University of Miami, and all participants provided informed consent prior to enrollment. One study was registered on ClinicalTrials.gov (Study 2; NTC03308344).

Mindfulness-based attention training

Mindfulness-Based Attention Training (MBAT) is a manualized and structured program designed to allow for contextual adaptation within various time-pressured, applied settings. Prior studies have investigated MBAT delivery in military cohorts (Zanesco et al., 2019; Jha et al., 2020, 2022; Nassif et al., 2023). As described herein, the program has more recently been adapted for delivery in a variety of civilian settings (e.g., Denkova et al., 2020, 2021, 2022).

The MBAT course consists of 4, 2-h sessions delivered over 4 consecutive weeks, with 1 session per week. Each session introduces one of four central themes that progress in the following sequence: concentration, body awareness, receptivity, and connection. These themes are coupled with their four corresponding mindfulness exercises (focused attention, body scan, open monitoring, and connection practices, respectively). In addition, participants are asked to complete formal mindfulness exercises that correspond with the weekly course material as part of daily out-of-class individual mindfulness practice. After the first week of training, participants are instructed to alternate between the first week's mindfulness exercise (i.e., focused attention) and the corresponding week's newly introduced mindfulness exercise (e.g., Week 2: body scan). This modular and thematic structure is designed to maximize scheduling flexibility for course meetings, while maintaining content flow in applied, organizational settings. Delivery details are described in Table 1.

Beyond scheduling flexibility, MBAT is designed to enable context-specific adaptation of the program to ensure that the themes, examples, and trainer-led discussions are relevant for the professional and lifestyle demands and challenges that specific cohorts may face (see Jha et al., 2020 and Denkova et al., 2021 for detailed descriptions of MBAT contextualized for soldiers and military spouses, respectively). While maintaining MBAT's core mindfulness themes and practices, program materials are customized to incorporate context-relevant vernacular and examples. These adaptations are made in collaboration with community members, guided by the principles of community-based participatory research (Wallerstein and Duran, 2006). In addition, context-customization is achieved in the interactive program elements via MBAT's train-the-trainer (TTT) dissemination model. Specifically, after participating in an MBAT teaching practicum, context-familiar trainers guide sessions to ensure that interactive discussions, participant questions, and guidance on how to best apply the MBAT themes to their lifestyle or situational challenges, benefit from trainers' own embodied context familiarity (see Jha et al., 2020 for more details on the MBAT trainer practicum).

Studies summary

Three of the five studies included herein have been published previously, and details regarding study designs can be found in their respective publications. The other two studies are unpublished. Study design characteristics are described below and summarized in Table 1.

Study 1

One hundred and twenty-one firefighters in South Florida were assigned by their work schedule/shift to receive MBAT (MBAT group: $n = 42$; M age = 43.61, SD = 8.23 years; 7 females), relaxation training (RT group; $n = 31$; M age = 45.38, SD = 6.80 years; 6 females), or to a no-training control (NTC group; $n = 48$; M age = 43.12; SD = 8.30 years; 10 females). In this study, while program materials were adapted for firefighters via collaboration with a community member, MBAT was delivered in person by a research-affiliated trainer. Both MBAT and RT participants were assigned 10–15 min of formal MBAT practices

to be completed on a daily basis outside of class (see Denkova et al., 2020 for more details). This study used a cluster-randomized controlled design, in that assignment to MBAT, RT, or NTC was done according to the work shifts of firefighters per the requirements set by the Fire Department so that training and testing can be incorporated into participants' workday shift schedules.

Study 2

In the Fall of 2018, 48 spouses or partners of military services members were assigned to receive mindfulness training (MBAT group; $n = 48$; M age = 37.60, SD = 6.61 years, 2 males), and in the Summer of 2019, 58 military spouses were assigned to a no-training control group (NTC group; $n = 58$; M age = 30.96, SD = 8.38 years; all females). The MBAT program was delivered in person by a context-familiar, non-research affiliated trainer. During the 4-week training interval, MBAT participants were assigned 10–15 min of formal, out-of-class MBAT practices. This study used a non-randomized design with the primary goal to examine the feasibility of MBAT delivery by peers who previously received a teaching practicum (see Denkova et al., 2021 for more details).

Study 3

Ninety-five employees from a large company in South Florida participated in this study. Of the ninety-five, fifty employees volunteered to participate in MBAT at work (MBAT group; $n = 50$, M age = 37.62, SD = 10.67 years; 30 females), and the remaining forty-five employees served as a no-training control group (NTC group; $n = 45$; M age = 40.51, SD = 11.85 years; 37 females). MBAT was delivered in person by a context-familiar, non-research affiliated trainer who was a member of the organization. During the 4-week training interval, MBAT participants were assigned 15 min of formal, out-of-class MBAT practices. This study used a non-randomized design and had the primary goal of examining the efficacy of MBAT delivery by recently trained organizational trainers (see Denkova et al., 2022 for more details).

Study 4

Seventy-six community leaders from a small-yet-prominent city, coming from various sectors, such as business, healthcare, education, public safety, and non-profit organizations, participated in this study. Of the seventy-six, forty-one leaders volunteered to participate in MBAT (MBAT group; $n = 41$, M age = 50.59, SD = 12.72 years; 31 females). A few months later, thirty-five leaders served as a no-training control group (NTC group; $n = 35$; M age = 51.61, SD = 9.67 years; 30 females). In this study, participants engaged in 2, 4-h MBAT sessions over 2 days delivered in person by a research- affiliated trainer. In the following 4 weeks participants were assigned daily 15-min practice and offered the opportunity to attend "office hours" in which they could meet with the trainer via teleconference session to discuss their experiences and ask questions regarding course content and materials. MBAT themes were contextualized for the community leader environment. For example, the connection theme addressed adaptive and effective leadership, explored team cohesion, and the cultivation of kindness/connection practices involving the intention of kindness to be directed towards oneself, a fellow leader in the participant's occupational environment, and their organizational team as a whole. This study used a non-randomized design and had the primary goal of examining the efficacy of MBAT in community leaders.

Study 5

Using a cluster-randomized design, fifty-one educators from a co-educational school in South Florida were assigned by their work location (e.g., school campus) to receive mindfulness training (MBAT group; $n = 30$; M age = 48.03, SD = 8.98 years, 24 females), or to a no-training control group (NTC group; $n = 21$; M age = 41.95, SD = 10.68 years; 18 females). The NTC group received MBAT after the second testing session (T2). MBAT themes were contextualized by incorporating educational (i.e., classroom) terminology and cultural references, and examples relatable to those working within an educational setting. MBAT was also delivered in person by a research-affiliated trainer. Training group participants were assigned 10–15 min of daily MBAT practices to be completed outside of class sessions. In addition, training group participants were encouraged to incorporate informal practices offered each week into their daily lives.

Procedure

Participants in all five studies completed two testing sessions (T1 and T2) separated by a 4-week interval over which the training groups received the MBAT program, and no-training control groups did not. Studies 1, 2, and 5 employed in-person testing proctored by 1 or 2 experimenters in a group setting with up to 10 participants (see Denkova et al., 2020, 2021). In studies 3 and 4, participants engaged in remote testing sessions through Inquisit Web (Millisecond Software, LLC), which is an online platform that facilitates remote data collection for research purposes. During each testing session spanning approximately ninety minutes, participants were instructed to complete a battery of tests in one sitting. Participants were also instructed to complete testing in a quiet space where they could minimize possible distractions and interruptions. Further, Inquisit locks participants' computers from opening/accessing any other screens during the duration of testing, thus minimizing potential distractions and interruptions. All testing sessions included a variant of the SART with embedded probes indexing subjective probe-caught mind wandering and meta-awareness (Robertson et al., 1997), and a series of self-reported questionnaires related to psychological health and emotional well-being.

Measures

Sustained Attention to Response Task

The Sustained Attention to Response Task (SART, Robertson et al., 1997) is a go/no-go task that is typically used as a measure of sustained attention. During the SART, single digits (0 through 9) were presented for 250 ms, and each digit was followed by an inter-trial interval with a fixation cross for 900 ms (Figure 1). Participants were instructed to withhold pressing the spacebar in response to the digit 3 (target) and to press the spacebar for all other digits (non-targets) as quickly as possible without sacrificing accuracy. Responses were recorded during the digit display, as well as the inter-trial interval. Target trials occurred very infrequently on about 5% of the experimental trials.

On occasion, two probe questions were presented in succession and distributed throughout the task. Across studies, on average, there

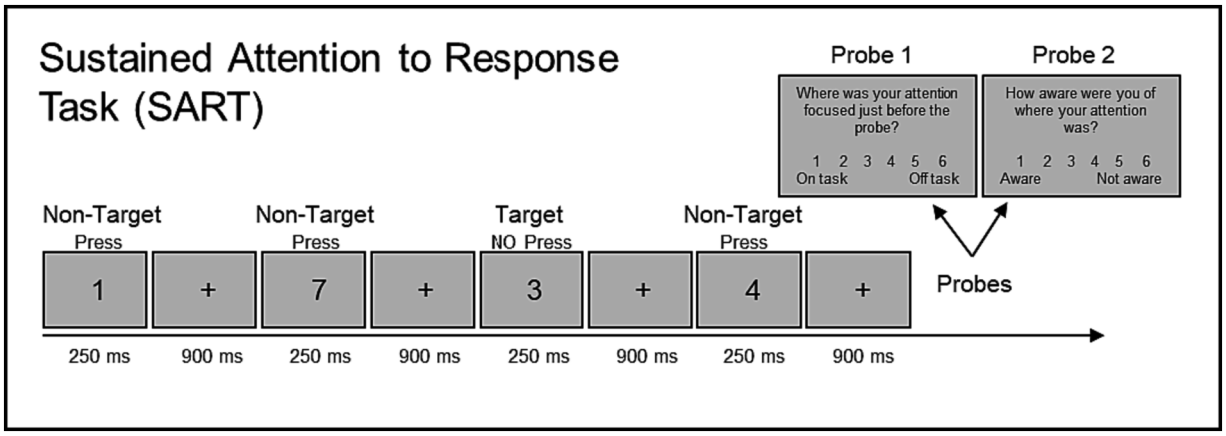

FIGURE 1
Demonstrates the design of the Sustained Attention to Response Task (SART). Single digits (0 through 9) were continuously presented on screen one at a time for 250 msec followed by an inter-trial-interval of 900 msec during which a fixation cross was presented. Participants were instructed to refrain from pressing the spacebar to the target number 3 (5% of trials) and to press the spacebar for all other non-target digits. Experience sampling probes intermittently interrupted task performance to ask participants to respond to two probe questions using a Likert-like 6-point scale.

were 20.9 trials between probes.[1] Participants were told that probe questions will occasionally ask about the focus of their attention. The first probe question (probe 1) asked, "Where was your attention focused just before the probe?" Participants were instructed to respond on a 6-point scale ranging from 1 (on task) to 6 (off task). Probe 1 is referred to as the Mind Wandering probe. The second probe question (probe 2) asked, "How aware were you of where your attention was?" Participants were instructed to respond on a 6-point scale ranging from 1 (aware) to 6 (unaware). Probe 2 is referred to as the Meta-Awareness probe. The probe questions were displayed until a response was made.

After the practice block, participants were instructed to complete two experimental blocks comprising target and nontarget trials and respond to probes presented in pseudorandom order. The specific number of trials and probes varied slightly across studies.[2] Task metrics included subjective probe responses and objective SART outcomes. Subjective probe responses were measured by separately calculating the mean of probe ratings for each probe question. Objective SART outcomes included task accuracy indexed by *A′* and variability in response time (RT). *A′* is a nonparametric measure of sensitivity (Stanislaw and Todorov, 1999), which yields a composite of hits (correctly withholding a response to target trials) and false alarms (incorrectly withholding a response to non-target trials). Variability in RT is indexed by the intra-individual coefficient of variation (ICV), which is calculated as the standard deviation of RTs for correct nontarget trials divided by the mean RT of correct non-target trials (i.e., for each participant: standard deviation RT/mean RT).

Statistical analysis

Data inclusion

Exclusion criteria for this meta-analysis were identical across all five contributing studies. While some of the prior published studies utilized an intent-to-treat approach for statistical analyses, including participants with missing data at one time point, we only included participants with complete data at both time points in the present meta-analyses because this facilitated the calculation of standardized effect sizes and aggregation of effects using meta-analysis methods. Of the 417 participants with T1 data in all five studies, 91 participants did not provide data at T2, and therefore, were not included in these analyses. An additional 22 participants were excluded from analyses due to problems with assessing their task performance because of a lack of adherence to task instructions or below chance performance ($A' < 0.5$) at T1 or T2. No other outliers were excluded from analyses. To allow for comparisons across studies, only participants in the MBAT and no-training conditions were included in analyses, and those in active comparison conditions (i.e., relaxation training, Study 1) were excluded. There was slight variability in rates of missing data across studies. Table 2 provides final reported sample sizes and descriptive statistics for dependent measures for each study.

Meta-analytic procedures

Measures of standardized effect size were calculated using the package *metafor* in R (Viechtbauer, 2010) from summary descriptive statistics for each of the five studies (see Table 2). First, the standardized mean change (SMC) from T1 to T2 for each condition (MBAT and NTC groups) was calculated for each of the five studies. A negative SMC reflects an attenuation in task accuracy (*A'*), reduced response time variability (ICV), a decrease in self-reported mind wandering, and greater meta-awareness of one's off-task thoughts

1 In studies 1, 2, and 5, probes were separated by 19.5 trials on average, *SD* =9.72, range=4–37. In studies 3 and 4, probes were separated by 23 trials on average, *SD* =14.46, range=7–76.

2 Experimental blocks comprised a total of either 519 (Studies 1, 2 and 5) or 635 (Studies 3 and 4) non-target trials, either 27 (Studies 1, 2, and 5) or 32 (Studies 3 and 4) target trials, and either 28 (Studies 1, 2, and 5) or 32 (Studies 3 and 4) sets of probes. The numbers of non-target and target trials and sets of probes are slightly different due to the switch in software platform from E-Prime 3.0 (Psychology Software Tools, Pittsburgh, PA) in Studies 1, 2, and 5 to Inquisit (Millisecond Software, LLC) in Studies 3 and 4.

TABLE 2 Descriptive statistics.

		Probe 1					Probe 2					A′					ICV				
		T1		T2			T1		T2			T1		T2			T1		T2		
Condition	*N*	Mean (SD)		Mean (SD)		*r*	Mean (SD)		Mean (SD)		*r*	Mean (SD)		Mean (SD)		*r*	Mean (SD)		Mean (SD)		*r*
Study 1																					
MBAT	34	1.62	(1.01)	1.51	(0.67)	0.324	1.76	(1.15)	1.67	(1.01)	0.600	0.90	(0.05)	0.90	(0.07)	0.426	0.29	(0.09)	0.29	(0.11)	0.453
NTC	42	1.60	(0.64)	1.68	(0.79)	0.738	1.61	(0.61)	1.76	(0.89)	0.617	0.89	(0.06)	0.90	(0.06)	0.473	0.29	(0.09)	0.27	(0.12)	0.640
Study 2																					
MBAT	40	1.78	(0.59)	1.73	(0.63)	0.788	1.79	(0.67)	1.68	(0.67)	0.501	0.89	(0.06)	0.90	(0.06)	0.526	0.26	(0.10)	0.25	(0.09)	0.661
NTC	41	1.63	(0.55)	1.84	(0.62)	0.536	1.61	(0.57)	1.77	(0.68)	0.654	0.86	(0.11)	0.87	(0.10)	0.577	0.30	(0.10)	0.33	(0.21)	0.455
Study 3																					
MBAT	29	1.56	(0.56)	1.56	(0.50)	0.360	1.49	(0.50)	1.52	(0.51)	0.588	0.88	(0.06)	0.92	(0.06)	0.588	0.28	(0.08)	0.21	(0.06)	0.465
NTC	18	1.76	(0.66)	2.14	(0.82)	0.760	1.63	(0.55)	1.86	(0.55)	0.602	0.87	(0.07)	0.88	(0.09)	0.709	0.26	(0.09)	0.27	(0.08)	0.606
Study 4																					
MBAT	29	1.90	(0.49)	1.77	(0.49)	0.600	1.88	(0.64)	1.69	(0.70)	0.784	0.90	(0.06)	0.93	(0.05)	0.553	0.24	(0.07)	0.25	(0.06)	0.670
NTC	26	1.84	(0.78)	2.03	(0.73)	0.620	1.85	(0.95)	2.03	(0.91)	0.774	0.90	(0.07)	0.92	(0.09)	0.715	0.24	(0.12)	0.22	(0.11)	0.895
Study 5																					
MBAT	25	1.67	(0.52)	1.61	(0.56)	0.543	1.47	(0.44)	1.50	(0.49)	0.607	0.91	(0.07)	0.92	(0.07)	0.661	0.27	(0.07)	0.25	(0.09)	0.443
NTC	20	1.98	(0.73)	2.05	(0.99)	0.593	1.88	(0.82)	2.07	(1.02)	0.499	0.88	(0.07)	0.90	(0.06)	0.098	0.30	(0.09)	0.30	(0.08)	0.234

Descriptive statistics are provided for all participants with complete data at both study time points including sample size (*N*), means, standard deviations, and bivariate correlations.

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from T1 to T2. Conversely, a positive SMC reflects improvement in task accuracy (*A'*), an increase in response time variability (ICV), an increase in mind wandering, and a decreased awareness of one's mind wandering from T1 to T2.

SMC values for each dependent measure were aggregated across the five studies in a multivariate mixed effects meta-analysis, which calculated a conditional weighted SMC for MBAT and NTC groups. Group effects were nested within their corresponding study, and study condition (MBAT vs. NTC) was included as a moderator variable to estimate the separate effects for MBAT and NTC groups. The model employed maximum likelihood estimation, and model effects were weighted according to the inverse variance.

To obtain the meta-analytic effect of MBAT on SART outcomes, a standardized effect size was calculated that reflects the difference (Δ) between MBAT and NTC groups' SMC from T1 to T2. An overall weighted ΔSMC was estimated across studies with a random effects model estimated using restricted maximum likelihood with weighting based on the inverse variance. The 95% prediction interval (95% PI) around the SMC and ΔSMC were also calculated, which reflects the range of expected effects observed from future studies. Finally, to measure the proportion of variance in the model explained by heterogeneity among the included studies, I^2 and Cochran's Q were calculated (Higgins et al., 2003). In addition, funnel plots were reviewed to evaluate the symmetry of effects, as well as the statistical power of each study to detect the meta-analytic effect.

Results

The meta-analysis of the five included studies ($N = 304$) identified a significant difference (ΔSMC) between MBAT and NTC groups over time (i.e., from T1 to T2) for mind wandering, meta-awareness, and ICV, but did not reveal a significant difference for *A'*. Descriptive statistics for each study may be found in Table 2. The results of the meta-analysis are described below.

Mind wandering

In a fixed effects meta-analysis of Probe 1, which measured the average self-reported mind wandering (probes rated "on-task" to "off-task"), the conditional SMC for MBAT groups did not significantly differ from zero (SMC = −0.113, $p = 0.108$, 95% CI [−0.251, 0.025], 95% PI [0.097, 0.389]). The 95% confidence interval around this effect overlapped with a small effect size (−0.251 to 0.025). In contrast, the SMC for NTC groups was significantly different from zero (SMC = 0.243, $p < 0.001$, 95% CI [0.105, 0.381], 95% PI [−0.251, 0.250]), indicating a small increase in subjective mind wandering over time. Figure 2A illustrates the SMCs for each study, as well as the mixed effects weighted estimates for MBAT and NTC groups.

Random effects meta-analysis of the difference between MBAT and NTC groups in standardized mean change (ΔSMC) was significant (ΔSMC = −0.387, $p < 0.001$, 95% CI [−0.594, −0.181], 95% PI [−0.594, 0.181]). [3] Together, these results indicate that MBAT was associated with a −0.387 ΔSMC between MBAT and NTC groups, which suggests that, over time, while participants in the NTC group increased in their mind wandering, participants in the MBAT group were protected against such increases. These patterns of change-over-time in mind wandering were small to medium in size.

Figure 2B depicts the ΔSMCs of each study, as well as the random effects weighted estimates for Mind Wandering scores among MBAT and NTC groups. Evaluation of I^2 and the Q statistic suggested that studies were largely homogenous in their magnitude of effects ($I^2 < 1\%$, $Q = 1.565$, $p = 0.815$). A funnel plot illustrating the ΔSMCs across all studies for mind wandering is depicted in Figure 3A. Based on this plot, studies appear generally symmetrically distributed around the meta-analytic effect size (ΔSMC = −0.387). The funnel plot also depicts the statistical power of each study to detect the meta-analytic effect. The median power of studies was 35.6%, suggesting that studies were largely underpowered to detect an effect size of this magnitude.

Meta-awareness

In a fixed effects meta-analysis of Probe 2, which measured awareness of subjective mind wandering (probes rated "completely aware" to "completely unaware"), the conditional SMC for MBAT did not significantly differ from zero (SMC = −0.118, $p = 0.096$, 95% CI [−0.256, 0.021], 95% PI [−0.256, 0.021]). The 95% confidence interval around this effect overlapped with small effect sizes (−0.256 to 0.021). In contrast, the SMC for NTC groups was significantly different from zero (SMC = 0.249, $p < 0.001$, 95% CI [0.112, 0.386], 95% PI [0.112 to 0.386]), indicating a small decrease in awareness over time. Figure 4A illustrates the SMCs for each study, as well as the mixed effects weighted estimates for MBAT and NTC groups.

Random effects meta-analysis of the difference between MBAT and NTC groups in standardized mean change (ΔSMC) was significant (ΔSMC = −0.374, $p < 0.001$, 95% CI [−0.571, −0.177], 95% PI [−0.571 to −0.177]).[4] These results indicate that MBAT and NTC groups had a small difference in their standardized mean change over time (ΔSMC = −0.374), suggesting that participants in the MBAT group had significantly different patterns of change over time compared to the NTC group. While the NTC group declined in their meta-awareness over time, participants in the MBAT group did not demonstrate significant reductions. These patterns of change-over-time in meta-awareness were small to medium in size.

Figure 4B depicts the ΔSMCs of each study, as well as the random effects weighted estimates for Meta-Awareness scores among MBAT and NTC groups. Evaluation of I^2 and the Q statistic suggested that studies were largely homogenous in their magnitude of effects ($I^2 < 1\%$, $Q = 1.050$, $p = 0.902$). A funnel plot illustrating the ΔSMCs for meta-awareness across all studies is depicted in Figure 3B. Based on this plot, studies appear roughly symmetrically distributed around the meta-analytic effect size (ΔSMC = −0.374). The funnel plot also depicts the statistical power of each study to detect the meta-analytic effect. The median power of studies was 43.7%, suggesting that studies were generally underpowered to detect an effect size of this magnitude.

3 The difference (Δ) in unstandardized mean change in mind wandering was also significant (ΔMC = -0.266, $p<0.001$).

4 The difference (Δ) in unstandardized mean change in meta-awareness was also significant (ΔMC = −0.264, $p<0.001$).

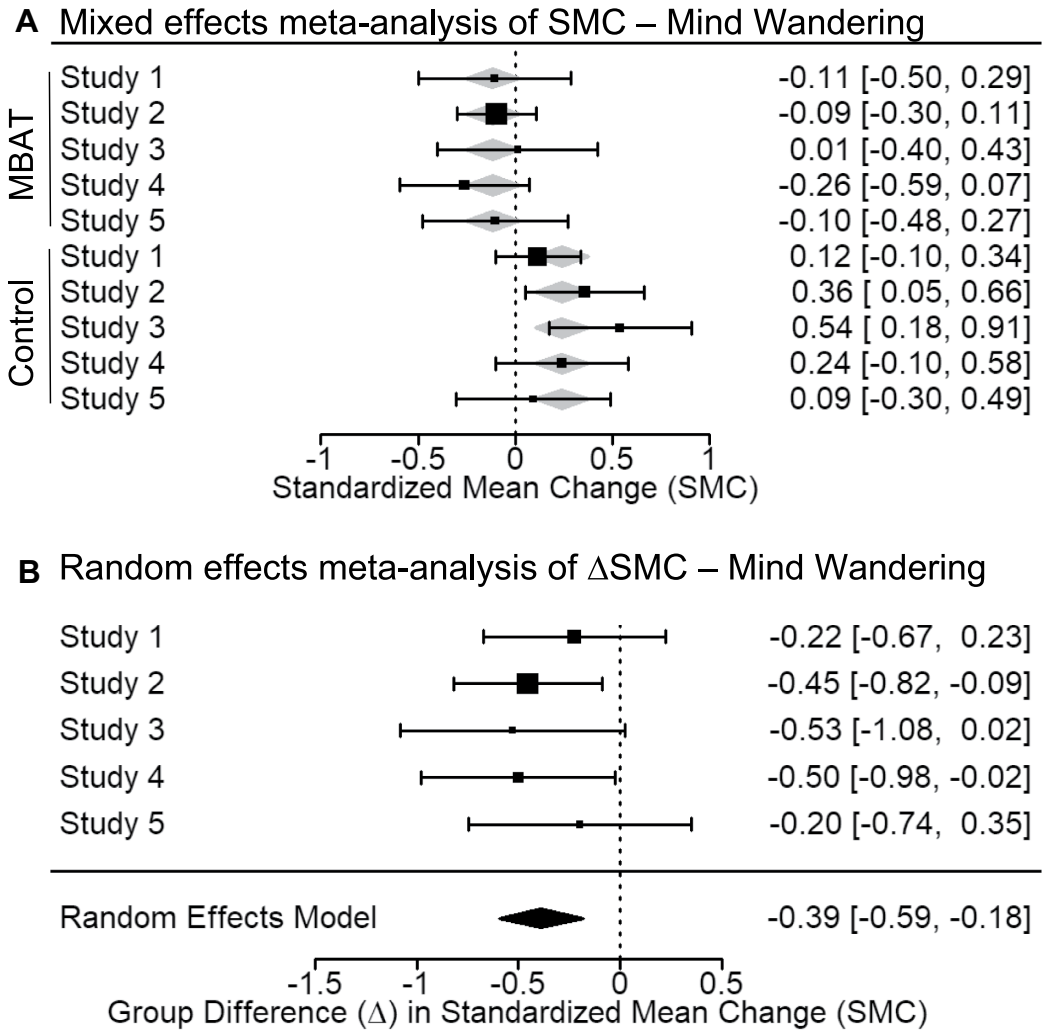

FIGURE 2
(A) Depicts the multivariate mixed effects meta-analysis of standardized mean change (SMC) from T1 to T2 in probe-caught mind wandering scores for MBAT and control conditions. Negative SMCs indicate that individuals mind wander less frequently from T1 to T2 with meta-analytic effect sizes and 95% confidence intervals shown as black boxes and error bars. **(B)** Depicts the difference in standardized mean change between MBAT and control groups (ΔSMC) in probe-caught mind wandering scores. A negative ΔSMC indicates greater decreases in mind wandering scores from T1 to T2 in MBAT groups relative to control groups. Based on the random effects model, the overall meta-analytic effect size and 95% confidence interval is provided below the individual study estimates.

Intra-individual coefficient of response time variability (ICV)

In a fixed effects meta-analysis of ICV, which measured response time variability, the conditional SMC for MBAT significantly differed from zero (SMC = −0.386, $p < 0.01$, 95% CI [−0.642, −0.130], 95% PI [−0.900 to 0.128]). The 95% confidence interval around this effect overlapped with small to medium effect sizes (−0.642 to −0.130), indicating an overall decrease in ICV over time. The SMC for NTC groups was not significantly different from zero (SMC = −0.051, $p = 0.587$, 95% CI [−0.236, 0.133], 95% PI [−0.375 to 0.272]). Figure 5A illustrates the SMCs for each study, as well as the mixed effects weighted estimates for MBAT and NTC groups.

Random effects meta-analysis of the difference between MBAT and NTC groups in the standardized mean change for ICV was significant (ΔSMC = −0.376, $p = 0.043$, 95% CI [−0.741, −0.011], 95% PI [−1.117 to 0.365]).[5] Together, these results indicate that MBAT and NTC groups had a small difference in their standardized mean change over time (ΔSMC = −0.376), suggesting that participants in the MBAT group had significantly different patterns of change compared to the NTC group. While participants in the MBAT group had reduced ICV, those in the NTC group increased

5 The difference (Δ) in raw mean change in ICV (response time variability) was not significant (ΔMC = −0.029, $p = 0.085$).

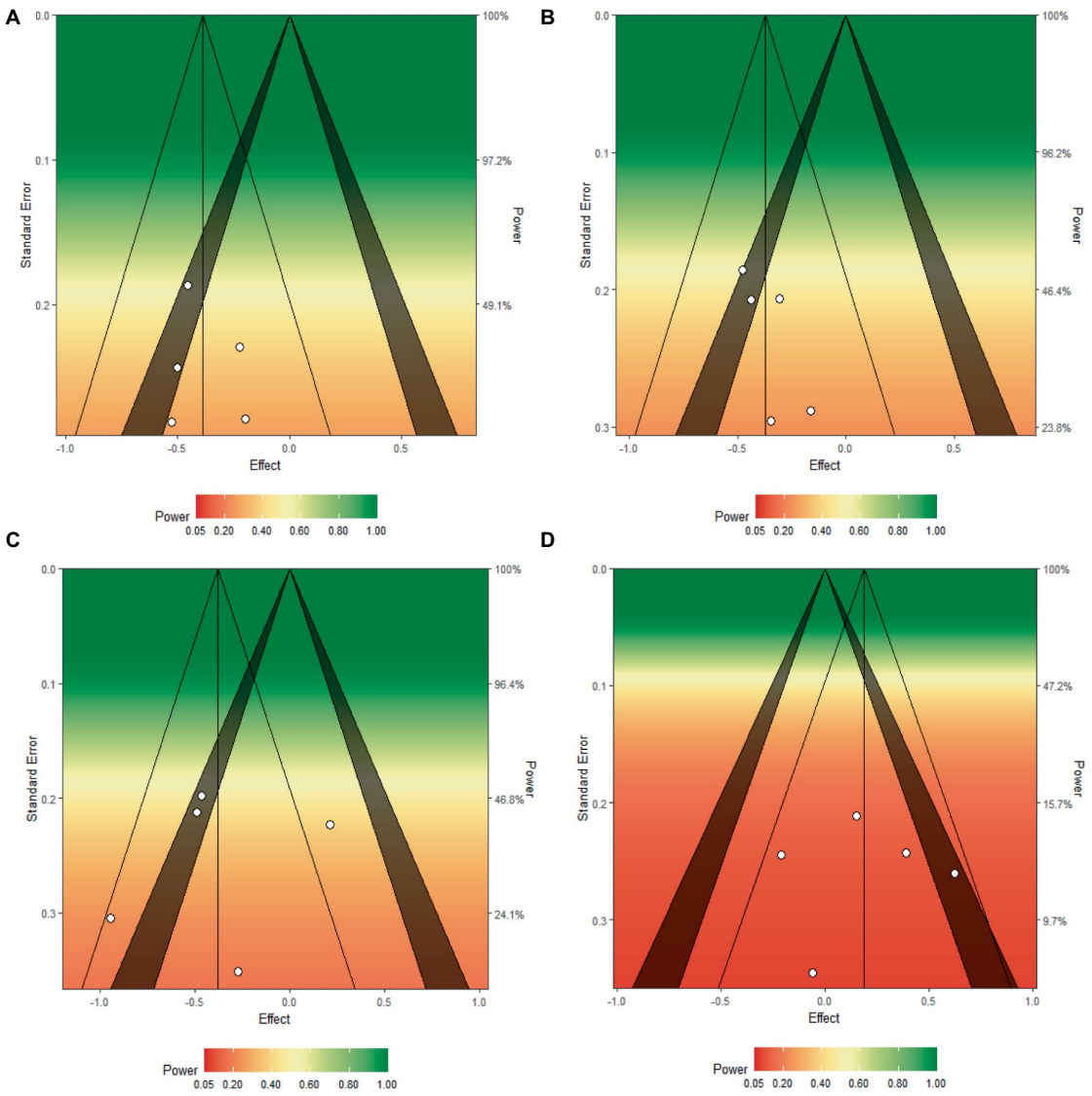

FIGURE 3
Funnel plots of the group difference in standard mean change (ΔSMC) for **(A)** mind wandering, **(B)** meta-awareness, **(C)** ICV, and **(D)** *A′*. ΔSMCs for each study are depicted as white dots and are plotted by the standard error from each respective study. The color gradient represents the overall statistical power of the meta-analytic effect from red (low power) to green (high power). The vertical line that bisects the triangle depicts the meta-analytic effect size for each of the outcomes. Estimates in the shaded region fall within the 5 to 1% significance level from zero.

over time. These patterns of change-over-time in ICV were small to medium in size.

Figure 5B depicts the ΔSMCs of each study, as well as the random effects weighted estimates for ICV scores among MBAT and NTC groups. Evaluation of the I^2 and the Q statistic suggested that, for ICV, studies were moderately heterogeneous in their magnitude of effects ($I^2 = 64.36\%$, $Q = 10.981$, $p = 0.027$). A funnel plot of results (Figure 3C) illustrates that included studies are slightly symmetrically distributed around the meta-analytic effect size (ΔSMC = −0.376). The funnel plot also depicts the statistical power of each study to detect the meta-analytic effect. The median power of studies was 39.1%, indicating that studies were largely underpowered to detect an effect size of this magnitude.

Accuracy (*A′*)

In a fixed effects meta-analysis of *A′*, measuring task accuracy, the conditional SMC for MBAT significantly differed from zero (SMC = 0.309, $p = 0.003$ 95% CI [0.108, 0.510], 95% PI [−0.042 to 0.660]). The 95% confidence interval around this effect overlapped with small to medium effect sizes (0.108 to 0.510), indicating a small increase in accuracy over time. In contrast, the SMC for NTC groups did not significantly differ from zero (SMC = 0.131 $p = 0.087$, 95% CI [−0.019, 0.282], 95% PI [−0.027 to 0.289]). Figure 6A illustrates the SMCs for each study, as well as the mixed effects weighted estimates for MBAT and NTC groups.

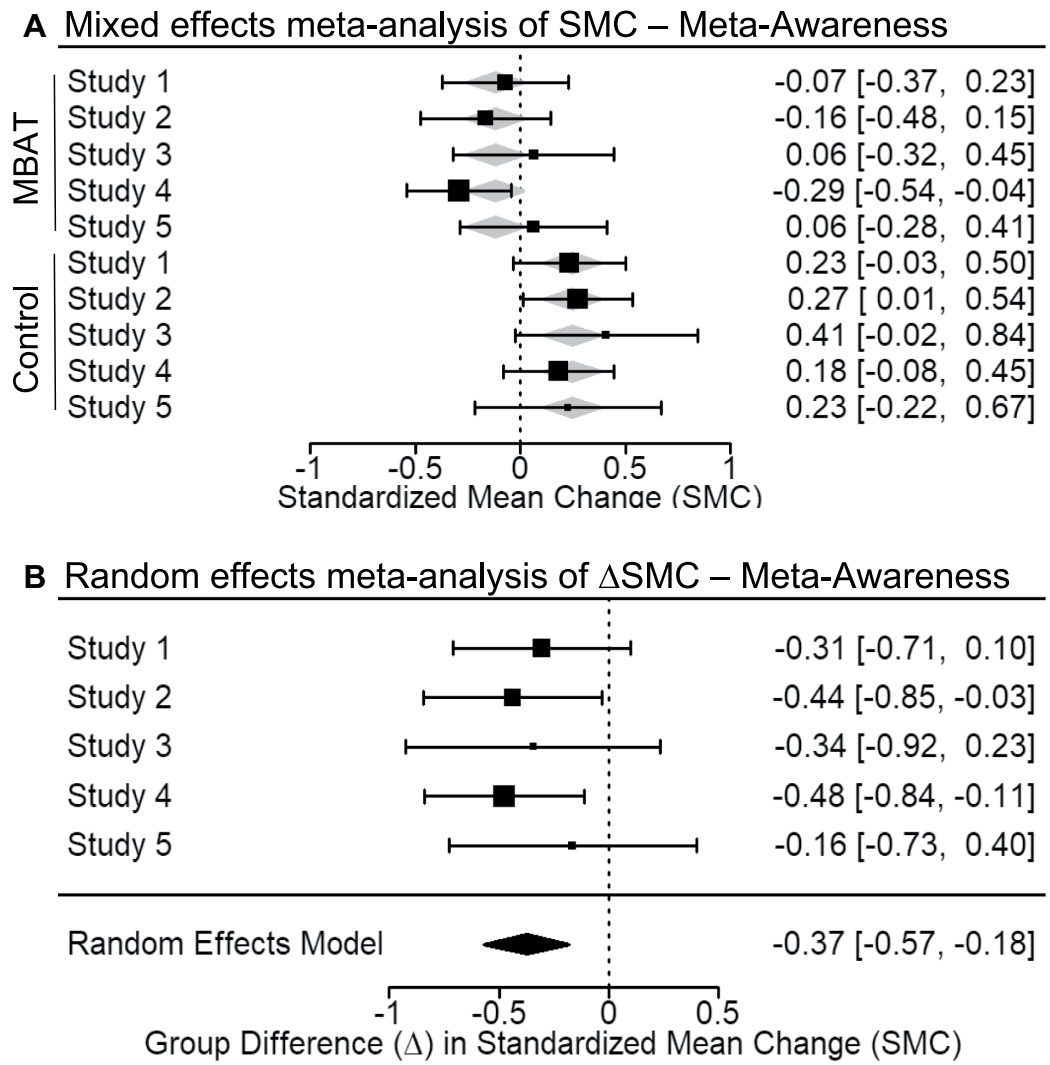

FIGURE 4
(A) Depicts the multivariate mixed effects meta-analysis of standardized mean change (SMC) from T1 to T2 in probe-caught meta-awareness scores for MBAT and control conditions. Negative SMCs indicate that individuals are more aware from T1 to T2 with meta-analytic effect sizes and 95% confidence intervals shown as black boxes and error bars. **(B)** Depicts the difference in standardized mean change between MBAT and control groups (ΔSMC) in meta-awareness scores. A negative ΔSMC indicates greater increases in awareness from T1 to T2 in MBAT groups relative to control groups. Based on the random effects model, the overall meta-analytic effect size and 95% confidence interval is provided below the individual study estimates.

Random effects meta-analysis of the difference between MBAT and NTC groups in the standardized mean change for *A′* was non-significant (ΔSMC = 0.189, $p = 0.202$, 95% CI [−0.101, 0.479], 95% PI [−0.315 to 0.693]).[6] Together, these results suggest that, across studies, MBAT and NTC groups did not differ in their standardized mean change over time (ΔSMC = 0.189).

Figure 6B depicts the ΔSMCs of each study, as well as the random effects weighted estimates for *A′* scores among MBAT and NTC groups. Evaluation of the I^2 and the *Q* statistic suggested that, for *A′*, studies were somewhat heterogeneous in their magnitude of effects ($I^2 = 40.71\%$, $Q = 6.706$, $p = 0.152$). A funnel plot of results suggests that included studies are slightly symmetrically distributed around the meta-analytic effect size (ΔSMC = 0.189), and the median power of studies was 12.1%, indicating that studies were largely underpowered to detect an effect size of this magnitude (see Figure 3D).

Discussion

We investigated the effects of a short-form MT program on self-reported mind wandering and meta-awareness, as well as objective performance during performance of a sustained attention task. An internal meta-analysis was conducted across five studies. Small-yet-significant differences between groups in standardized mean change (ΔSMC) from pre- to post-training were found for mind wandering and meta-awareness. Specifically, while the no-training groups

6 The difference (Δ) in raw mean change in *A′* (task accuracy) was not significant (ΔMC = 0.0103, $p = 0.248$).

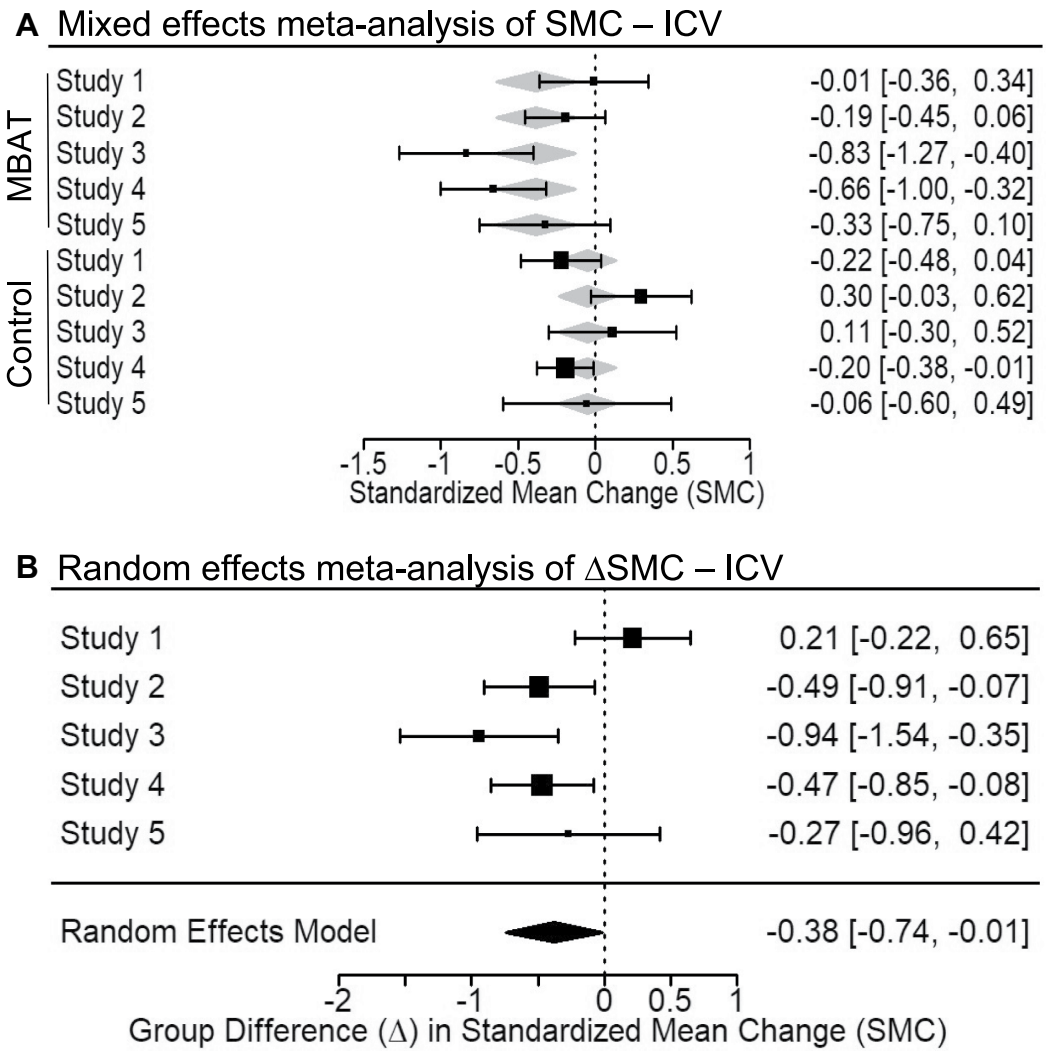

FIGURE 5
(A) Depicts the multivariate mixed effects meta-analysis of standardized mean change (SMC) from T1 to T2 in response time variability (ICV) for MBAT and control conditions. Negative SMCs indicate a decrease in ICV from T1 to T2 with meta-analytic effect sizes and 95% confidence intervals shown as black boxes and error bars. **(B)** Depicts the difference in standardized mean change between MBAT and control groups (ΔSMC) in ICV. A negative ΔSMC indicates greater reduction in ICV from T1 to T2 in MBAT groups relative to control groups. Based on the random effects model, the overall meta-analytic effect size and 95% confidence interval is provided below the individual study estimates.

showed increases in mind wandering and reductions in meta-awareness over time (i.e., T1 to T2), those who received MBAT did not change over time in mind wandering or meta-awareness. These findings suggest that compared to the no-training groups, MBAT groups demonstrated functional stability which can be interpreted as a protection against increase in self-reported mind wandering and decrease in meta-awareness (see Jha et al., 2017).

In addition to the protective effects on mind wandering, our findings revealed greater attentional stability, as reflected in less variable response time variability over time in the MBAT groups. Indeed, while the no-training control participants did not significantly change in their response time variability during the SART from T1 to T2, the MBAT participants had reduced response time variability from T1 to T2 (SMC = −0.386). This is consistent with findings from several studies of MT that have reported reductions in response time variability during tasks of sustained attention following training (e.g., van den Hurk et al., 2010; Mrazek et al., 2012; Zanesco et al., 2013; Morrison et al., 2014). While the effects for ICV were small, the confidence intervals around this effect were large.

While we observed significant group differences in change-over-time in mind wandering, meta-awareness, and ICV, we did not observe such effects in SART *A'* scores. Significant changes in *A'* from T1 to T2 for the MBAT condition (SMC = 0.309) were observed. However, the magnitude of this change did not significantly differ from the change-over-time found in the NTC group.

As is often the case with early-stage intervention studies, sample sizes were small. Analyses of statistical power indicated that overall, the five studies analyzed herein were underpowered relative to reported effect sizes. The median power of studies contributing to *A'* was 12.1%, while the median power of studies contributing to mind

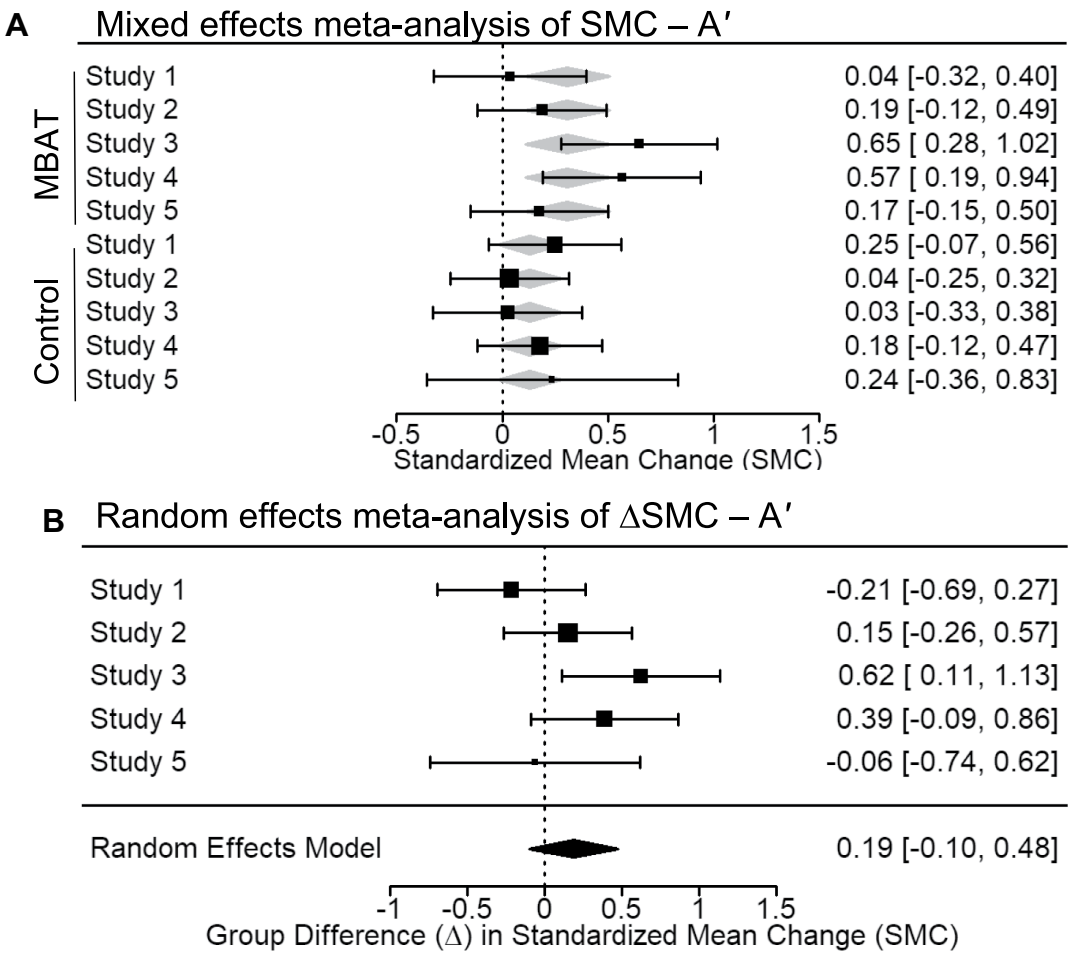

FIGURE 6
(A) Depicts the multivariate mixed effects meta-analysis of standardized mean change (SMC) from T1 to T2 in *A′* for MBAT and control conditions. Positive SMCs indicate an increase in *A′* from T1 to T2 with meta-analytic effect sizes and 95% confidence intervals shown as black boxes and error bars. **(B)** Depicts the difference in standardized mean change between MBAT and control groups (ΔSMC) in *A′*. A positive ΔSMC indicates greater increase in *A′* from T1 to T2 in MBAT groups relative to control groups. Based on the random effects model, the overall meta-analytic effect size and 95% confidence interval is provided below the individual study estimates.

wandering, meta-awareness, and ICV was 35.6, 43.7, and 39.1%, respectively. Our meta-analytic approach aims to address the small sample size of individual studies by aggregating effects across studies and increasing our statistical power to detect differences between MBAT and control groups.

By protecting against increases in mind wandering, MBAT may be a useful tool for reducing errors in time-pressured, applied contexts. In addition, as suggested in recent studies, these changes may mediate improvements in other psychological outcomes. A growing literature suggests that mind wandering may be implicated in fluctuating affective states (Andrews-Hanna et al., 2013; Mason et al., 2013), and mind wandering has gained utility as a marker for depressive thinking (Smallwood et al., 2007), rumination (Marchetti et al., 2016), worsened mood (Song and Wang, 2012), and symptoms of stress (Seli et al., 2019), which have all been shown to predict the onset of psychological disorders. As such, protecting against increases in mind wandering may also protect against psychological health challenges.

It is important to mention that the present study defined and operationalized mind wandering in the context of an ongoing task when its occurrence hinders task performance, as revealed in several studies and recent meta-analyses on this topic (see Randall et al., 2014; Bonifacci et al., 2023). In contrast, other studies have defined and operationalized mind wandering in a task-free context resulting in phenomena such as daydreaming, creative thinking, and other aspects of spontaneous thought (e.g., Christoff et al., 2016), which may have positive impacts (Gericke et al., 2022). While there is active research examining the boundary conditions under which mind wandering and affiliated forms of spontaneous thought may have deleterious vs. salutary effects (see Mooneyham and Schooler, 2013; Zeitlen et al., 2022), there is far less debate regarding the costs of mind wandering when it competes with task performance in real world organizational settings (see Thomson et al., 2014).

While study results favor the view that continued investigation of MBAT via larger-scale designs is warranted, there are a number of

limitations that should be considered. First, three of the five studies included herein used non-randomized designs. While the studies were aimed at examining MBAT's early-stage 'proof-of-concept' feasible delivery and efficacy, it will be critical for future studies to randomly assign participants. In addition, they should make use of active control interventions, such as alternate forms of training already being implemented in the participant setting. Indeed, in many applied contexts, professionals are provided workplace interventions aimed at bolstering their wellness and work performance. Thus, it is critical that future research directly compares the effects of MBAT to such extant, active control interventions via random assignment.

Second, while we inquired whether participants had prior experience with MT, their prior experience was not accounted for in the study analyses. Given that prior meditation experience has previously been found to affect the frequency with which one experiences mind wandering episodes, this variable may reflect a potential confound (Brandmeyer and Delorme, 2018), and should be controlled for in future investigations of short-form MT. Similarly, although we attempted to assess out-of-class mindfulness practice in several of our studies, we did not investigate individual differences in mindfulness practice (see Jha et al., 2010) in the present meta-analysis. Finally, some researchers have suggested the need for caution in the use of internal meta-analyses. Indeed, while internal meta-analyses provide a powerful method to increase statistical power by aggregating results across a line of related studies, they also provide an opportunity for analytic flexibility that can result in an increased probability of detecting false positive outcomes (Vosgerau et al., 2019). We attempted to mitigate this concern by including all our relevant, available studies of MBAT in civilian, applied settings regardless of whether those studies demonstrated significant benefits in the mindfulness intervention group, including data from several unpublished studies. The aim of our internal meta-analysis was to aggregate extant studies of MBAT in these civilian applied and organizational settings in order to evaluate the overall effects of the program and motivate further research in this domain. We acknowledge that some of our outcomes may reflect false positives, and the true effect size associated with the intervention may be smaller in magnitude than observed in our meta-analysis.

In sum, the current results suggest that MBAT may hold promise as a cognitive training tool. It may protect against increases in mind wandering, while increasing attentional stability in applied and organizational settings and should be investigated further. Going forward, studies of MBAT should ensure random assignment, formally consider participants' previous mindfulness experience, recruit larger samples, and assign well-matched active control groups. Nonetheless, the present study highlights the potential value of early-stage research with small convenience samples to spur stakeholder engagement and collaboration prior to conducting larger-scale studies. Applied research is disadvantaged by the all too common "file drawer" phenomenon of withholding reporting of studies that fail to meet the gold standard because they entail convenience samples and non-random assignment to group. Reporting early-stage research while fully acknowledging design limitations, helps to advance intervention-based applied research and ultimately supports interventions to be better positioned to achieve the "highest level of potency" (Onken et al., 2014) and avoid the fate of the implementation cliff.

Data availability statement

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author.

Ethics statement

The studies involving humans were approved by Institutional Review Boards at the University of Miami. The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study.

Author contributions

APJ conceived of and designed the experiments. APJ and SLR conceived of and developed the MBAT mindfulness intervention. SLR supported implementation and delivery of the MBAT mindfulness intervention. APJ, APZ, ED, and JB oversaw all aspects of data collection. MMP, APZ, APJ, and ED contributed to different stages of data analyses. All authors contributed to the article and approved the submitted version.

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Conflict of interest

APJ and SLR are co-developers and copyright holders of the Mindfulness-Based Attention Training (MBAT) program materials.

The remaining authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

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The phenomenology of attentional control: a first-person approach to contemplative science and the issue of free will

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There are two basic aspects of attentional control. The ability to *direct attention* toward different objects is typically experienced as a fundamental indicator of attentional freedom. One can control what one attends to and directing attention is a relatively simple task. In contrast, *sustaining attention* on a chosen object proves to be difficult as mind-wandering seems to be inevitable. Does the problem of sustaining attention, mean that we are fundamentally unfree? We discuss this issue in light of an introspective study of directing and sustaining attention, looking specifically into the question of whether it is possible to experience the source of attention, i.e., the subject enacting freedom through attention. The study involved six persons performing different attention tasks over the course of about a month. Common experiences and contrasting reports are presented. This forms the basis for a discussion of the method of introspection and in particular of how to approach conflicting reports.

KEYWORDS

attention, freedom, first-person perspective, introspection, contemplative science

1 The theory, practice and challenges of introspective research in relation to freedom and attention

We will begin by considering the idea of introspective research and how it can be used to investigate freedom and attention. Section 1.1 below gives an overview over the idea of introspective research and some problems it faces. A strong and weak conception of introspection is introduced, representing a high and low degree of certainty, respectively. Both conceptions are problematic and it is suggested that the key challenge for introspective research is to develop methods that yield a moderate degree of certainty. Section 1.2 presents the problem of free will and asks: How can introspective research be made use of to inform the discussion of free will? Directing and sustain attention is brought in relation to the issue of freedom and the question of the source of attention, i.e., who or what is the source of attentional control.

1.1 The idea of introspective research

First person methods, such as introspection (Weger and Wagemann, 2015a), phenomenology (Giorgi, 2009), and descriptive psychology (Brentano, 1982), are typically approached with a certain skepticism with regards to their status as viable forms of scientific inquiry. More or less a century has passed since the early attempts at creating a foundation of introspection (Beenfeldt, 2013) and phenomenology (Farber, 2006) as scientific disciplines. Despite numerous attempts (Giorgi, 2009), no specific first person methodology has been commonly recognized to have the necessary rigor to become part of the standard repertoire of scientific methods. However, what often goes unnoticed, and what proponents of first person methods tend to point out, is that many scientific disciplines rely on accurate first person accounts. For instance, the correlation between physiological processes and subjective experiences not only depends on accurate physical measurements, but also on the person having those experiences being able to report accurately on them. All forms of inquiry involving first person experiences will therefore depend on the rigor of the methods used to investigate such experiences. Current studies that make use of naïve first person reports may, for instance, overlook ambiguities inherent in lived experience or inaccurate reports may be used to support specific hypotheses that could have been challenged by the reports of subjects who have undergone introspective training. The case of the rubber hand illusion is an example of the former (Valenzuela Moguillansky et al., 2013) the Libet-experiment is a good example of the latter (Jo et al., 2015). Furthermore, introspective training such as meditation is known to increase the accuracy of reports (Fox et al., 2012).

In other words, the general lack of rigorous first-person methods can be seen as a fundamental challenge to the whole field of psychology and neighboring disciplines such as contemplative science that either implicitly or explicitly rely heavily on first person accounts. In the context of this article, we understand contemplative science as a combination of first-person and third-person approaches when systematically investigating what the mind experiences through meditative practice (Sparby, 2017). Since the mind first and foremost is a first-person phenomenon, first-person approaches are the ones that are most suited to investigate meditative experiences. However, since first-person approaches are less developed than third person ones, contemplative science depends specifically on the development of first-person approaches in order to advance as a field. Unless terms referring to first-person meditation experiences are rigorously defined, the validity of empirical research on such experience is strongly limited (Sparby and Sacchet, 2022). For example, research on advanced states of meditation, such as advanced concentrative absorption meditation, sometimes referred to as jhāna (Yang et al., 2023), will have limited validity of so-long as "jhāna" refers to different sets of first-person experiences, which is arguably the case (Sparby and Sacchet, 2024).

What also often goes unnoticed is that scientific theorizing itself depends on a form of introspection. When, for instance, someone is devising a theory or falsifying a hypothesis, they make use of certain inferential structures that are not derived from the external senses. The structures of inferences, such as modus ponens, or pure concepts or mathematical insights, enter conscious awareness through an act of introspection. Typically, there is no awareness of this act since the focus is on the content rather than on the act. Nonetheless, theorizing involves acts of introspection. Interestingly, one does not ask *how many* agree that a mathematical equation or valid inference is true; the truth of such matters is gleaned directly from the content. In contrast, empirical psychological studies depend on having a high enough sample size in order to provide convincing results. Phenomenology has, since its beginnings, been concerned with the possibility of finding the essential structure of something, through for instance what Husserl called *Wesensschau* or eidetic intuition (Husserl et al., 2001), *without* investigating the degree of intersubjective agreement on the results of such an intuition. And this is a central issue when evaluating the truthfulness of introspection as well. Is it possible to perform some mental procedure that will give insight into certain characteristics of psychological phenomena in such a way that the question of how many agree that the phenomena exhibit these characteristics falls away? A positive answer to this question is fundamental to what can be called a *strong conception* of introspection. In contrast, a *weak conception* of introspection only takes introspective results as preliminary results that are to be investigated further based on larger sample sizes yielding statistical significance. On the one hand, the strong conception of introspection seems far-fetched – intersubjective agreement can hardly be abandoned outright – on the other hand, the weak conception of introspection only gives us an explorative method. We can ask, however, whether there is a domain between these two extremes. Can we develop introspective methods that are more than explorative and provide results that can be attributed with a moderate, if not mathematical, level of certainty?

If we look to the history of philosophy, we can indeed find claims stating that introspective insight is the only reliable type of insight; it is the only kind of insight that is truly indubitable. Descartes' statement *cogito ergo sum* is a famous example, though the truth of this claim has been contested ever since it was uttered. A recent defense of the certainty of *cogito ergo sum* was formulated by Jaako Hintikka, who interpreted the statement as pointing to the insight that one cannot *perform the act* of doubting that one exists without at the same time *confirming to oneself* that one exists (Hintikka, 1962). However, it has been more common to take a critical stance in relation to introspection. As already mentioned, introspection encountered fundamental problems early on in its development, and has continued to be challenged. A typical example of this is a study done by Nisbett and Wilson (Nisbett and Wilson, 1977), which showed that we often make mistakes when we investigate our own decision making process, and the criticism of introspection continues today (Schwitzgebel, 2008; Smithies, 2013). Some research exists, showing that introspection may become more reliable when it is done methodologically through for instance micro-phenomenology (Petitmengin et al., 2013; Sparby et al., 2021), Although micro-phenomenology is mostly conducted by guiding others to investigate their experience systematically, it may also be done in a way where a person investigates their own experience (Sparby et al., 2020b; Sparby, 2023) and methodical advancements like relying on a cultivation of the sense of certainty may improve the reliability of reports (Sparby et al., 2020a). Still, the empirical evidence that it is possible to improve the reliability of reports is scarce.

Hence, one may describe the current situation like this: introspection is, by some, counted as the most secure source of knowledge, others view it as very unreliable. Tim Bayne has already identified this state of affairs, referring to the former as optimists and the latter as pessimists with regards to the status of introspection

(Bayne, 2015). Some forms of introspection seem more reliable than others. For example, to use Bayne's terminology, *scaffolded introspective judgments* seem more reliable than *freestanding* ones. My introspective judgment that I currently am having a visual experience of a red tomato is *scaffolded* by there being a red tomato in front of me. Internal phenomena, such as a decision process, do not rely directly on sensory support and introspective judgments about such processes are known to be unreliable (Nisbett and Wilson, 1977; Petitmengin, 2006).

However, even if introspection is sometimes unreliable or even if there are cases that are difficult to decide introspectively, this does not mean that introspective methods are in principle problematic. Indeed, sensory perception is often known to be unreliable – even systematically unreliable given the right conditions – which has been shown very clearly through different examples of perceptual illusions, for example in relation to lightness perception (Adelson, 2000). And yet it would not occur to us to claim that perception should be dismissed in general.

To illustrate in more detail: An interesting case is provided by Wittgenstein, who speaks of a kind of arithmetic of color, i.e., a form of knowledge of the essence of colors, a phenomenology that can be developed by simply looking at and reflecting on the nature of colors. For instance, Wittgenstein states that white will be the brightest color in any picture (Wittgenstein, 2007, p. 17). It seems hard to disagree. Similarly, a pure blue will always be darker than a pure yellow (Wittgenstein, 2007, p. 17). If we have compared colors like that once, we know that for any similar pair of blue and yellow, blue will be the darker color. Hence we can, with the help of single phenomena, uncover necessary truths. In relation to other colors, however, it is not so clear. Which of the colors red and blue are darker? Violet and blue? Even though there are some cases that are unclear, this does not mean that all are, and it certainly does not mean that sensory information is always unreliable. In the same vein, though introspection may in some cases be unreliable, this does not mean that it always will be. There may be cases where we can uncover necessary truths by investigating phenomena introspectively. Again, this does not mean that we can or should abandon intersubjectivity; in particular in cases where getting clear introspective results is challenging, seeking intersubjective confirmation is valuable in that it provides a general safeguard against human fallibility. Easy cases of introspection, like whether I feel warm or cold in a daily life context does not need external confirmation, but for investigating complex topics such as freedom and attention within a scientific context, critical intersubjective exchange does provide a way of challenging, and thereby securing, the accuracy and universality of reports and hence takes a definite methodical step toward making the results more certain. Other ways of increasing reliability include using micro-phenomenology, This will be addressed again in the discussion.

1.2 Free will and attention

"Free will" is a very broad topic and has been debated for centuries. A distinction can be made between freedom in the sense of being *able to decide* and *being able to act* (Keil, 2017), which can also be called a distinction between internal and external freedom. A person can deliberate and make a decision to move from A to B while at the same time not being able to do so because some external obstacle, like a closed door, stands in the way. In such a case, the person would be inwardly free but still not free to carry out their will externally. In the debate about free will, it is usually internal freedom that is cast into doubt.

Though most will agree that it indeed *seems* that we are free, it is a currently widespread view that free will is an illusion. For instance, recent studies suggest that the sense of having made a choice, i.e., having committed a freely willed action, may be a *post hoc* construction (Wegner and Wheatly, 1999; Bear and Bloom, 2016). The "experience" of freedom can then be understood as being produced by subconscious processes in the mind or the brain (Wegner, 2003), a position that remains controversial (Bayne, 2005; Carruthers, 2007). Hence, describing the *phenomenology* of freedom, i.e., the way freedom appears, might very well be compatible with both affirming and denying that we are actually free. However, denying free will despite the appearance of the opposite will require an additional explanation as to how and why the illusion of freedom appears. Affirming that free will exists faces the problem of explaining how a physical universe can accommodate non-physical powers or abilities. These are all complex topics that cannot be settled here. Though it common to deny that free will exists, there is work currently being done in philosophy that supports the view that free will is real. J.T. Ismael recently suggested that physical laws can be considered to be similar to the laws that regulate how chess pieces are moved around on a chess board while playing chess (Ismael, 2016); the laws limit the ways the pieces can move, but do not indicate how they will actually move within those boundaries. Furthermore, Steward explores the Aristotelian option of anchoring freedom in the capacity for self-movement (Steward, 2012), and such concepts as self-movement can be helpful in analysing freedom, regardless of whether or not agency really exists. There are also deep and complex issues involved in defining and realizing freedom comprehensively. Freedom does not necessarily involved being *unlimited*, but can involve the limiting of, for example, the realization of one's desires and rather "binding" oneself to the dictates of reason (one's own nature) (Kant, 2012). Indeed, one can even speak of a dialectic of freedom in relation to limitations and going beyond them, which is vital to consider when speaking of the social and spiritual realization of freedom (Sparby, 2016). Here we are primarily interested in the experience of freedom and hence we can bracket both the issue of whether (internal) freedom is real and also the more complex issues relating to the realization of freedom. However, a theory of freedom that does not want to end up with an epistemological dualism – in which appearances never accord with how things really are – must show how the apparent experience of freedom can be reconciled with the facts of reality. For instance, if it is impossible to have direct access to the source of action through a widening of attention, this reconciliation will remain incomplete; the experience of committing an act would be forever separate from the one who commits it and hence we could never have certain knowledge of our freedom. This will be discussed in section 4.1.

Attention can both be directed and sustained. We can direct attention toward an object or a series of objects, and we can choose to hold our attention steady on an object, which is the same as sustaining attention. Sustaining attention on the same object for more than a short moment is generally more difficult than directing attention. Sustaining attention is bound to lead to mind-wandering. Consequently, it seems that we have more control over directing attention than sustaining it.

Attention itself can be said to be free to the extent to which it can be linked to the capacity of self-movement. Directing attention seems to be a clear manifestation of the ability of self-movement and therefore also of freedom. We can move our body, which is a manifestation of the power of self-movement, but if we stop moving the body, it stays in place. This is different from how self-movement manifests in attention. Attention does not stay in one place, if left to itself. Hence we have to extend the notion of freedom to include the ability for a person to resist movement, if they so choose to. It is not hard to sustain attention for a short time, but the challenge grows as the time span of the task becomes longer. When mind-wandering occurs, this is a form of unintended movement of attention. Thus, sustaining attention can only be said to be a realization of freedom given the condition that an intention to sustain attention over time is present. Without being able to sustain and control attention, without having meta-awareness or being mindful of what we are doing in the moment and whether what we are doing is in accordance with our ideals, we are severely limited in the way we can express our freedom. As Metzinger has pointed out, our freedom or autonomy is limited by our lack of control over our attention and thoughts (Metzinger, 2013). It may seem that Metzinger intends to argue that cognitive agency is a complete myth, that all mental action is determined by subpersonal processes. However, his claim is that we do not have mental autonomy, including control of our attention, for roughly two thirds of our lives. Metzinger's idea of mental autonomy, or M-autonomy, is based on the notion that we are only able to act according to our ideals and hence to express our nature as rational creatures to the extent that we can maintain awareness of our ideals and cognitive agency over time. Increasing control over attention and mind-wandering can therefore be seen as a precondition of the realization of freedom, and the practice of attention tasks such as meditation and mindfulness can be viewed as different means of increasing freedom, as these contribute to the control and stabilization of attention and decrease of mind-wandering (Feruglio et al., 2021). Metzinger also accepts the idea that meditation is a way of systematically cultivating M-autonomy.

Does directing attention always involve sustaining attention, even if for a short time, at specific places for instance in the sensory field? Is it possible to sustain attention without continually directing it toward an object? These are examples of the kind of empirical questions that introspection can help shed light on. However, the research literature on attention is vast, and there are numerous issues in which introspection does not stand immediately at the foreground. Wu has suggested that there are five central questions in the field of attention (Wu, 2014):

1 The metaphysical question: What is attention?
2 The question of function: What role does attention play?
3 The question of properties: What are characteristic features of attention?
4 The question of mechanism: How is attention implemented?
5 The question of consciousness: What is the relationship between attention and consciousness?

With a little reflection, however, we can see that introspection would always, at least tacitly, be involved in answering these questions. Investigating the mechanism of attention, for instance, looking at how attention is related to human physiology, the eyes, the brain, and so on, would depend on correlating experiential reports with physiological data. The quality of the correlation not only depends on the accuracy of the physical measurements, but also on the accuracy of the reports. Since there are no established means assuring the quality of introspective reports, current research on attention could be viewed as inherently flawed. The current study is an initial investigation into how introspective methods can increase the accuracy of first person reports and hence quality of attention research.

Furthermore, Dicey Jennings has pointed out (Dicey Jennings, 2014) that although Wu mentions subject-centred or phenomenological approaches, his list lacks the question of the *source* of attention. What or who directs and sustains attention? Can we speak of an agent in relation to this? What is the experience of this source? Is it possible to direct attention toward the source or can it only be explored indirectly? This is another example of how introspection can become more explicitly involved in the research on attention. For instance, before one can even begin to look for neurological correlates of the source of attention, the source of attention will first have to be described, and a consensus about the meaning of this term in all its facets will have to be reached. Some subject-centred approaches to attention and agency do exist (Depraz and Depraz, 2004; Gallagher, 2012; Jennings, 2012), but they have not addressed the question of the source of attention through methodical introspection, as attempted in the present study.

To summarize, the primary questions of this study are: What is the phenomenology of directing and sustaining attention? How does directing and sustaining attention relate to freedom? What is the phenomenology – if any – of experiencing the source of attention?

2 Method

This study involved six participants. Their academic background ranges from philosophy, psychology and physics to medicine and aesthetics. All have an expertise in different forms of attention practices, such as meditation, precise observation of patients, and active perception of art. Most participants offer different forms of training in these fields and are also colleagues working together on different research projects. During an initial meeting, the topic was discussed, and different forms of introspective tasks and practices for directing and sustaining attention were explored. It was agreed upon to direct and sustain attention using a real apple seed, then to use an imagined representation of that apple seed, and finally to see whether it is possible to direct attention toward the source of attention and sustain it there. An apple seed was chosen since it is a visually simple object that is relatively easy to represent in imagination and also easily accessible. After 2 weeks the participants met again to discuss their experiences. It became clear that certain tasks had been performed differently by the participants and that some clarification was necessary to establish a consensus about how to actually perform the practices. In particular, three clarifications were made: *Sustaining* attention consists of focussing one's attention on an object without thinking about the object; the task should be conducted with both a real and an imagined object; an attempt should be made to direct and sustain attention at the source of attention after working both with a real an imagined object. This resulted in the following eight tasks:

1 With a real apple seed
a Direct attention toward the seed

b Sustain attention on the seed
c Direct attention toward that which directs and sustains attention
d Sustain attention on that which directs and sustains attention

2 With an imagined apple seed
a Direct attention toward the seed
b Sustain attention on the seed
c Direct attention toward that which directs and sustains attention
d Sustain attention on that which directs and sustains attention

These tasks were practiced for another 3 weeks. The reported duration of practice ranged from 5 min working on a single task and up to a total of 1 h and 15 min for completing all tasks. During these 3 weeks the participants also shared and reflected on their experiences among themselves. All participants met again for a final time to present and discuss their results. Some time was spent on discussing theoretical aspects relating to freedom and attention, and some on comparing experiences, uncovering which of them were the same or similar and which were different, opposite, or unique. Due to the complexity of the reports and issues involved, and to allow close analysis and comparison, it was agreed that the participants were to submit written reports to one of the participants, who would then conduct a thematic analysis (Guest et al., 2012) assisted by an analysis-software (MAXQDA), which was conducted by the first author. In a final meeting with three participants, the analysis was presented and the results were discussed. After this meeting the reports were read through once more, a few further experiences were identified, the identification of specific text passages was revised, and the categorical structure was finalized. In some cases where the reports were unclear, the participants were asked to elaborate. All participants had the chance to check the presentation of the results before the analysis was completed.

3 Results

The analysis resulted in 669 text passages being identified and this formed the basis for creating a taxonomy of the reported experiences. Common experiences (experiences reported by four or more participants) will be presented in 3.1 as well contrary reports in 3.2. When reports are quoted, the participant number is stated within the brackets following immediately after the quoted text. A full taxonomy of the experiences is provided in the Supplementary file S1.

3.1 Common experiences

Common experiences are experiences that are reported by four or more of the participants and relate to the following topics: Agency, distractions, mind-wandering, effort, insight, affects visual experiences, arousal, and difficulties.

3.1.1 Agency

All participants reported on different aspects of agency, which relates to the sense of self described above. In particular, four participants stated that one's activity or intentionality is experienced indirectly through conducting the tasks. As one participant states: "It is clear to me that I generate activity all the time [2]." Another participant elaborates after having conducted task 1c (directing attention toward that which directs and sustains attention):

> First I asked myself: Where I am? Or who am I within this activity, within this act of perception? I am not the apple seed and all its properties, but rather that which determines the direction, modality, and movement. "I" experience "myself" as the one who acts through changing the aspects, which is initiated "through" "me". I experience my self through the "expected" change that is "induced". It is an experience of a self-activity happening through intentionally changing what is perceived [5].

The emphasis here is that the self is experienced through perceptual change and the intentional change that lies behind that.

Two participants reported that agency is only noticed retrospectively, i.e., after having conducted a task and reflecting on who is conducting the activity. Again, further results pertaining to this will be presented below. One participant notes that discovering one's agency can also be connected to a sense of joy, though, as another participant states, conducting the tasks can also, because mind-wandering keeps occurring, be experienced as discovering the limits of one's agency. As one participant notes: "The question of who directs attention in relation to the representational task [i.e. 2c] makes the answer "I" appear. But that is initially just a word; what is behind it is to begin with not possible to experience [3]." This statement opens up the discussion about whether it is possible to experience the source, which will be treated in section 3.3.1 and 4.1.

3.1.2 Distractions

There were four participants reporting on distractions, either specific ones or in general. Distractions can be either external (e.g., noises in the environment) or internal (e.g., inner images), and they can be of comparatively stronger and weaker degrees. In some cases, the participants were aware that something, such as the feeling that the body is cold, is a distraction; in others cases, the awareness that something is a distraction was not present, like when an association has presented itself in consciousness (which can lead to mind-wandering, see below). Distractions include: Memories, associations, things one has to take care of in daily life, inner issues with which one is concerned, bodily sensations (muscle tension, pain), noises in the environment, internal talk, insights, and internal quasi-visual shapes.

One participant reports that a lack of activity or focus can lead to becoming distracted: "Additionally, it can happen, when there is too little activity and focus, that I "slip off" into the nearest environment and find new "interesting" things there [2]." Another participant notes that distractions can come either as separate or combined elements. For instance, a series of memories that are visually represented inwardly can appear in combination with internal talk, forming a narrative. When the distractions only contain one element, they were stated to be easier to notice.

3.1.3 Mind-wandering

All participants reported on episodes mind-wandering. Mind-wandering can be distinguished from distractions in that mind-wandering consists of a series of connected mental events arising from a distraction. Here is an example of a report of a mind-wandering episode: "There was a moment of mind-wandering as the memory appeared of how my father handled the food and the apple seeds [1]."

And another: "For example, when inwardly constructing the brown object that is the apple seed, it happens that I, accompanied by the thought "brown as a hazelnut," think "hazelnut, hazelnut cream, hazelnut cream during the visit to the family of my brother last weekend"; and then I was suddenly within the world of memories associated with this weekend [5]." The types of mind-wandering events mentioned are fantasies, streams of associations, memories, and reflections (one participant notes that it is possible to mind-wander even when the eyes are open and the gaze fixed). Indicators of mind-wandering come from the different dimensions of experience already mentioned:

1 Level of Consciousness: Tiredness (low degree of arousal)
2 Cognitive: Looking for the source of attention, transitions within an overarching task, surprises, thinking without visual content, forgetfulness
3 Imagination: Quick images that pull attention away
4 Perceptual: Staring
5 Affects: Curiosity, fear, lack of interest, irritation, a wish to do something else (boredom)
6 Volition: Lack of effort, or that the intention for doing the tasks is not internal to the subject
7 Somatic: Bodily sensations

Certain more or less effective anti-dotes to mind-wandering were also noted:

1 Performing the attention task with a physical rather than inwardly represented object
2 Consciously calming down
3 Giving oneself a command, or pulling oneself together, or activating the will
4 Remaining in continual attentional activity
5 Not giving in to impulses

Five participants note that remaining in continual attentional activity works well as an antidote. However, there is no guarantee that mind-wandering is reduced over time even when conducting concentration tasks with strong effort.

3.1.4 Effort

Four participants report on different aspects of effort. The attentional tasks mostly require continual effort; the inner image, for instance, rarely stabilizes and becomes continuous. One participant, however, reports the following: "The image of the apple seed […] has to be recreated in every moment and this requires significant effort; rarely there is an experience of a continuity of the image beyond a few moments. But when it happens, it is a gift and is experienced as a liberation [3]." In other words, even though the experience of stabilization is rare, when it happens, it can be a very positive experience.

3.1.5 Insight

Four participants describe different ways in which they gain insight into the experience of freedom or autonomy or start questioning whether or in what way we really are free. One participant describes an insight into how freedom is enacted through being able to both direct attention and re-direct after becoming distracted. Another participant, however, identifies a split in consciousness: "There is some resistance to going back to the object. How is this autonomy then? Immediate wishes and set intentions are separate; I identify with one former on a surface level and the latter on a deeper level [6]." Thus the participant questions whether directing attention is necessarily a case of freedom or autonomy in that there is a conflict between the intention to focus and the wish to not do so.

3.1.6 Affects: Joy

The one emotion that is mentioned most often (by five participants) is the emotion of joy (other emotions are mentioned three times or less). The experience of joy is connected to either the sense of being active, to the stabilization of attention, or sustaining attention at the source.

3.1.7 Visual experiences

Reports on visual experiences relate to either aspects of imagination and perception or to a domain between both where imaginal and perceptual elements can intermingle.

A common experience is that it can be challenging to construct and sustain an inner image. As one participant notes, the sensory concreteness of the inner image is missing. Another participant notes that the inner image might resist being shaped as intended or even that the image starts to shift its shape spontaneously. The only common perceptual report is that distortions that happen when attention is sustained on a real apple seed. The impression can become blurry, a whiteness can appear around the seed, or the visual field itself becomes blank or grey. In contrast, the reports about the domain that lies between imagination and perception is quite rich; a light can be experienced, flickering or shimmering phenomena can appear, there can be a play of after images, or other impressions of colors and shapes appear in a quasi-visual field.

3.1.8 Arousal: tiredness

Five participants describe experiences relating to tiredness. Three note that tiredness makes the concentration tasks difficult, for instance through mind-wandering becoming more prominent, and one participant reports having fallen asleep during the task.

3.2 Contrary reports

There were contrary reports in relation to the central question of whether it is possible to experience the source of attention. The reports can be divided into claims that it is possible or impossible to direct and/or sustain attention at the source and that it is easy or difficult. The claims that it is easy or difficult are subcategories of the claims that it is possible. Furthermore, there were some contrary reports relating to positive and negative affect, and to the level of consciousness.

3.2.1 It is possible to direct and/or sustain attention at the source

Some participants report being able to direct attention to the source by directing attention to the activity that is involved in conducting a task. A participant states: "One can become aware of the source through the "mirror" of the objects; the activity of the observer mirrors itself in the constant change in the aspects of the perceived object [5]." Participant [2] has a similar observation:

> To direct attention towards that which directs and sustains attention. That is for me now and then a completely delightful state: to notice that it is me – my own activity that brings forth the image of the apple seed inwardly. At least it is clear to me that only that happens, which is really intended by me – otherwise not much would happen and the image of the apple seed would not appear. How the processes take place on a more detailed level and who directs them, how they are directed and how calm re-enters, to that I can say nothing yet. That escapes the capacity of observation which I currently possess [2].

Hence it is stated that the source can be observed, though what is observed is the activity of bringing forth the image. Note, however, that the participant implies that it could become possible to say more about some parts of the process of attending to an object, and about the source, through an improvement of the capacity of observation.

One participant states that it is impossible to direct attention to the source while observing an external object:

> The question about who directs perception towards the apple seed was not possible to treat while the perceptual task was being done, it could only be done subsequently. Then, however, the immediacy of the perceptual activity was no longer present; one had, to put it like this, extrapolate it from memory, and, doing this, it became apparent that one had to use an image of the apple seed as support. Then I had, however, proceeded from the perceptual task to the imaginal task. It was not clear to me how I could have done the task differently [3].

Thus it seems possible to direct attention toward the source, but only in retrospect. Another participant reports that it is possible to direct and sustain the attention on the source while conducting the task with an external object, but notes thcat it seems more difficult:

> It seems even more difficult to find the source of the activity of directing and sustaining attention when the eyes are open. The body seems to stand more in the focus. When looking for the source, I direct attention to the eyes, towards the body. Maybe this is because there isn't much activity involved in fixing the gaze? You just hold the eyes at one place; it isn't really hard. When shifting the gaze I certainly go to the eyes if I try to locate the source of the activity. When moving the eyes around quickly it is easier to notice that it is me who's doing it. Then it also becomes clear again that attention is different from vision; I can move my eyes around while my attention is elsewhere. A frustration arises from not finding the source – not getting a sense of how I am directing my gaze – while it still seems so obvious that it is I am moving the eyes/the gaze [6].

The same participant reports that directing and sustaining attention on the source is not only possible, but also easier than working with an inner image: "I can direct attention to the source of that which creates the image without re-creating the image. [This is] [e] asier than creating an inner image [6]"; "[It is] [m] uch easier to focus on the source. The sense of the source seems immediate. [6]"; "It seems very easy to rest in the source of the activity of directing attention, but it is not possible to locate the existence of the source anywhere in space [6]." Here is a similar also slightly more elaborate account:

> Directing and sustaining at the source: There is an inner vibrancy, clarity. But also an emptiness. Inner shimmering or flicker. Light (vague). Noticing a separation between the sense of activity and the source; the activity is more connected to the body/the sense of vibration. The source feels deeper, more "inward" and backward at the same time, like it's in another kind of space, but I'm losing orientation when looking for it. A sense of relief of not having to do a task. This is much easier than imaging an image [6].

To summarize, there are a range of claims relating to the possibility of either directing attention to the source or sustaining it there: Such attention (i) is possible; (ii) is possible and even easier than creating an inner image; (iii) is difficult, for instance while the eyes open; (iv) is only possible in retrospect; (v) is possible through noticing who is performing the attentional activity.

3.2.2 It is impossible to direct and/or sustain attention at the source

It has already been indicated that some participants connect the possibility of being aware of the source of attention with being active. A further participant states: "I was not able to rest within the source while completely forgetting the apple seed [4]." Another participant offers the following remark:

> To rest within the continually active going-out-of-oneself (the source of the activity) is not possible. […] to "rest" within that which directs attention, i.e. that which is the origin of attention, is not possible. One would have to duplicate oneself. One can try to direct the attentional direction to […] the represented object and at the same time to the creation of the representation. But also then the activity shows itself in the feeling of what has been done by oneself and in the change of the formation of the image [5].

And elaborates:

> To rest in that which directs attention (towards the apple seed): Observations: I cannot direct perception towards the source of the continual change and movement of the attentional direction; I can only try: in doing that the apple seed (the observed object) fades somewhat. When doing that, I enter into non-objectivity. The source is continual activity, which tries to grasp itself.
>
> […] To direct attention towards that which directs and makes attention rest: As already stated, the productivity and its source can be experienced more strongly in the production of an image than in external (sense-)perception. Likewise, the source cannot be viewed as an object [5].

Here the point is not only that the source can only be brought into view through being active, but also that it is impossible to see the source as an object.

3.2.3 Positive and negative affect

It can also be noted that although five reports contain references to joyful feelings that can be experienced while conducting the task (and three note a calming affect), there are a few cases of negative affects, such as resistance, aversion, or strain. One report states: "I experience resting [attention] on this image as completely artificial,

extremely strenuous, und not really attainable [1]." The same participant connects this to the fact that the intention was not really internal, i.e., it originated in another person or a group of persons (i.e., the research group). One participant notes the contrast between positive and negative affect explicitly: "There's a theme of frustration with losing the object of attention, on the one hand, and joy and happiness that comes as a result of working with attention like this, on the other [6]."

3.2.4 Level of consciousness

One participant notes that the task itself can result in tiredness. In contrast, one participant reports: "Sometimes the mind stabilizes; everything becomes more clear and I feel more awake." It might not be surprising that conducting a task can be tiring, but that it can lead to becoming more awake, can be viewed as significance. Possible explanations for this will be discussed below.

4 Discussion

The results will first be discussed in relation to the question of whether it is possible to introspect in the source of attention (4.1). Then issues relating to freedom and the stabilization of attention in general will be discussed (4.2), followed by some remarks on the methodical aspect of introspective research and contemplative science (4.3).

4.1 The source of attention

The most central issue in relation to freedom that has arisen from this study is whether it is possible to experience the source of attention directly or only indirectly, i.e., through or while being active. This issue has been discussed in philosophy at least since Kant (1904) and Fichte (Fichte, 1971), and it has been recently treated by Strawson (2010), 2015). In Kant's view, since the subject could only appear to itself as an object, it is impossible for it to appear to itself as it is in itself. This echoes one of the reports of this study: "Likewise, the source cannot be viewed as an object [5]." Arguing against this view, Fichte claimed that the self can be present to itself immediately in an act of intellectual intuition:

> This intuiting of himself that is required of the philosopher, in performing the act whereby the self arises for him, I refer to as *intellectual intuition*. It is the immediate consciousness that I act, and what I enact: it is that whereby I know something because I do it. We cannot prove from concepts that this power of intellectual intuition exists, nor evolve from them what it may be. Everyone must discover it immediately in himself, or he will never make its acquaintance. The demand to have it proved for one by reasoning is vastly more extraordinary than would be the demand of a person born blind to have it explained to him what colors are, without his needing to see (Fichte, 1982, p. 38)

Self-consciousness is, by Fichte, conceived as an activity that can perceive itself, or, more precisely, the activity of self-consciousness and the perception thereof "together form a single essence" (Prager, 2010, p. 9). The idea of a pure activity goes back to Aristotle, who argued that "within the series of things which are intelligible *per se*, absolute primacy is given to the kind of substance which is completely simple and in a state of pure activity (Clearly, 1995, p. 398). For Aristotle, pure activity is exhibited by the highest being, i.e., God or the unmoved mover (Aristotle, 1984, pp. 1071b5–1073a1), but it can also be achieved by contemplation, which is the "purest of all activities" and "the most final good" (Korsgaard et al., 1996, p. 239). And as indicated, Strawson has recently explored the claim that the subject can "take itself as it is in the present moment of awareness as the object of its awareness" (Strawson, 2011, p. 274); Strawson offers a theoretical argument for the possibility of such a form of awareness, but notes that the actual experience of it requires a "sort of meditative condition":

> […] it's simply a matter of coming to awareness of oneself as a mental presence (or perhaps simply as: mental presence) in a certain sort of alert but essentially unpointed, global way. The case is not like the eye that can't see itself, or the fingertip that can't touch itself. These old images are weak. A mind is rather more than an eye or a finger. […] It's a matter of first focusing on the given fact of consciousness and then letting go in a certain way. As far as the level of difficulty is concerned, it's like maintaining one's balance on a parallel bar or a wire in a let-go manner that is relatively but not extremely hard to attain. One can easily lose one's balance—one can fall out of the state in question—but one can also keep it, and improve with practice. (Strawson, 2011, pp. 292–293)

Strawon claims that not only is it theoretically possible for the subject to be present to itself as it is in the present moment, but also that this is a task that is achievable; though it is perhaps difficult initially, the ability to remain in such a state can be trained and in the end it might even become easy.

The pure present moment self-awareness of a subject can possibly be interpreted as pure activity. Though such an interpretation will have to be worked out in more detail, the idea of pure activity can potentially resolve the issue of the conflicting reports. Discovering and attending to the source of attention more fully may be an issue of having developed a certain capacity, which is also implied in one report ("That escapes the capacity of observation that I currently possess"). Several participants noted that being active is a requirement for noticing who or what is being active. This does not mean, however, that the source of attention is *not* itself an activity; it could be a form of pure, and *simple* activity. If it is a pure and simple activity, this can explain why it is at once difficult to reach while at the same time it is relatively easy to attend to as soon as it is discovered. A pure activity is different from any other activity, in that it does not relate to an activity external to the subject itself – hence it may require a difficult and unfamiliar form of attention. When pure activity is discovered, however, it becomes easy to sustain attention on it, since this does not require one to make use of any external sense organs or mental capacities external to the subject; it remains, simply, present to itself. To make use of an image of Aristotle (1984, p. 1071b11): The self-awareness of the source may be represented as a circular motion, like a stream flowing continuously and continually around in a circle, where the singular moments of awareness turns into an uninterrupted flow of an overarching awareness. Whether or not this is in accordance with actual experience, i.e., whether attending to the source is an experience of pure activity and whether such a form of attention is

trainable and can potentially become easily available, cannot be decided based on the basis of the present material.

A problem of conflicting introspective reports that mirrors the one discussed above has been encountered within the field called cognitive phenomenology. Cognitive phenomenology asks whether cognition has a certain quality or qualia, a "what-it-is-likeness," just like tasting an ice cream is experienced in a certain way. The problem encountered in cognitive phenomenology is that some people claim that cognition is connected to unique class of qualia, while other do not (Bayne and Montague, 2012). The reason for this may be that only some people have the capacity of experiencing this kind of qualia. Furthermore, theoretical presuppositions may also lead to either connecting qualities of experiences to thinking that really are disconnected or a failure to identify such connections. Similarly, directing and sustaining attention at the source may be a capacity that can be developed, claims to the effect that it is possible to attend to the source may either wrongly connect certain subtle qualities to the source or rely on a failure to identify an underlying activity that mediates the experience, or it might be the case that theoretical presuppositions involving the notion that it is impossible to attend to the source may block the actual experience of it.

Again, these issues cut to the core of the methodological foundation of introspection and presents challenges to be met by future studies and theoretical work. The question of whether it is possible to attend to the source immediately remains open. Even if it is true that the source of attention can only be attended to indirectly, i.e., through an activity that is reflected upon after the activity has come to an end, this does not make future introspective research on the source of attention futile; it would, however, need to take into account that what the source is cannot be experienced directly. And if the source cannot be experienced directly, this opens up for the possibility that conscious experiences, such as memories of previous events, are indeed constructions, produced either by subconscious processes or the brain, and hence subjective. Although such a reductive position can never be confirmed directly either, simply because it involves the claim that everything in consciousness is always mediated by something external to it, the result is in either case an epistemological impasse that cannot be overcome unless a way is found to justify that it is possible to have an immediate access to consciousness as it is in itself.

4.2 Freedom and the stabilization of attention

As described earlier, being able to direct and sustain attention is arguably a condition of freedom (Metzinger, 2013). The research literature also distinguishes "captured attention" from consciously directed attention (Wu, 2014); insofar attention is captured, freedom is also limited. We can also conceive of a state in which attention is captured sustainedly. Examples of this are trance-states that cannot be consciously exited. Are such trance states the result of successful meditative stabilization of attention? If so, full stabilization of attention would actually be contrary to freedom; freedom requires the ability of shifting attention to any object of choice. Even though in a trance state a wish to do something else might not be present, the inability of exiting the trance, i.e., directing attention elsewhere, means that freedom is inhibited. There are, however, deep meditative states in which stabilization is complete, while the ability of exiting the state is still present (Snyder and Rasmussen, 2009). Hence such a full stabilization of attention would be compatible with free will, but only when the condition of being able to exit the state at will is met.

4.3 Remarks on the introspective research method and contemplative science

The intention of this study was to bring actual introspective reports to bear on the issue of free will and the possibility of experiencing the source of attention. Other methods of first-person, introspective research such as micro-phenomenology (Petitmengin, 2006) exist and have been used to explore the process of stabilization of attention (Sparby, 2019a,b). While the present article adds to the content of the introspective research, one of its main contributions is methodical: How does one approach the topic when a group of researchers are involved who take equal part in the introspective research process? A main challenge is the existence of conflicting reports on fundamental issues. This may make it less likely to become convinced of the potential of involving introspective reports in the discussion of epistemological and ontological problems. There are different ways of approaching this. One way (1) is to make theoretical prejudice clear at the outset of a study and make an effort to bracket such prejudice while introspecting. This can counteract cases where prejudice actually influences experience or the descriptions of it in such a way to make it contradict the reports of others with a different theoretical outlook. A second (2) way is to consider whether certain experiences depended on a certain level of expertise. If so, it may be necessary to develop more precise roadmaps of how to access such experience in order for others to be able to investigate them. A third (3) way is to consider whether conflicting reports may be describing different aspects of the same phenomena and whether some concepts can be found that unify the descriptions.

This study has revealed an example of an approach that combines 2 and 3: We suggest that directing attention toward its source and sustaining it there may be a case of maintaining attention within an essence that consists of simple and pure activity. This form of activity may be difficult without practice. It may be noted that this is a theoretical suggestion that will have to be investigated further, but it also gives a direction for future studies. Consequently, a productive way of dealing with disagreement is to device further empirical tasks, informed by one or more of the approaches (1–3) that were just mentioned.

In general, the way to move from a weak conception of introspection – i.e. one that only results in a preliminary investigation – to a stronger conception, is to make specific methodical suggestions for how to address concrete issues or problems that are already known or arise in the course of a new study. In general it can be recommended to conduct studies over a long time period during which tasks are repeatedly performed, as this can reveal both invariant structures and variable characteristics of phenomena. Moreover, it is advisable to conduct introspective studies in groups that engage both empirically and reflectively with the phenomena, since this not only helps counteract fallibility and one-sided theoretical viewpoints, but also begins to reveal which structures may be invariable across larger populations.

Introspective results become more strongly convincing when the conceptual structures or conditions of a phenomenon are clearly and simply formulated. An example of this would be Husserl's idea of protention and retention as acts of consciousness that are a necessary condition for the experience of music (Husserl, 1986). To experience, for instance, an interval, requires that the first tone is both anticipated to continue while the second tone appears and is retained while the second notes resounds. While this may be convincing on a theoretical level, one may still ask: Is this actually what musical experience is like? Hence, conceptual and empirical investigations can mutually support each other. Carving out the nature of something at its joints through an introspective study, revealing for instance the basic structure and features of an emotion, will provide convincing results not only because it manages to unite a series of subordinate features through the identification of underlying structures, but also because people actually experience the emotion in question like this and can potentially learn more about their experience by considering it in light of the introspective results.

A final way of making introspective results more secure is triangulation. Triangulation in this context means to relate certain introspective results to other domains of knowledge, which is also a basic dimension of what scientific activity consists of (Hoyningen-Huene, 2016). One example is to correlate a statement indicating a specific level of arousal with relevant biological measurements. For instance, decreased breathing might be an indicator of low arousal. However, triangulation can always be challenged based on either source of empirical data. Slowed down breathing or even breath cessation may in some cases indicate high arousal, as evidence by some studies on deep meditative states (Badawi et al., 1984; Travis and Wallace, 1997). In such cases, an introspective report of high arousal may be challenged by the exhibited behavior, but the interpretation of the behavior may with equal justification be challenged by the introspective account. This shows the limit of triangulation, but problems like this may also result in developing a better understanding both of behavior and first-person experiences, as it may lead to investigating the phenomena more closely and refining our understanding of behavior: Is the arousal that arises in conjunction with breath slowing down somehow experienced differently from the arousal that arises on conjunction with increased breath rate? Is the former correlated with different physiological markers of arousal than the latter? These questions, and the way one would have to go about answering them precisely, shows the relevance of introspective research within a larger context of scientific conduct.

We have given an example of how contemplative first-person research may proceed in a group setting in a way that sheds light on contemporary issues in psychology and philosophy. It has become clear that introspective observation, although essential, is only one part of the process. Equally important is the conceptual work done in relation to the results of the introspective observation. This kind of work becomes especially relevant when the introspective observation shows different results: Is this due to individual differences? How does one argue that one result is false and the other correct? Are there ways of conceptual integration that make it possible to explain different observational results?

Traditionally, contemplative practice has been focused more on general structures of meditative development irrespective of individual differences and less on the details of what goes on in the mind of individuals, including disagreements of experiential reports. Contemplative science that involves first-person reports now has a chance of remedying this by including introspective methods in group settings. While this kind of work is time intensive and cognitively challenging, it is not different from other fields of science in this regard. What is different in the form of contemplative science that we outline here, is the requirement of the involvement of the whole person; one is not only studying one's own experience in-depth, but also one's own experience in relation to the experiences of others. This expands the purely introspective approach to include an intersubjective aspect (Weger and Wagemann, 2015b; Trnka and Smelik, 2020), which is fundamental to the scientific pursuit of truth.

5 Conclusion

This study shows the potential for using introspection in conjunction with conceptual analysis to study central issues within psychology and philosophy, such as attention and freedom. An overview of the different aspects of the phenomenology of attention has been developed, including common experiences, contrary cases, and significant single cases. Though freedom can be experienced through the activity of directing and sustaining attention, a consensus about whether or not it is possible to experience the source of attention did not arise. However, the different descriptions resulted in a tension that provoked deeper theoretical reflection, and it was suggested that the notion that the source consists of pure activity might unify the different viewpoints that were expressed. This gives a direction for future introspective research on the topics of freedom and attention.

Data availability statement

The datasets presented in this article are not readily available because the data belongs to the respective authors. They may provide their own data individually upon request. Requests to access the datasets should be directed to terje.sparby@gmail.com.

Author contributions

TS: Conceptualization, Investigation, Methodology, Writing – original draft, Writing – review & editing. DC: Conceptualization, Investigation, Methodology, Writing – review & editing. DH: Conceptualization, Investigation, Methodology, Writing – review & editing. FE: Conceptualization, Investigation, Methodology, Writing – review & editing. DT: Conceptualization, Investigation, Methodology, Writing – review & editing. UW: Conceptualization, Investigation, Methodology, Writing – review & editing.

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Supplementary material

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Day-to-day associations between mindfulness and perceived stress: insights from random intercept cross-lagged panel modeling

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Objective: Mindfulness is frequently seen as a protective factor of stress, but self-report measures of mindfulness may overlap with other related constructs, such as mental health, and could thus not only be a predictor, but also an outcome of stress. This study thus aimed to examine the longitudinal bidirectional associations between the use and perceived helpfulness of the four mindfulness facets Observe, Describe, Nonjudge, and Nonreact with daily perceived stress.

Methods: Participants from a large ($N = 1,276$) mixed student and community group sample filled out a brief daily diary over the time span of 7 days. Bidirectional cross-lagged effects were investigated using the random-intercept cross-lagged panel model, an extension of the traditional cross-lagged panel model that allows to differentiate between stable between-unit differences and time-varying within-unit dynamics. In addition, we controlled for several baseline and sociodemographic confounders.

Results: At the within-subject level, the use of Actaware was associated with higher perceived stress on the next day ($\beta = 0.03$, $p = 0.029$). The use ($\beta = -0.04$, $p = 0.025$) and perceived helpfulness ($\beta = -0.05$, $p = 0.014$) of Nonreact were associated with lower perceived stress on the next day. In turn, perceived stress was associated with lower perceived helpfulness of Describe ($\beta = -0.04$, $p = 0.037$) and Nonreact ($\beta = -0.03$, $p = 0.038$) on the next day. In addition, there were several residual correlations between mindfulness facets and perceived stress within days. At the between-subject level, there was a positive association between the random intercept of Describe and daily stress ($r = 0.15$, $p = 0.003$). In addition, while baseline perceived stress was negatively associated with the random intercepts of the mindfulness facets, two baseline components of mindfulness were not associated with the random intercept of perceived stress.

Conclusion: On the currently investigated time scale, our results challenge prior results and assumptions regarding mindfulness as a buffering and protective factor against daily stress. With the exception of Nonreact, mindfulness was either positively associated with perceived stress, or in turn perceived stress appeared to interfere with the ability to stay mindful in daily life.

KEYWORDS

mindfulness, daily hassles, stress, random intercept cross-lagged panel model (RI-CLPM), longitudinal, structural equation modeling (SEM), daily diary study

1 Introduction

When the demands of our environment exceed our adaptive capacities, we experience stress (Cohen et al., 2007). Already minor daily hassles, such as arguing with friends or family, can be experienced as stressful, and contribute to overall levels of stress (Chamberlain and Zika, 1990; Almeida, 2005; Donald et al., 2016). Therefore, daily stressors can both have an immediate impact on our personal well-being, but also accumulate and lead to more serious negative reactions (Almeida, 2005), and in the long run negatively influence our physical and mental health (DeLongis et al., 1988; Serido et al., 2004).

However, individuals vary in their responses to stressful events, and adaptive personal and social resources may allow us to cope better with them (Almeida, 2005). Protective factors that can buffer the negative implications of stressful events in our everyday lives are thus highly relevant (Wu et al., 2013). As such, mindfulness programs, such as mindfulness-based stress reduction (MBSR; Kabat-Zinn, 1982), have been reported to reduce stress and increase quality of life (Khoury et al., 2015). Mindfulness as a personality trait was associated with more adaptive stress-responses and lower levels of perceived stress as well (Weinstein et al., 2009; Bao et al., 2015). This stress-buffering account of mindfulness was suggested as a central pathway between associations of mindfulness and health, both through bottom-up (i.e., lower stress-reactivity) and top-down processes (i.e., adaptive emotion regulation in the face of stress; Creswell and Lindsay, 2014). Together, such findings caused considerable attention to mindfulness as a potential protective factor that could reduce negative health outcomes associated with stress (Conner and White, 2014; de Frias and Whyne, 2015; Conversano et al., 2020).

Originally, the concept of mindfulness has its roots in Buddhist meditation practices (Kabat-Zinn, 1994, 2003; Bodhi, 2011). It was introduced in Western psychology and medicine in the second half of the 20th century and quickly gained popularity (Kabat-Zinn, 2013). One of the most commonly referred definitions describes mindfulness as purposeful and non-judgmental moment-to-moment awareness (Kabat-Zinn, 1994, p. 4; Kabat-Zinn, 2003). In another influential operational definition, Bishop et al. (2004) proposed two components of mindfulness, self-regulated attention (SRA) and orientation to experience (OTE). SRA describes the attentional component of mindfulness and the ability to intentionally bring one's attention to the present moment. OTE describes an open, accepting, and non-judgmental attitude toward one's own experiences and the present world (Bishop et al., 2004). Other approaches define mindfulness as a collection of related processes including acceptance, defusion, contact with the present moment, and a transcendent sense of self (Fletcher and Hayes, 2005). Common mindfulness skills (such as observing and describing) as well as the way how these skills should be performed (such as non-judgmentally, accepting, in the present moment, and effectively) were suggested as well (Dimidjian and Linehan, 2003).

Many of these aspects of mindfulness are assessed in widely-used mindfulness self-report inventories, such as the Five Facet Mindfulness Questionnaire (FFMQ, Baer et al., 2006). As a prominent measure of trait mindfulness, the FFMQ assesses mindfulness with five facets (i.e., scales) Observe (actively perceiving internal and external stimuli), Describe (the ability and tendency to describe internal experiences with words), Actaware (being attentive toward one's own actions), Non-judge (taking a neutral, non-judgmental stance toward one' own thoughts and feelings) and Non-react (attending to feelings and thoughts without being carried away by them). Interestingly, these facets could possibly also be subsumed under the two-component model of mindfulness (Bishop et al., 2004). Actaware and Non-judge were suggested to load on OTE and Observe on SRA. Describe and Non-react were suggested to load on both factors (Tran et al., 2013). This two-dimensional structure of the FFMQ yielded good model fit across multiple studies (Tran et al., 2013, 2014; Burzler et al., 2019; Borghi et al., 2023), and combines the advantages of the empirically derived five-facetted structure of the FFMQ with the theoretical two-component model of mindfulness.

The general tendency to be mindful (trait mindfulness) can be distinguished from an individual's degree of mindfulness at a specific time point (state mindfulness; Medvedev et al., 2017). Increases in state mindfulness may lead to increases in trait mindfulness (Kiken et al., 2015), but increases in trait mindfulness may also lead to increases in state mindfulness [see Burzler and Tran (2022)]. Thus, effects of state and trait mindfulness can be hard to disentangle (Medvedev et al., 2017), and this can lead to difficulties when studying mindfulness only at single or only a few time points [for a further discussion of this topic and also on the relevant differentiation of trait mindfulness into dispositional and cultivated aspects in this context, see Burzler and Tran (2022)].

Adding to this, there is currently no scientific consensus on the exact definition of mindfulness (Van Dam et al., 2018), and especially self-reported mindfulness has been criticized in regard to its construct validity and conceptual ambiguity (Goldberg et al., 2017). Accordingly, the results of a recent meta-analysis indicated that self-reported mindfulness is no unique mediator of the effects of mindfulness interventions, but instead may (at least partially) be rather a correlate or consequence of self-reported mental health (Tran et al., 2022). Psychometric findings indicate that common factors underlie the five facets of mindfulness and proposed mechanisms of mindfulness (e.g., emotion regulation, attention regulation; Bednar et al., 2020). Thus, self-report measures of mindfulness, such as the FFMQ, may not only measure mindfulness, but also some of its supporting mechanisms. This could explain increases in trait mindfulness following non-mindfulness-based therapies (e.g., Tran et al., 2022) and the overlap of trait mindfulness with other constructs, such as neuroticism, emotion regulation, and mental health [see Tran et al. (2020)]. Yet, these trait overlaps are likely also facilitated by semantic and sentiment similarities of the item contents of the respective widely used scales (Fischer et al., 2023).

Based on these potential trait overlaps of mindfulness with related constructs, one could expect longitudinal bidirectional associations between mindfulness, neuroticism and mental health: And indeed, mindfulness is longitudinally related to lower neuroticism and neuroticism to lower mindfulness (Wang et al., 2022). Also, lower mindfulness does not only predict lower mental health longitudinally, but lower mental health predicts lower mindfulness as well [Kocovski et al., 2015; Gómez-Odriozola and Calvete, 2020; but see Snippe et al. (2015)].

Such findings raise the question of whether mindfulness may have unique effects on perceived stress and whether stress may not also influence day-to-day mindfulness. One previous multi-study investigation Weinstein et al. (2009) reported that mindfulness negatively predicts perceived stress in daily data and is positively associated with the use of adaptive coping mechanisms. Another study

Donald et al. (2016) reported specific positive effects of present-moment awareness (corresponding to Actaware in the FFMQ) on more self-efficacious coping and small *positive* associations with perceived daily stress. This indicates that mindfulness may (beneficially) affect coping with stress, but does not necessarily decrease perceived stress levels. However, none of these prior studies investigated the possibility of bidirectional effects. Stress was treated only as an outcome in analysis.

Given this prior evidence, a re-investigation of both the associations of mindfulness facets with perceived stress and the clarification of the temporal order of effects (i.e., from perceived stress to mindfulness facets or vice versa) remains an important research desiderate. In this context, a methodologically interesting approach is the random intercept cross-lagged panel model (RI-CLPM; Hamaker et al., 2015), an extension of the traditional cross-lagged panel model (CPLM). The RI-CLPM allows investigating longitudinal cross-lagged paths (thereby testing for the possible bidirectionality of associations), while simultaneously differentiating between trait-like between-subject components and state-like within-subject fluctuations. While this analytic approach has been recently used to investigate the longitudinal associations between mindfulness and neuroticism (Wang et al., 2022), to our knowledge the RI-CLPM has not yet been applied to investigate the longitudinal associations between mindfulness and perceived stress.

1.1 The present research

In summary, mindfulness is frequently seen as a protective factor of stress and previous studies indeed indicated longitudinal associations of mindfulness on responses to stressors in the everyday life (Weinstein et al., 2009; Donald et al., 2016). However, it is possible that the longitudinal associations between mindfulness and stress are bidirectional and may depend on specific mindfulness facets. Further, both daily mindfulness and perceived stress may be affected by confounding variables, such as participants' meditation experience and trait mindfulness levels and baseline levels of perceived stress. The capability and likelihood of being, and staying, mindful in everyday life likely depends on baseline mindfulness levels and prior experience of cultivating mindfulness skills (Burzler and Tran, 2022). Differences in mindfulness between student and non-student (i.e., community) samples have been reported as well (e.g., Tran et al., 2013). Lastly, perceived stress and mindfulness were both associated with age and biological sex in prior research (e.g., Weinstein et al., 2009).

In the present study, we thus aimed to provide a comprehensive investigation with the three study goals of (1) investigating the longitudinal associations between different mindfulness facets and perceived stress in daily life and (2) clarifying their temporal order, while (3) controlling for a number of baseline and sociodemographic variables: the two components of trait mindfulness, SRA and OTE; meditation experience; baseline perceived stress; student status; and participant sex and age. For this, we examined the associations between the daily use and perceived helpfulness of the mindfulness facets Describe, Actaware, Nonjudge, and Nonreact with perceived stress across the time span of seven subsequent days in a large, mixed student and community sample, utilizing the RI-CPLM. The Observe facet was not assessed, based on prior findings of weak or no associations of Observe with positive mental health and stress-relieving outcomes (e.g., Bergomi et al., 2013; Medvedev et al., 2018). The traditional CPLM has been applied in the past in the investigation of the longitudinal bidirectional associations between mindfulness and mental-health-related outcomes (e.g., Gómez-Odriozola and Calvete, 2020; Tumminia et al., 2020). However, this approach fails to account for person-level associations and potentially leads to spurious cross-lagged effects or the underestimation of true effects (Lucas, 2023). To investigate whether the application of the simpler CPLM would have led to biased results, we also provide results with this model for comparison.

For the within-subject level, we expected that everyday use and perceived helpfulness of mindfulness facets predict lower daily stress longitudinally (H1), but that daily stress longitudinally predicts the everyday use and perceived helpfulness of mindfulness facets as well (H2). At the between-subject level and across the investigation period (seven consecutive days), we expected that the overall higher use or perceived helpfulness of the mindfulness facets is associated with overall less perceived stress (H3). A schematic display of the hypothesized model is provided in Figure 1.

2 Materials and methods

2.1 Participants

This study used data from a mixed student and community sample, with a total of $N = 1{,}276$ German-speaking participants (53% women; age: $M = 32.4$, $SD = 14.7$ years, range: 17–85 years). Sample characteristics are displayed in more detail in Table 1.

2.2 Procedure

Participants were contacted by 22 research assistants through word-of-mouth advertising and were invited to fill out a printed questionnaire or an electronic PDF. The questionnaire alongside an informed consent form was either personally handed out to participants or sent via email. Participants were asked to provide information on their sociodemographic background and meditation experience. As the data were assembled within a larger research project, participants filled out a total of eight self-report instruments, of which two were relevant for this study (for an overview of all administered scales as well as their respective position within the survey, see https://osf.io/7tnwq/).

In addition, participants were asked to fill out a brief diary over the time span of 7 days at the end of the questionnaire, assessing the use and perceived helpfulness of four mindfulness skills, as well as perceived daily stress levels, at the end of each day. Afterwards, the questionnaires were again personally collected by the research assistants or obtained via email.

Participation was completely voluntary and all data were fully anonymous. No identifying personal information was collected in the questionnaire (also, the consent form was not signed by name, but ticked for agreement, like it is customary in online surveys; emails were deleted after saving the attached and filled-out PDFs with generic and non-identifying file names) and all data were entered and made available in the database only by persons not in

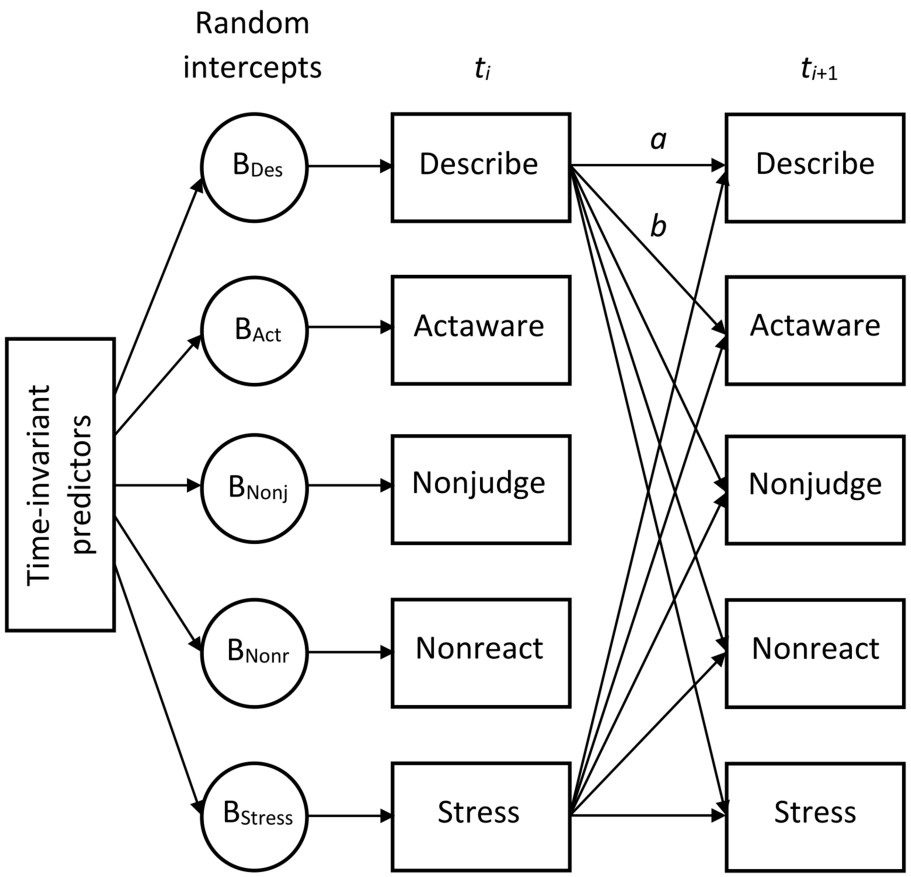

FIGURE 1
Simplified schematic representation of the statistical models. t_i, time point (with *i* going from 1 to 6); *a*, autoregressive effect; *b*, cross-lagged effect. The actual models included autoregressive effects for all variables and cross-lagged effects between all variables. The residuals of all daily measured variables were allowed to intercorrelate at each time point (t2–t7; for t1, the variables were allowed to covary), as were the residuals of all random intercepts, which captured the trait-like between-subject differences of the trajectories of the individual participants. The random intercepts had paths to their associated variables at each time point. All time-invariant predictors were allowed to intercorrelate. In Models 2 and 3, they had paths to each of the random intercepts (as depicted). In Models 1 and 4, the time-invariant predictors had instead paths to each daily measured variable. The structure of the within-subject part of the models is presented in a simplified form. The actual models also contained one latent variable per daily measured variable and autoregressive and cross-lagged effects were between these latent variables, not between the observed variables (as depicted).

direct contact with the participants. All data collection took place prior to the COVID-19 pandemic.

2.3 Measures

All scales and items were presented in German. For all scales, McDonald's ω and Cronbach's α were calculated using the MBESS package in R (Kelley, 2022). Sample reliabilities for all scales were >0.70 and are displayed in Supplementary Table S1.

2.3.1 Five facet mindfulness questionnaire

Trait-mindfulness was assessed using the German 23-item short form (Tran et al., 2013) of the Five Facet Mindfulness Questionnaire (FFMQ; Baer et al., 2006). The facets Observe, Describe and Nonjudge were measured by four items, and Nonreact was measured with all seven items of the full form. All items were rated on 5-point Likert scales ranging from 1 = *never or very rarely true* to 5 = *very often or always true*. The full form of the FFMQ showed high reliability and validity across different samples (Baer et al., 2008), and the German short form showed improved psychometric properties compared with the full form (Tran et al., 2013).

2.3.2 Perceived stress questionnaire

Subjectively perceived stress prior to the diary assessment was assessed using a sum score of the German revision of the Perceived Stress Questionnaire (PSQ; Fliege et al., 2005), which comprises 20 items that are rated on a 4-point Likert scale (1 = *almost never*; 2 = *sometimes*; 3 = *often*; 4 = *usually*). The German short form of the PSQ showed high reliability and high validity (Fliege et al., 2005).

2.3.3 Meditation experience

Different aspects of meditation experience were assessed with several items. The first item assessed the subjectively perceived experience with meditation or mindfulness practices on a 5 point-Likert scale ranging from 1 = *no experience*, 2 = *a little*, 3 = *some*, 4 = *a lot*, to 5 = *very much experience*. The second item targeted the frequency of meditation or mindfulness practice (0 = *never*; 1 = *not regularly*; 2 = *once a week*; 3: *twice a week*; 4 = *three times a week*; 5 = *four times a week or more*). In addition, participants were asked to

TABLE 1 Sample characteristics.

Characteristic	*n*	%
Sex		
Female	671	52.6
Male	602	47.2
Not specified	3	0.2
Nationality		
Austria	633	49.6
Germany	566	44.4
Other/not specified	77	6
Highest educational level		
Compulsory/vocational education	233	18.3
Upper secondary education	706	55.3
Tertiary education	324	25.4
Not specified	13	1.01
Currently studying	636	49.8
Currently employed	753	59.0
Meditation frequency		
Never/not regularly	1,075	84.3
At least once a week	166	13.0
Not specified	35	2.7
Most common types of meditation practice[a]		
Yoga	84	50.6
Zen	17	10.2
Other	65	39.2

Total $N = 1,276$ German speaking adults. [a]Among all participants who meditated at least once a week ($n = 166$).

provide information on their average meditation/mindfulness practice duration on a day in minutes, as well as the total years of practice. Lastly, participants also reported their most practiced meditation type. While most of these items served for mere descriptive information, based on previous studies, the frequency of meditation or mindfulness practice was included as an indicator of meditation experience in the analysis of this study (Soler et al., 2014; Cebolla et al., 2017).

2.3.4 Daily diary measures

A short survey consisting of five single items was used to assess the use and perceived helpfulness of four mindfulness facets and perceived stress levels across seven time waves (t1–t7) at the end of each of the seven subsequent days (the original German items and English translations can be found on https://osf.io/7tnwq/). Experience sampling studies frequently make use of single-item measures and such single items were also used in a previous study on the effects of present-moment awareness on stress (Donald et al., 2016). Single items are generally seen as a psychometrically appropriate, flexible, and brief alternative that can yield similar results like multi-item measures when administering long or full forms of psychometric self-report measures is infeasible (Wanous et al., 1997; Gardner et al., 1998; Fuchs and Diamantopoulos, 2009; Gogol et al., 2014). In this study, the use of single item measures allowed to enroll a large sample size over seven time waves.

The four mindfulness facets Describe, Actaware, Nonjudge, and Nonreact were assessed with four items that were rated with two response scales each concerning their daily use and perceived helpfulness, all rated on scales ranging from 1 = *not at all* to 10 = *very much*. Item contents were taken and adapted from items of the FFMQ, a self-report scale with high validity and reliability (e.g., Baer et al., 2008; Tran et al., 2013). The perceived stress level on each day was rated with a single item, ranging from 1 = *none* (no stress on the given day) to 10 = *maximum* (highest subjective stress level on the given day).

2.4 Statistical analyses

2.4.1 Exploratory structural equation modeling

The two-factor higher-order structure of the five facets of mindfulness was investigated using exploratory structural equation modeling (ESEM; Marsh et al., 2014). ESEM is a combination of exploratory factor analysis (EFA) and confirmatory factor analysis (CFA), in which items are allowed to cross-load on factors, while the same model fit indices can be obtained as in classical CFA. Therefore, ESEM can be seen as an integration of (some) the best features of EFA and CFA, with realist assumptions (i.e., closer to a "messy reality"), while simultaneously preserving the flexible analytic possibilities of CFA (Marsh et al., 2014).

The ESEM has already been applied to derive two higher-order factors of the FFMQ in multiple previous studies (Tran et al., 2013, 2014; Burzler et al., 2019; Borghi et al., 2023). Therefore, in this study, as suggested for cases with a more clearly defined *a-priori* factor structure, target rotation was used (Marsh et al., 2014). Based on theoretical considerations [see Tran et al. (2013)] and empirical results from the previous studies, estimation of the loadings on SRA was free for Observe, Describe and Nonreact, and constrained to zero for Actaware and Nonjudge, whereas for OTE the loadings from Describe, Actaware, Nonjudge and Nonreact were free, while the loading of Observe was constrained to zero (CFA within ESEM analysis). Analyses were performed in R version 4.2.1 using the ESEMcomp package version 0.2 (Silvestrin and De Beer, 2022).

As the factor loadings of the five facets of mindfulness on the two higher-order factors were shown to differ between student and non-student (i.e., community) samples (Tran et al., 2013), a multigroup analysis was performed, with group (0 = community; 1 = student) as the grouping variable. Based on the results from the multigroup ESEM analysis, group-specific regression factor scores were obtained and used in subsequent analysis (DiStefano et al., 2009).

2.4.2 Random intercept cross-lagged panel modeling

To test our main hypotheses, RI-CLPMs were used (Hamaker et al., 2015). The RI-CLPM is an extension of the classic cross-lagged panel model which specifically and additionally models cross-lagged relationships and autoregressive effects of variables over time. In contrast to the traditional approach, the RI-CPLM also allows differentiating between stable between-unit differences and time-varying within-unit dynamics. Longitudinally observed variables are decomposed into several components: A grand mean for each variable

across all time waves; random intercepts capturing the time-invariant (trait-like) between-unit deviations from the grand means; and a within-component, captured by differences of the observed measurement at each time wave and its expected score, based on its grand mean and random intercept. In addition, several extensions of the model are possible, such as the inclusion of time-invariant predictors (Mulder and Hamaker, 2021).

The present study examined four models each (Models 1–4) for the use of the four mindfulness facets and their perceived helpfulness. A schematic graphical representation of the statistical models is presented in Figure 1. Model 1 allowed for autoregressive effects of all mindfulness facets and perceived stress from 1 day to the next, and the cross-lagged effects of all mindfulness facets to perceived stress on the following day, and of perceived stress to all mindfulness facets on the following day. In addition, the time-invariant predictors age, sex (0 = female, 1 = male), group (0 = community, 1 = student), SRA and OTE factor scores, baseline perceived stress, and meditation frequency were included as predictors of all daily observed measures.

Model 2 constrained the effects of the time-invariant predictors on the observed daily measures to be equal across waves, i.e., they were only used as predictors of the random intercepts [see Mulder and Hamaker (2021)]. Model 3 also constrained the autoregressive and cross-lagged effects, as well as the residual covariances, to be equal across time waves, to reduce model complexity. Lastly, Model 4 constrained the variances and covariances of the random intercepts to zero, yielding models that were statistically equivalent to the traditional CPLM, to allow comparisons of our results with this approach. Analyses were performed in R version 4.2.1, using the lavaan package version 0.6–14 (Rosseel, 2012).

2.4.3 Data-analytic decisions

Across the entire set of study variables, 9.72% of observations were missing (i.e., 9,549 out of a total of 98,252 data points), and the percentage of missing observations was highest in the diary measures (11.56%; 9,289 of 80,388 cells). However, Little's MCAR test (Little, 1988; computed with the R package naniar; Tierney et al., 2021) indicated that the probability of a missing observation was not associated with other cases of the same or other observed variables, $\chi^2(10910) = 9{,}546$, $p = 1.00$. Thus, missing values were handled in analysis via full-information maximum likelihood (FIML) estimation.

Concerning their distributions, scores in most measures and scales were approximately normally distributed, with some moderately skewed distributions (e.g., Nonjudge, meditation frequency). In the measurement and structural models, standard errors were thus estimated with robust maximum likelihood estimation (MLR), accounting for non-normality in endogenous variables.

Model fit was assessed by the comparative fit index (CFI) and the Tucker-Lewis index (TLI; good fit: >0.95, acceptable fit >0.90), the root mean square error of approximation (RMSEA; good fit: <0.05, acceptable fit <0.08), and the standardized root mean squared residual (SRMR; good fit: <0.08). Cutoffs were chosen according to Kenny (2020). To compare competing models, ΔCFI $\leq$0.010 (Cheung and Rensvold, 2002; Chen et al., 2008) and lower AIC and BIC values (Lin et al., 2017) were used as criteria. Satorra–Bentler χ^2 tests are reported as well, but are not interpreted due to the large sample size (Kenny, 2020). We also note that while cutoff values for good and acceptable fit are a widely used alternative to the Satorra–Bentler χ^2 test, they may depend on measurement and data conditions, making such global fit indices somewhat arbitrary as well (Barrett, 2007). The significance level was set to $\alpha = 0.05$ (two-sided) in all analyses.

2.5 Open practices

Open data, open materials, and open code for this study are provided under https://osf.io/7tnwq/.

3 Results

Means, standard deviations, intercorrelations, and scale reliabilities (where applicable) for all time-invariant variables are displayed in Supplementary Table S1. The means and standard deviations of the time-varying, daily measured variables are reported in Supplementary Table S2.

3.1 Higher-order factors of mindfulness

The multigroup ESEM analysis indicated a good model fit, $\chi^2(2) = 10.321$, $p = 0.006$, CFI = 0.99, TLI = 0.897, RMSEA = 0.069 [0.019, 0.127], SRMR = 0.011. The low TLI value and relatively high RMSEA value could be attributed to the larger number of parameters (and, hence, low degrees of freedom) in this analysis, which is typical for ESEM models, were cross-loadings are estimated as well.

In both groups, Observe and Describe loaded highest on SRA, and Actaware, Nonjudge, and Nonreact loaded on OTE. In addition, in the community group, Nonreact loaded on SRA, and Describe on OTE. Descriptively, the association between SRA and OTE differed between the two groups, but it was not significant in either group (student group: $r = 0.39$, $p = 0.149$; community group: $r = -0.08$, $p = 0.434$). Factor loadings for both groups are displayed in Supplementary Figure S1.

3.2 Associations of the use of the mindfulness facets with daily stress

Models 1, 2, and 3 all had a good fit, and the differences in fit indices between the models were small and below the proposed cut-off values (see Table 2). Model 3 (constraining the effects of the time-invariant predictors, the autoregressive and the cross-lagged effects, and the residual variances all to be equal each across time points) proved to be the most parsimonious model and is reported in the following. Constraining the variances and covariances of the random intercepts to zero as well (Model 4, which resembled the traditional CPLM without random intercepts) resulted in a model with poor fit and large differences in the fit indices compared to the other models above the chosen cut-off values (see Table 2). We briefly describe the results from Model 4 in Section 3.4 below.

3.2.1 Within-subject effects

Detailed results are presented in Supplementary Table S3. The autoregressive paths from all time-varying variables to subsequent

TABLE 2 Fit indices and model comparisons concerning the use and helpfulness of the mindfulness facets and daily stress.

									Model comparisons				
Model	χ^2	*df*	CFI	TLI	RMSEA	SRMR	AIC	BIC	$\Delta\chi^2$	Δdf	ΔCFI	ΔAIC	ΔBIC
Use of the mindfulness facets													
1	472.88	432	0.998	0.995	0.010	0.018	203109	205752					
2	713.54	642	0.996	0.995	0.010	0.023	202934	204495	240.66	210	−0.002	−175	−1257
3	854.49	755	0.995	0.994	0.011	0.025	202898	203877	140.95	113	−0.001	−36	−618
4	3205.55	770	0.869	0.854	0.054	0.116	205614	206515	2351.06	15	−0.126	2716	2638
Helpfulness of the mindfulness facets													
1	482.39	432	0.997	0.995	0.011	0.017	204880	207523					
2	693.44	642	0.997	0.997	0.009	0.020	204668	206229	211.05	210	<0.001	−212	−1294
3	817.91	755	0.997	0.996	0.009	0.022	204615	205594	124.47	113	<0.001	−53	−635
4	3115.05	770	0.882	0.868	0.054	0.140	207356	208257	2297.14	15	−0.115	2741	2663

days were all significant ($ps < 0.001$). Standardized effect estimates were between 0.18 and 0.20 for Describe, between 0.19 and 0.21 for Actaware, between 0.21 and 0.22 for Nonjudge, between 0.23 and 0.24 for Nonreact, and between 0.28 and 0.30 for daily stress. Thus, daily stress appeared to have the largest carry-over effect to the following day.

Considering the cross-lagged effects, the more frequent use of Actaware predicted higher daily stress level on the following day ($\beta = 0.03$, $p = 0.029$), whereas the more frequent use of Nonreact predicted lower daily stress level on the following day ($\beta = -0.04$, $p = 0.025$). There were no cross-lagged effects for Describe and Nonjudge to perceived stress on the next day, or from perceived stress to any of the four mindfulness facets ($p > 0.05$). Further, there were significant correlations at t1 between Actaware and perceived stress ($r = -0.10$, $p = 0.016$) and between Nonreact and perceived stress ($r = -0.25$, $p < 0.001$). At t2–t7, there were residual correlations between Describe and daily stress (*r*s between −0.08 and −0.07, $ps < 0.001$) and between Nonreact and daily stress (*r*s between −0.26 and −0.21, $ps < 0.001$).

In summary, at the within-subject level, we found associations concerning the use of Actaware and Nonreact to perceived stress on the next day (partial support for hypothesis H1), but no effects from perceived stress to the use of mindfulness facets on the next day (no support for H2). In addition, we found covariation between the mindfulness facets and perceived stress within days.

3.2.2 Between-subject effects

Detailed results are presented in Supplementary Table S4. The random intercepts of Describe and daily stress were positively correlated ($r = 0.15$, $p = 0.003$), indicating that participants who used the mindfulness facet Describe more frequently on average also reported higher daily stress on average. The random intercepts of Actaware, Nonjudge, and Nonreact were not associated with the random intercept of daily stress, but the random intercepts of all mindfulness facets intercorrelated positively with one another (*r*s ranging from 0.35 to 0.54, all $ps < 0.001$).

With regards to the covariates considered, women had higher random intercepts in Describe ($\beta = -0.13$, $p < 0.001$) and Nonjudge ($\beta = -0.12$, $p < 0.001$) than men, as was the case for younger vs. older participants (Describe: $\beta = -0.13$, $p < 0.001$; Nonjudge: $\beta = -0.11$, $p = 0.010$). Students had lower random intercepts in Actaware ($\beta = -0.14$, $p < 0.001$) and Describe ($\beta = -0.07$, $p < 0.049$) than members of the community, and meditation frequency was positively associated with the random intercepts in Nonjudge ($\beta = 0.06$, $p = 0.045$) and Nonreact ($\beta = 0.07$, $p = 0.037$).

The SRA and OTE were positively associated with the random intercepts of the mindfulness facets: SRA showed the highest relationship with the random intercepts in Describe ($\beta = 0.23$, $p < 0.001$) followed by Nonreact, Nonjudge and Actaware. OTE showed the highest relationship with the random intercepts of Actaware ($\beta = 0.30$, $p < 0.001$), followed by associations with Describe and Nonreact, but the relationship with Nonjudge was nominally not significant ($\beta = 0.07$, $p = 0.074$). Neither SRA ($\beta = 0.01$, $p = 0.742$) nor OTE ($\beta = 0.06$, $p = 0.165$) predicted the random intercepts of daily stress.

Baseline PSQ scores, in turn, were strongly positively associated with the random intercepts of daily stress ($\beta = 0.61$, $p < 0.001$). Interestingly, they were also negatively associated with the random intercepts of the mindfulness facets Actaware ($\beta = -0.10$, $p = 0.011$) and Nonreact ($\beta = -0.16$, $p < 0.001$).

In summary, at the between-subject level, we found associations of the use of the mindfulness facets with participant sex and age, student status, and meditation frequency. Only the random intercepts of Describe and perceived stress were correlated, and this association was positive (directionally opposed to the expectation of H3). However, higher baseline levels of stress predicted the less frequent use of the mindfulness facets Actaware and Nonjudge on average, but trait mindfulness did not predict the average level of daily stress.

3.3 Associations of the perceived helpfulness of the mindfulness facets with daily stress

As in the previous analysis, Model 3 emerged as the most parsimonious model (see Table 2). Again, the traditional CPLM (Model 4; see below) had only poor model fit.

3.3.1 Within-subject effects

Detailed results are presented in Supplementary Table S5. Again, all autoregressive paths were significant (mindfulness facets: βs between 0.17 and 0.22; daily stress: β between 0.28 and 0.30; all ps < 0.001). Considering to the cross-lagged effects, higher perceived helpfulness of Nonreact predicted lower daily stress on the following day ($\beta = -0.05$, $p = 0.014$), but, in turn, higher daily stress predicted also lower perceived helpfulness of Describe ($\beta = -0.04$, $p = 0.037$) and Nonreact ($\beta = -0.03$, $p = 0.038$) on the following day. In addition, the perceived helpfulness of all mindfulness facets correlated with daily stress. These bidirectional effects provide partial support for hypotheses H1 and H2.

3.3.2 Between-subject effects

Detailed results are presented in Supplementary Table S6. There were no associations of the random intercepts of the mindfulness facets with daily stress (again not supporting H3), but the random intercepts of all mindfulness facets intercorrelated positively with one another.

Again, women had higher random intercepts in Describe ($\beta = -0.14$, $p < 0.001$) and Nonjudge ($\beta = -0.09$, $p = 0.004$) than men. Older participants this time had *higher* random intercepts in Nonjudge ($\beta = 0.13$, $p < 0.001$) than younger participants. Meditation frequency was positively associated with the random intercepts of Describe ($\beta = 0.06$, $p = 0.024$), Nonjudge ($\beta = 0.08$, $p = 0.006$), and Nonreact ($\beta = 0.10$, $p < 0.001$).

SRA and OTE were, again, associated with the random intercepts of the mindfulness facets. The baseline PSQ scores were positively associated with the random intercepts of daily stress and negatively with the random intercepts of all mindfulness facets.

3.4 Results of the CPLM for comparison

3.4.1 Use of mindfulness facets

The CPLM indicated cross-lagged effects that were not apparent in the above RI-CPLM: Daily stress positively predicted the more frequent use of Describe ($\beta = 0.04$, $p < 0.001$), Actaware ($\beta = 0.04$, $p = 0.005$), and Nonreact ($\beta = 0.05$, $p < 0.001$). In addition, daily stress and Nonreact correlated negatively at each time point (rs ranging from −0.14 to −0.22), and on t2–t7 daily stress also correlated negatively with the facets Describe ($r = -0.06$) and Actaware ($r = -0.04$; see Supplementary Table S7 for a full display of all parameter estimates).

3.4.2 Helpfulness of the mindfulness facets

Again, the CPLM indicated cross-lagged effects that were not apparent in the above RI-CPLM: higher perceived helpfulness of Describe ($\beta = 0.04$, $p = 0.025$) and Nonjudge ($\beta = 0.03$, $p = 0.026$) predicted more daily stress on the subsequent day, and in reverse, more daily stress predicted higher perceived helpfulness of Describe ($\beta = 0.04$, $p < 0.003$), Actaware ($\beta = 0.03$, $p = 0.014$), and Nonreact ($\beta = 0.03$, $p < 0.01$) on the subsequent day. In addition, there were significant (residual) covariances between daily stress and all four mindfulness facets (see Supplementary Table S8 for a full display of all parameter estimates).

4 Discussion

The present study investigated the day-to-day associations between the use and perceived helpfulness of four mindfulness facets and perceived stress over the course of 1 week in a large, mixed student and community sample, using the random intercept cross-lagged panel model. We obtained evidence concerning the covariation of mindfulness and perceived stress on the same day, which is suggestive of construct overlaps reported for mindfulness and other mental-health-related outcomes on the trait (vs. state) level as well. However, we also observed a number of cross-lagged longitudinal associations. Longitudinal associations were (1) unidirectional from mindfulness to stress for Actaware (more frequent use predicted *more* subsequent stress), (2) bidirectional for Nonreact (more frequent use and perceived helpfulness predicted less subsequent stress and more prior stress predicted less perceived helpfulness), and (3) unidirectional from stress to mindfulness for Describe (more prior stress predicted less perceived helpfulness). The cross-lagged longitudinal associations were only small in magnitude and in part both corroborated and questioned prior results on the buffering and protective qualities of mindfulness against stress in daily life. Importantly, mindfulness also *increased* the amount of perceived stress in the present study, while stress appeared to interfere with the ability to stay mindful in daily life as well.

Beneficial effects of Nonreact on mental-health-related outcomes have already been highlighted in prior research. Nonreact was reported to facilitate adaptive emotion regulation strategies, like cognitive reappraisal, and prevent maladaptive emotion strategies, like suppression (Desrosiers et al., 2014; Curtiss et al., 2017). Additionally, Nonreact also loads on a common factor with decentering (Bednar et al., 2020), which is considered a core mechanism of stress regulation (Creswell and Lindsay, 2014).

According to the (extended) process model (e.g., Gross, 2015), emotion regulation operates in feedback loops in relation to situations that elicit emotional responses. Emotion regulation attempts to modify these emotional responses in five ways: situation selection and modification (altering the frequency or external aspects of emotional situations, e.g., via evasion); attentional deployment (directing attention toward or away from the emotional situation, e.g., via rumination or distraction); cognitive change (concerning the situation's emotional meaning, e.g., trying to see positive aspects as well); and response modulation (changing the experiential, behavioral, and physiological responses themselves, e.g., via suppression of expression, the use of substances, exercise, or sleep).

One may argue that mindfulness more or less discourages options one to four and mainly focuses on option five, response modulation [cognitive change plays an important role in mindfulness as well, but likely is only an indirect consequence of an accepting and non-judgmental attitude rather than an explicit goal for most mindfulness practices; for a recent account on how mindfulness may affect emotion regulation, or may be considered an emotion-regulation strategy itself, see Raugh and Strauss (2023)]. Nonreact most closely corresponds to response modulation. Therefore, effects of Nonreact observed here and elsewhere may be grounded in its direct relation to emotion regulation, which is not equally the case for the other mindfulness facets [see Bednar et al. (2020)].

The present study thus suggests that Nonreact might not only have facilitating, or otherwise indirect, effects on mental health via its associations with emotion regulation (Desrosiers et al., 2014; Curtiss et al., 2017), but also direct effects on daily stress, because it may be considered an emotion regulation strategy by itself. In contrast, the other mindfulness facets might not have such effects, because they do

not directly address emotion regulation [but see Raugh and Strauss (2023)]. This line of research should be followed up.

As only the use and perceived helpfulness of a distinct group of facets showed any longitudinal associations, hypotheses H1 and H2 were only partially supported. Also, the mindfulness facets had no uniform, and also not uniformly negative, effects on the day-to-day perception of stress (*cf.* Weinstein et al., 2009). Yet, the positive longitudinal association of Actaware with higher perceived stress was in line with previous results (Donald et al., 2016). Whether this association reflects a higher awareness of stress that actually is conducive to higher-quality self-regulation and coping (Donald et al., 2016) could not be directly supported. Coping mechanisms (apart from the mindfulness facets themselves) were not assessed in the present study. Also, the present study did not assess the actual *burden* of daily stress, but only its extent. Similarly paradoxical phenomena have been reported for the association between mindfulness and motivation in previous research as well. Motivation for tasks and goals, which did not align with one's *own* values and interests, was reported to decrease with higher mindfulness, which could be equally considered beneficial rather than detrimental [see Walach et al. (2007) and Oberleiter et al. (2022)]. Yet, more research is currently still needed on such seemingly paradoxical effects of mindfulness.

Concerning the between-subject effects, there was only one relevant association between the random intercepts of the mindfulness facets and daily stress and this association was also *positive*; H3 was thus not supported. Participants who described their internal experiences with words more often also reported higher stress levels across the study period. This is again in line with findings that mindfulness may be associated not only with lower perceived stress, but also with *higher* stress.

The lack of further within-subject effects in the present study could have a methodological explanation as well. It is possible that there are lagged effects that just were not captured in our study design [see Rohrer and Murayama (2023), for an in-depth discussion on the interpretability of within-subject effects in the RI-CPLM]. Lagged effects could have occurred on shorter time scales, for example, from 1 h to the next, or, vice versa, effects could have been even more stable and could have occurred on even longer time scales, like from 1 week, or 1 month, to the next. Our data only captured a single week and were based on daily measurements. Future studies thus should investigate especially shorter time scales (i.e., collect more frequent real-time data over the course of each day) to rule out that associations were masked or blurred in the present study because of its design.

The observed residual covariances between the mindfulness facets and perceived stress on the same day could indeed be indicative of relevant shorter time scales that were not fully captured in our study design. At the same time, the observed associations of baseline perceived stress (PSQ scores) with the trait-like components (as captured in the random intercepts of the RI-CPLM) of the use of Actaware and Nonjudge indicated that longer time scales may have played some role as well. However, as Self-regulated Attention (SRA) and Orientation to Experience (OTE) did not likewise predict the average perceived stress level across the study period, these findings again appeared to favor a direction of stress to mindfulness regarding causality (i.e., stress interfering with the ability to stay mindful), rather than the other way around. Importantly, SRA and OTE did also predict the more frequent use and higher perceived helpfulness of the mindfulness facets across the study's observation period, as did meditation experience. Still, this did not turn the observed order of associations around.

Staying mindful in daily life thus may also need to be considered a correlate or consequence of low prior stress rather than protecting against future stress. This finding fits nicely with prior meta-analytic results, which reported associations of changes in mindfulness with changes in mental health not only in mindfulness-based interventions, but also in non-mindfulness-based active control groups, and even in inactive control groups (Tran et al., 2022). It is also compatible with mounting evidence criticizing the construct validity of mindfulness (Goldberg et al., 2017) and highlighting its overlap with other constructs and mental health not only in empirical sample data (Bednar et al., 2020; Tran et al., 2020), but also in the item contents of widely used self-report scales themselves (Fischer et al., 2023).

Thus, the patterns observed in the present study may be possibly more or less independent of its temporal resolution. Instead, they might have to do with the way mindfulness is assessed, and is accessible, in self report. This topic is currently lively discussed in the literature [for an overview, see Burzler and Tran (2022)], but there may be no easy or immediate improvement or solution available. Probably, self-reported mindfulness cannot be sufficiently disentangled from other constructs, such as mental health or emotion regulation, at all.

Therefore, we also recommend utilizing non-self-report measures of mindfulness in future studies to rule out measurement bias and minimize common method variance. A number of behavioral measures have been proposed in the past [for an overview, see Treves et al. (2019)] and recently (e.g., Hadash et al., 2023). Alternatively, research may also switch to biological markers of stress and health [for overviews in the field of mindfulness intervention research, see Bossert et al. (2023) and Grasmann et al. (2023)]. However, many options might not easily lend themselves to the temporal resolution of the present study (or even shorter time scales). Some promising biomarkers of stress either operate only over longer periods of time [e.g., methylation of the serotonin transporter SLC6A4 gene; see Grasmann et al. (2023)] and/or might be too costly or complicated for (often-)repeated applications. Similarly, the behavioral mindful awareness task of Hadash et al. (2023) requires a 20-min mediation session to complete. Hence, not all problems may be adequately addressed via the use of such alternative approaches alone.

Concerning the FFMQ, we obtained further evidence for the good fit of a two-factor higher-order structure. This factor structure is thus not only theoretically in line with the two-component model of mindfulness (Bishop et al., 2004), but has up until now also been repeatedly empirically supported (in five independent datasets, including the current: Tran et al., 2013, 2014; Burzler and Tran, 2022; Borghi et al., 2023). In both the student and the community group, Observe and Describe loaded highest on SRA and Actaware, Nonjudge, and Nonreact on OTE. In the community group, Nonreact loaded on SRA as well. This pattern of results fits in nicely with previous reports.

In line with recent critique of the traditional CPLM (e.g., Hamaker et al., 2015; Lucas, 2023), modeling our data without random intercepts yielded a worse model fit and spurious cross-lagged effects (that were, however, also small in magnitude). We thus refrain from interpreting these additional observations as evidence for the presence of further such effects, but rather reported them to highlight the real possibility of statistical artifacts in the analysis of longitudinal data with inadequate methods.

Several effects of confounding variables on the use and perceived helpfulness of mindfulness were discernible. Women and younger participants reported more frequent use of the mindfulness facets Describe and Nonjudge than men and older participants and perceived those facets as more helpful as well. Participants, who mediated more often, also reported more frequent use of the mindfulness facets Nonjudge and Nonreact, and perceived the facets Describe, Nonjudge, and Nonreact as more helpful in the face of stress. In addition, students reported less frequent use of the mindfulness facet Actaware and Describe than non-students. This further highlights influences of student status, age, biological sex, and participants' meditation experience and practice and, in turn, the necessity to consider basic demographic information and further person-level variables when studying the effects of mindfulness [see also Weinstein et al. (2009), Tran et al. (2013), and Burzler and Tran (2022)].

Summing up, we obtained evidence for both unidirectional and bidirectional associations between mindfulness and daily stress. Not all mindfulness facets appeared to contribute to stress-buffering effects, and stress may also interfere with the ability to stay mindful in daily life. The pattern of results is a likely consequence of *both* the conceptual ambiguity of mindfulness and its unique modus operandi. Future studies should strive to address issues relating to: (1) shorter time scales and, hence, high-frequency data collection over the course of the day; (2) the perceived burden of stress [and possibly also different components of stress, such as environmental, perceptual, or emotional; see Lobel and Dunkel-Schetter (1990)]; (3) alternative (i.e., non-self-report) measures of mindfulness and/or stress; (4) facilitating and indirect effects of mindfulness on further emotion regulation strategies; as well as (5) the actual malleability of the situations and events that are perceived as stressful by participants (because they might not be amenable to change at all – at least in the short run – which may further dilute the possible effects of mindfulness on daily stress).

4.1 Limitations

The present study also has some limitations. We used single-item measures for the daily measurements that conceivably are less reliable than multi-item inventories and did not assess the mindfulness facet Observe. The absence of Observe might have influenced the associations of the other facets with the investigated constructs. However, the two components of trait mindfulness, SRA and OTE, uniquely predicted the use and perceived helpfulness of mindfulness facets, and PSQ scores strongly predicted the average level of daily stress across the study period. This suggests that reductions in reliability or validity of the single-item measures were in all likelihood only small.

In addition, it may be that state mindfulness only protects from specific components of stress, such as environmental, perceptual or emotional components (Lobel and Dunkel-Schetter, 1990), for which the present stress measure did not differentiate. Potentially confounding variables, like neuroticism or emotion regulation, were not assessed. Given that only self-reports were used, the results may also be subject to common method variance. Further, the use and perceived helpfulness of the mindfulness facets, as well as daily stress, was assessed only retrospectively at the end of each day. Hence, reports could have been affected by recall bias and the momentary state at the time the diary was filled out. Also, as daily data were not collected in real-time (e.g., online), this could have introduced further undesirable sources of variance connected to recall bias. Finally, the temporal resolution of the present study (only daily measurements) may have masked or blurred relevant associations at shorter time scales.

Even though mindfulness and its beneficial effects are frequently discussed and studied in non-clinical populations, effects may be more noticeable in clinical populations (Keng et al., 2011). Accordingly, mindfulness may mitigate stress appraisals and reduce stress reactivity more noticeably only in high-stress populations (Creswell and Lindsay, 2014). We used a large ($N > 1{,}000$) sample from the general population, which has benefits in regards of generalizability and allowed for high statistical power. However, this comes at the cost of potentially overlooking effects that may become evident only in high-stress or clinical populations. Investigations of bidirectional day-to-day effects between mindfulness and stress in populations that may be specifically prone to high stress levels thus remain an important goal for future research as well.

Data availability statement

The datasets presented in this study can be found in online repositories. The names of the repository/repositories and accession number(s) can be found at: https://osf.io/7tnwq/.

Ethics statement

Ethical approval was not required for the studies involving humans because all procedures performed in this study adhere to the ethical standards of the 1964 Helsinki Declaration and its later amendments or comparable ethical standards. Study participation did not affect the physical or psychological integrity, the right for privacy, or other personal rights or interests of the participants. The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study.

Author contributions

OB: Conceptualization, Data curation, Formal analysis, Methodology, Visualization, Writing – original draft, Writing – review & editing. MV: Methodology, Writing – review & editing. UT: Conceptualization, Investigation, Methodology, Project administration, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Supplementary material

The Supplementary material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fpsyg.2024.1272720/full#supplementary-material

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Report from a Tibetan Monastery: EEG neural correlates of concentrative and analytical meditation

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The positive effects of meditation on human wellbeing are indisputable, ranging from emotion regulation improvement to stress reduction and present-moment awareness enhancement. Changes in brain activity regulate and support these phenomena. However, the heterogeneity of meditation practices and their cultural background, as well as their poor categorization limit the generalization of results to all types of meditation. Here, we took advantage of a collaboration with the very singular and precious community of the Monks and Geshes of the Tibetan University of Sera-Jey in India to study the neural correlates of the two main types of meditation recognized in Tibetan Buddhism, namely concentrative and analytical meditation. Twenty-three meditators with different levels of expertise underwent to an ecological (i.e., within the monastery) EEG acquisition consisting of an analytical and/or concentrative meditation session at "their best," and with the only constraint of performing a 5-min-long baseline at the beginning of the session. Time-varying power-spectral-density estimates of each session were compared against the baseline (i.e., within session) and between conditions (i.e., analytical vs. concentrative). Our results showed that concentrative meditation elicited more numerous and marked changes in the EEG power compared to analytical meditation, and mainly in the form of an increase in the theta, alpha and beta frequency ranges. Moreover, the full immersion in the Monastery life allowed to share the results and discuss their interpretation with the best scholars of the Monastic University, ensuring the identification of the most expert meditators, as well as to highlight better the differences between the different types of meditation practiced by each of them.

KEYWORDS

analytical meditation, concentrative meditation, Buddhist monks, EEG, neural correlates

1 Introduction

Meditation refers to a set of highly differentiated practices that, through specific mental training, improve physiological functions and self-regulating abilities of practitioners, as well as their cognitive, emotional, and spiritual aspects (Van Dam et al., 2018). Meditative practices are at the basis of Eastern traditions, cultures and philosophies, such as Buddhism and Hinduism, which describe meditation mainly through its mental and mystical facets. In the Western culture, the study of meditation is tightly related to the concept of mindfulness. This term was defined by John Kabat-Zinn as "the awareness that arises by intentionally paying attention, in the present moment, to the flow of experience from moment to moment, in a non-judgmental way" (Kabat-Zinn, 1991). To reach the mindful state, a set of contemplative practices derived from the Buddhist tradition, such as Samatha and Vipassana, have been simplified and standardized to be applied in secular and clinical contexts such as the psychotherapy of depression and anxiety disorders, as well as stress reduction (Vago and Silbersweig, 2012; Farb et al., 2015; Jerath et al., 2015).

Investigating mindfulness and meditation practices from a western perspective is complex, since the plethora of these practices is vast and heterogeneous (Fox et al., 2016; Fox and Rael Cahn, 2021). However, there are some elements common to the different meditation traditions, which have been empirically classified by the Contemplative Neuroscience field (Lutz et al., 2008; Nash et al., 2013; Dahl et al., 2015). An influential classification of meditative practices was first proposed by Lutz et al. (2008), who defined two macro-areas: (1) Open Monitoring Meditation (OMM), which involves non-reactive monitoring of the contents of experience; and (2) Focused Attention Meditation (FAM), which entails the voluntary focusing of attention on a chosen object (usually the breath). Both practices are widely used in mindfulness-based protocols, and involve the ability to intentionally activate, direct and sustain various attention processes, hence strengthening the ability to be aware of thought processes, emotions and the body (Lutz et al., 2008).

The OMM does not require focusing on a specific object but is characterized by the expansion of the attention range to the whole external environment and to the internal mental space, to become aware of every perception, thought and emotion present in the field of awareness. Therefore, the meditator remains receptive to elements that gradually enter the field of awareness, although non-reactive toward them, avoiding cognitive interpretations and emotional responses (Dahl et al., 2015). OMM can be a used as preparatory step for other types of meditation and was associated with activations of crucial regions for body awareness, interoception, and attention monitoring such as the inferior frontal gyrus, the pre-motor cortex, the dorsolateral prefrontal cortex, the anterior dorsal cingulate cortex and the insula, as shown by a meta-analysis of functional Magnetic Resonance Imaging (fMRI) studies (Fox et al., 2016). Significant deactivations were also observed in the thalamus, a structure involved in the selective filtering of sensory signals arriving from the environment, which may lead to an open and receptive state to sensory stimuli (Fox et al., 2016).

FAM in Tibetan Buddhism is called Concentrative Meditation and represents, in such tradition, one of the two main forms of meditation, together with analytical meditation (Dalai Lama, 1995; Wallace, 1999). It is the most studied form of meditation, due to its straightforwardness. The meditator initially focuses the attention on the breath (or another object, for instance the recitation of mantra) and, each time the mind gets distracted and starts wandering from one thought to another (i.e., mind wandering; see Buckner and Carroll, 2007), the meditator has to become aware of it, detach from the contents of the distractors, and gently refocus the attention on the breath (Wallace, 2006). With practice, distractors will become more rarefied, and the mind will be able to focus on the object, reaching deeper states of concentrative absorption characterized by calm and mental stability. When this state is stable and naturally maintained without effort, it is called Shamatha.

Some consensus is being reached regarding the activity and connectivity of specific cortical networks during Concentrative meditation, mainly using fMRI and Electroencephalogram (EEG) studies (Cahn and Polich, 2006; Fox et al., 2014; Tang et al., 2015; Fox et al., 2016). In this context, the so-called Default Mode Network assumes great importance. It includes the medial prefrontal cortex, the posterior cingulate cortex, the posterior inferior parietal lobule, and the precuneus, and has been associated to verbal thinking concerning the self, autobiographical memory, introspection and mind-wandering, but also to rumination, stress, and depression (Brewer et al., 2011; Raichle, 2015). An important meta-analysis of fMRI studies (Fox et al., 2016) revealed that Concentrative meditation increases the activity of brain regions associated to cognitive and attention control. Activations were reported in the premotor cortex, dorsolateral prefrontal cortex, and anterior dorsal cingulate cortex. In addition, deactivations were reported in the posterior cingulate cortex and posterior inferior parietal lobule, main nodes of the Default Mode Network (Fox et al., 2016). These data suggest that Concentrative meditation can reduce spontaneous thoughts about past and future events, leading to a state of consciousness focused on the present moment (Fox et al., 2016). At the EEG level, coherent findings revealed that Concentrative meditation is related to enhanced alpha and theta power, compared to a resting state condition, in both healthy individuals and patients (Lomas et al., 2015). More specifically, Concentrative meditation appeared to be related to increases of both anterior and posterior alpha power, and to fronto-temporal and parieto-occipital theta activity. Finally, it is also related to increased posterior gamma power, while no clear changes were found for beta activity (Lee et al., 2018). This co-presence of high gamma, alpha and theta activity may indicate a state of consciousness characterized by enhanced awareness, relaxed alertness and well-being (Lomas et al., 2015).

According to the Tibetan Tradition, starting from Shamatha, one can explore other meditative states, e.g., analytical or vipassana meditation. Analytical meditation consists of fixing the mind on a specific idea or concept, with concentration and steadiness. In the Tibetan Buddhism, analytical meditation is used to break down these ideas or concepts into their constituent parts. Therefore, the attentional focus cultivated through analytical meditation naturally includes the awareness of certain philosophical principles that support meditators' ability to perceive reality (Mehrmann and Karmacharya, 2013). In addition, this practice requires a deep knowledge of the theoretical basis of the meditation, as well as the ability to keep the mind focused on a specific concept, such as the nature of reality, the meaning of Karma, reincarnation, the nature of impermanence, etc. In this sense, analytical meditation does not differ from Vipassana, which in Tibet

is called Lhakthong, meaning "to see more," or "to see beyond," and is used to analyze and explore in depth the object of attention.

Despite the undeniable progress made by scientific research on contemplative practices, a clear convergence toward common conclusions is not observed in the literature, and there are still many outcomes and states of consciousness that have not been examined in the scientific literature. Some of the most pressing questions and concerns include the lack of clarity in the definition of mindfulness and meditation, the challenges of measuring meditation experience, the need for more diverse samples in meditation research, and the need for more research on the long-term effects of meditation. Additionally, there are debates regarding the efficacy and safety of meditation-based interventions, the potential for adverse effects of meditation such as increased anxiety, depression, or dissociation, as well as the potential for biases in meditation research such as exaggerated positive claims, often caused by public misunderstandings and inaccurate news media publicity ("mindfulness hype") (Van Dam et al., 2018; Vieten et al., 2018). It is the authors' opinion that one of the main problems arises when one tries to compare the objective results of the measurements with the meditator's first-hand experience. This is because the narration of this experience and the terminology used depend on the context and the cultural and experiential background of the meditator. Recently, some studies aimed at reducing this gap by directly collaborating with monastic universities (Jiang et al., 2020; Lott et al., 2020; van Vugt et al., 2020; Medvedev et al., 2022). In this direction, one of the peculiar characteristics of this work, consists in the fact that all the volunteers who participated in the research (monks and Geshe of the Sera Jey Monastery) have the same cultural background and have shared for at least 10 years the life of the monastery. Furthermore, they have been examined without taking them out of their usual context.

Considering the scientific world's growing interest in contemplative practices and taking note of the fact that, despite the huge number of publications on the subject, there are still several controversies and open issues (see Van Dam et al., 2018; Vieten et al., 2018), at the University of Pisa we decided to exploit a series of favorable conditions for attempting to make an original contribution to the exploration of this fascinating and still largely unknown territory. In 2016, at the suggestion of His Holiness the Dalai Lama, the Lama Tzong Khapa Institute of Pomaia (the largest center of Mahayana Buddhism in the West, about 35 min from Pisa) and the University of Pisa entered into a cooperation agreement in sectors of teaching, science and cultural dissemination on topics of common interest. Since many masters and resident Lamas of the ILTK had studied at Sera Jey, it was easy to enter into an agreement with the Sera Jey Monastic University as well. In this way the possibility of collaboration was also created with one of the most authoritative and ancient institutions of Tibetan Buddhism. The opportunity was unique, allowing us to work with a group of meditators belonging to the same tradition, with the same cultural background, and who share the same environment and the same habits of life in a stable and homogeneous context, fruit of a millenary tradition. In these conditions, the same definitions and the same taxonomy crystallized over the centuries constitute a common heritage, and it is also possible to have the voluntary collaboration of expert meditators, with tens of thousands of hours of meditative experience, without removing them from their environment.

Another peculiarity of the population of volunteers recruited for the research is the fact that, although they all came from the same context, it was made up of meditators with very different levels of experience: from beginners with less than 1 year of practice and, on average, 20/30 min of daily practice, to intermediates with a practice period of between 1 year and 10 years and 60/90 min of daily practice, up to advanced ones, who all with more than10 years of practice and at least 6 months of retreat exclusively dedicated to meditation. In this case, although there are differences depending on the type of retreat chosen by the volunteer, typically 4 daily meditation sessions lasting about 2 h are practiced interspersed with equally long periods of rest which correspond about 30,000 h in 10 years. All volunteers were experts in at least one of the two most practiced types of Meditation in Tibetan Buddhism in the Sutra system: Concentrative Meditation and Analytical Meditation.

In this study, we characterize the neurophysiological correlates of analytical and concentrative meditation by means of an EEG study in a cohort of beginners, intermediate and expert meditators from the Sera-Jey Tibetan Monastery. We hypothesized that both subject-specific peculiarities as well as different levels of expertise would result in meditation sessions of different durations to achieve specific mental states. In this light, we asked each volunteer to "do their best" with the only constraint of performing a 5-min closed-eye resting state baseline at the beginning of the meditation session. On these datasets, we perform several different analyses aiming at: (i) characterizing the changes in the time-varying EEG spectra underpinning analytical and concentrative meditation, (ii) identifying the key neural correlates distinguishing analytical and concentrative meditation, and (iii) exploring the influence of expertise on such differences.

2 Materials and methods

All the data acquisition was performed in a period of 12 weeks within the social, cultural and environmental context shared by all the volunteers for at least the last 10 years of their lives. A detailed description of such a context is given below.

2.1 Context: full immersion in a Tibetan Monastery

One of the characteristics of this work consists in the fact that the volunteers belong to a homogeneous sample both from the point of view of cultural and historical heritage and from that of habits and living environment. For this reason, we believe it is appropriate to devote space to the description of these two aspects.

Sera Jey Monastery was founded in the early 15th Century by Kunkhen Lodroe Rinchen Senge, at the time of Lama Tsong Khapa (1357–1419), founder of the Gelukpa School, the one to which also His Holiness the Dalai Lama belongs. In 1959, before the Chinese occupation, the number of monks exceeded 5,600. A few hundred people, including lamas, geshes and monks, managed to escape to India and moved to the settlement of Bylakuppe in the Mysore district of the state of Karnataka. The Sera Jey Monastery has been rebuilt and the community of monks currently numbers around 3,000 individuals. So, the unbroken lineage of masters dating back to the founder of the Gelukpa School survived and flourished again

on the Indian plateau (about 1,000 m above sea level), covered by jungle. Monks and Geshe stay in Khangtsens, that are sections of the Monastery each one corresponding to one different region of Tibet and each new coming monk is placed in a specific Khangtsen according to his place of origin.

Sera Jey Secondary School and the monastic Education Board are affiliated to the Sera Jey Monastic University. The university offer course for 25 years and at the end of the curriculum, at the age of about 35, students are awarded the title of Geshe which is equivalent to a PhD in Buddhist Philosophy.

This monastic institute follows the pure and unbroken lineage of Buddha's teachings and its classical commentarial works written by the eminent ancient Indian Buddhist scholars and practitioners of the prestigious Nalanda University in India. This Indian rich spiritual knowledge and practices has been spread and well flourished across the Asian countries through various mediums, the complete teachings of Buddha and the lineages of Nalanda spiritual treasure and practices were fully inherited by Tibetan master scholars in Tibetan language in the 7th century. The monastic curriculum primarily consists of memorization, dialectal debate, prayer and meditation. The monks study five major philosophical subjects based on classical Indian Buddhist texts. The five subjects are: (i) Valid Cognition (Pramana) to learn how to use valid reasoning in analyzing the texts; (ii) Perfect of Wisdom (Prajnaparaminta) to learn how to develop the realization of the path and grounds to enlightenment; (iii) The Midddle Way (Madyamika) to learn about the profound views of dependent origination and emptiness (Shunyata); (iv) Monastic Discipline (Vinaya) to learn how to live moral life as monastic rules and regulation set out by Buddha; and (v) Phenomenology (Abhidharma) to learn different aspect of mind and mental factors and theory of karma. To study the above major subjects in depth and details to earn final degree in Buddhist philosophy, the monastic Board of Education laid out the complete syllabus based on the scriptural texts and the commentarial works of Tsongkhapa, the founder of Gelugpa School, and his disciples on the classical works of eminent Indian Buddhist scholars of Nalanda University (developed between the 1st and 11th centuries) such as Nagarjuna, Dharmakirti, Dignaga, Arya Asanga, Chandrakirti and Visubhandu.

The most gifted ones can continue for another 6 years and obtain the title of Geshe Larampa. Graduates Geshes then join nearby Tantric College of Gyumed to study tantric and esoteric meditative practices for 1 year. Some graduate Geshe enter the monastic and meditation and retreat center where they put into practice spiritual knowledge by performing ritual and contemplative meditation for several years codified protocols of meditative practices, unchanged for centuries, accumulating tens of thousands of hours of practice. They dedicate oneself to meditation in a structured way after having completed their studies. The others highly learned Geshes remain in the monasteries to teach or contribute to the life of the Monastery and the University or assigned to teach Buddhist philosophy and doctrine in India, Nepal, Bhutan, Taiwan and the rest of the world where there are several Tibetan culture centers linked to Sera Jey.

A Committee for Sera Jey Philosophical Studies & Board of Examination is responsible for the administration of Monastic University courses, and Sera Jey Modern Education Department holds a similar responsibility that of a modern Academic University Department.

2.2 Participants

Twenty-three Geshes and monks (all males) from the Sera Jey Monastery took part in the experiment. All subjects gave their written informed consent. The studies involving humans were approved by ethical committee of the University of Pisa (n. 0117745/2020). The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study. The data collection took place over the course of three stays at the Sera Jey Monastery, whose overall duration was approximately 12 weeks. This allowed acquiring data from the participants in their own cultural environment, aiming at limiting potential uncomfortable conditions for the meditators. Details on the subject's population are reported in Table 1. We divided the participants into three classes based on their level of experience. Nine participants were considered beginners -B- (i.e., 20/30 min of daily practice and less than 1 year of experience), 6 intermediate -I- (i.e., 60/90 min of daily practice and between 1 year and 10 years of experience) and 8 advanced -A- (i.e., full-time meditators with at least 6 months of retreat).

2.3 Experimental procedure

Before starting the experiment, participants filled in a questionnaire reporting their level of experience, the type of meditation usually practiced, the reference system (tantra or sutra) and whether they have been on retreat. Details on the questionnaire are reported in the Supplementary materials (ms_neri_et_al_frontHumNeu_supp_mat_questionnaire.docx).

Then, the experiment began, and participants were asked to perform analytical and/or concentrative meditation sessions, under the sutra system.

Briefly, concentrative meditation (shamata) involves focusing and sustaining attention on a single object, for example the breath or a point of visual fixation or a mantra. This allows the mind to calm down and eliminate noises and discursive thoughts, and to reach the so-called "calm abiding" (Tibetan: shinè), a state of pure awareness without content. This corresponds to a calm and concentrated mind and to a suspension of conceptual thought. This state can also be used as a starting condition for other types of meditation used to investigate, for example, the roots of the mind–body relationship.

Instead, analytical meditation is a form of meditation in which the meditator initially directs his/her attention to what appears to the mind without attachment and by cultivating awareness. Then, the meditator focuses and analyzes in depth a particular concept of the Dharma (e.g., emptiness, compassion, lamrim, consciousness and its levels). As a result, this practice corresponds to a clear mind and is well described as a logic/conceptual task. This mental state can be also reached by practitioners during the so-called Tibetan debate, which consists in a verbal challenge between two experts on Buddhist philosophy and Buddha teachings (van Vugt et al., 2020), although debate is not needed for performing analytical meditation.

Meditators were invited to commit themselves as fully as possible to the chosen practice and left free to "do their best" without time limits, but with the only constraint of performing a 5 min long resting-state baseline before the session. Moreover, to allow everyone to do their best without external forcing, meditators were also

TABLE 1 Study population.

ID	Category	Age	Retreat periods (years)	N. of concentrative sessions	N. of analytical sessions
1	A	54	5	1	0
2	A	64	7	4	0
3	A	51	13	1	1
4	A	55	5	3	0
5	A	50	2	1	1
6	A	40	0.5	1	1
7	I	78	N/A	1	1
8	A	78	9	1	0
9	I	37	N/A	1	1
10	A	53	11	1	1
11	B	36	N/A	1	0
12	I	34	N/A	0	1
13	B	39	N/A	0	1
14	B	36	N/A	0	1
15	I	41	N/A	0	2
16	B	29	N/A	0	1
17	I	50	N/A	0	1
18	B	39	N/A	0	1
19	B	39	N/A	0	1
20	B	31	N/A	0	1
21	B	36	N/A	0	1
22	I	46	N/A	0	1
23	B	34	N/A	0	1

For each subject ID, category, age, periods of retreat and number of sessions performed for each type of meditation are reported. Category describes the experience of the subject and can be among A (advanced), I (intermediate), B (beginners). N/A, not applicable.

allowed to retire to another room during the meditation session. Within these heterogeneous datasets, we aimed at identifying the greatest deviations from the resting state baseline. Accordingly, since we did not have detailed information on the various phases of the sessions, the entire session was studied. At the end of the session, the volunteer underwent a debriefing about meditation (reported in the questionnaire).

2.4 Physiological data acquisition

We acquired EEG signals using a portable electroencephalograph with 19 channels according to the 10–20 international standard (EBNeuro BE PLUS LTM, Florence – Italy). Signals were acquired at a sampling rate of 512 Hz. The system was provided with a special shoulder bag for the portable recorder, allowing the subjects to freely move during the experimental session (e.g., retiring in a quiet place). The subject was prepared with preliminary scalp scrubbing before wearing the EEG cap. The contact resistance of all the electrodes was measured before the start of the experiment and kept below 25 KW throughout the recording. At the end of the experiment, contact resistances were checked again to handle possible non-negligible differences in the impedances.

2.5 Physiological data analysis

2.5.1 Preprocessing

EEG signals were downsampled to 100 Hz, after applying a low-pass antialiasing filter (cut-off frequency = 45 Hz). The obtained signals were high-pass filtered at 1 Hz with zero-phase non-causal filter. Then, signals were examined for the presence of bad channels through a two-step semi-automatic procedure. First, those channels whose correlation with the reconstructed version obtained from their neighbors was lower than a predetermined threshold (here set to a value of $\rho = 0.7$) (Mullen et al., 2015) were removed. Then, the EEG signals were visually inspected to check for the presence of potential noisy channels not captured by the correlation criterion (Urigüen and Garcia-Zapirain, 2015; Billeci et al., 2023). Removed channels were recovered through spherical spline interpolation (Delorme and Makeig, 2004). Afterwards, EEG signals were re-referenced to the average of all channels and analyzed with independent component analysis (ICA) using the AMICA algorithm (Palmer et al., 2011). ICA allows to decompose the EEG signals into sets of (maximally) statistically independent components, which represent independent sources of brain activity as well as different kinds of artifacts (e.g., muscular, ocular, channel noise). This procedure was found to be particularly suited for cleaning the EEG signal on the scalp by

reconstructing it discarding the artefactual components (Urigüen and Garcia-Zapirain, 2015). Moreover, the interpretation of brain activity-related components was found to be particularly advantageous in terms of interpretability of brain sources in low density recording systems (Callara et al., 2020). Here, we reconstructed the activity on the scalp by removing the contribution of artifact-related components. All steps were performed using EEGLAB (Delorme and Makeig, 2004), and MATLAB custom scripts.

2.5.2 Time-varying power spectral density analysis

For each subject, we obtained time-varying estimates of the power spectral density (tvPSD) of EEG signals using a sliding-window approach with 5-min-long non-overlapping windows (i.e., dividing the recording in 5 min consecutive time intervals and performing a PSD analysis for each of them). Within each of these windows, PSD was estimated using Welch's overlapped segment averaging estimator on 5 s long consecutive windows, with 80% overlap and an imposing a zero-padding equal to 1,024 to improve PSD visualization. Finally, PSD was expressed in dB.

2.5.3 Feature extraction

Starting from the tvPSD estimates, we extracted two main sets of features of interest: Average Frequency Band (AFB) PSD features and Continuous High Resolution (CHR) PSD ($\Delta f = 0.0488$ Hz) features. AFB PSD features were obtained for each electrode by taking the average tvPSD in the following bands: δ (1–4 Hz), θ (4–8 Hz), α_1 (8–10 Hz), α_2 (10–12 Hz), α_3 (12–14 Hz), β_1 (14–20 Hz), β_2 (20–30 Hz), and γ (30–45 Hz). From these averages, we derived a global index of tvPSD by averaging it over all the electrodes (hereinafter called global PSD). Accordingly, we obtained a total of 8 features whose dynamics during the meditation session were analyzed by comparing their values with respect to the resting-state baseline.

CHR PSD features were designed to describe the time evolution of PSD within each recording. Specifically, they allow to explore, frequency by frequency, the PSD changes across each frequency band that could be masked by the averaging process performed to estimate AFB PSD. The features describe maximal positive (Δ+) and negative (Δ-) changes with respect to basal condition of the tvPSD across different frequency bands. In addition, the maximum variation of the Alpha peak with respect to basal condition was considered ($\Delta_{\alpha\text{-peak}}$). This last feature was obtained by visually inspecting the spectrum and taking the maximum of the CHR PSD in the α band for each 5-min-long window. From a visual inspection of the CHR PSD, we noted the presence of a marked peak in the spectrum in the β range (hereinafter called *bump*) in several EEG traces. We extracted the number of sessions in which they were present, the difference between their maximum and its value during the baseline (Δ_{bump}) and the frequency at which they occurred.

2.6 Effect of years of retreat on EEG neural correlates

The maximum variation of the alpha peak with respect to basal conditions ($\Delta_{\alpha\text{-peak}}$) was further used to investigate the effect of the years in retreat of advanced meditators on EEG neural correlates. We focused on this feature since it was the one that showed the most marked differences between the two types of meditation (see section 2.9), and given its possible relationship with inhibitory attentional mechanisms (Foxe and Snyder, 2011; Hanslmayr et al., 2011; Diepen et al., 2019; Antonov et al., 2020). This analysis was performed on a smaller sample made of 4 monks performing a total of 11 sessions (mean = 2.2 sessions each monk). We decided to limit the analysis to these 4 monks to have rigorous control over the time spent in meditation. Indeed, all of them had been engaged for a minimum of 6 months to a maximum of 7 years in the same type of retreat (Yamantaka retreat), which involves a very specific number of meditation sessions (i.e., 4 per day), lasting approximately 2 h each.

2.7 Statistical analysis

Because of the great heterogeneity of the dataset in terms of session variability (i.e., subjects "did their best" with no specific constraints on the duration of the meditation session), we performed both within session statistics to quantify the evolution of the EEG spectrum within the meditation session, and between session statistics to compare the two types of meditations.

Within-session statistics were performed separately for each subject. Particularly, we evaluated significant differences between each 5-min long window of the meditation session and the resting baseline. To this aim, for each AFB PSD feature, we used a Wilcoxon rank sum test to test the null hypothesis of no significant difference between conditions ($\alpha = 0.05$). Multiple hypothesis testing was controlled with the Benjamini-Yekutieli false-discovery-rate (FDR) method, which controls the level of false positives under the presence of a (generic) dependency structure among tests (Benjamini and Yekutieli, 2001). Based on this analysis, we extracted descriptive statistics of each type of meditation by quantifying the percentage of windows in which AFB PSD significantly differed from the baseline.

Between session statistics were performed at the group level on CHR PSD features. To this aim, we used linear mixed models (s) as implemented in the fitlme MATLAB function. These models allowed to handle the heterogeneity of our dataset, i.e., (i) the partially unpaired data (i.e., some subjects performing only one type of mediation and some others performing both) and (ii) the unbalanced number of observations (i.e., some subjects performing more than one session). For each feature, we fitted a specific model as in Equation (1), with $\text{meditation}_{\text{type}}$ as fixed factor and random intercept. Multiple hypothesis testing was controlled with the FDR method (Benjamini and Yekutieli, 2001).

$$feat \sim 1 + \text{meditation}_{\text{type}} + (1|id) \tag{1}$$

Finally, to investigate the effect of the years spent in retreat of advanced meditators on the maximum variation of the alpha peak, we used the model in Equation (2) with time_in_retreat as fixed factor and random intercept.

$$\Delta_{\alpha-\text{peak}} \sim 1 + \text{time\_in\_retreat} + (1|id) \tag{2}$$

3 Results

We gathered data from 23 subjects performing analytical and/or concentrative meditation for a total of 35 sessions. Sixteen of these sessions were concentrative meditations, while the remaining 19 were analytical.

3.1 Within session changes in tvPSD of analytical and concentrative meditation

We observed significant differences during each meditation session compared to a resting baseline. Most of the observable differences occurred during the concentrative sessions, although changes were present also in some of the analytic sessions. A prototypical example from the same participant of the changes elicited by analytical and concentrative sessions on tvPSD is reported in Figure 1, while single subject statistics are reported for each participant in the Supplementary materials (single_subject_ranksum_tests_results.zip). Particularly, for each subject we report the time windows during which AFB PSD features significantly differed from the baseline.

For the concentrative meditations, we observed that most changes emerge after 20/25 min from the beginning of the session and that these last until the late stages of the meditation session (an exemplary subject of this phenomenon is reported in Figure 1D). This effect which seems to be replicable across expert meditators, should be confirmed/refuted in intermediates by enlarging the sample size for this last group. For the analytical meditation, changes were less evident compared to the concentrative sessions.

In Table 2, we summarize the within-subject analysis by reporting, for both types of meditation, the percentage of windows during the session that significantly differed from the baseline. We observed that concentrative meditation induced more changes in the EEG spectrum compared to analytical meditation in all frequency bands except for β_1, for which, changes were comparable between meditative practices. Yet, both types of meditation produced significant changes compared to the baseline. A scalp distribution of maximal positive and negative differences observed during the meditation session is reported for each type of meditation in Figure 2. Concentrative meditation showed most marked changes in positive deviations from the baseline compared to analytical meditation. Among these, changes were mostly observed in α band for frontal and posterior regions. Similarly, most

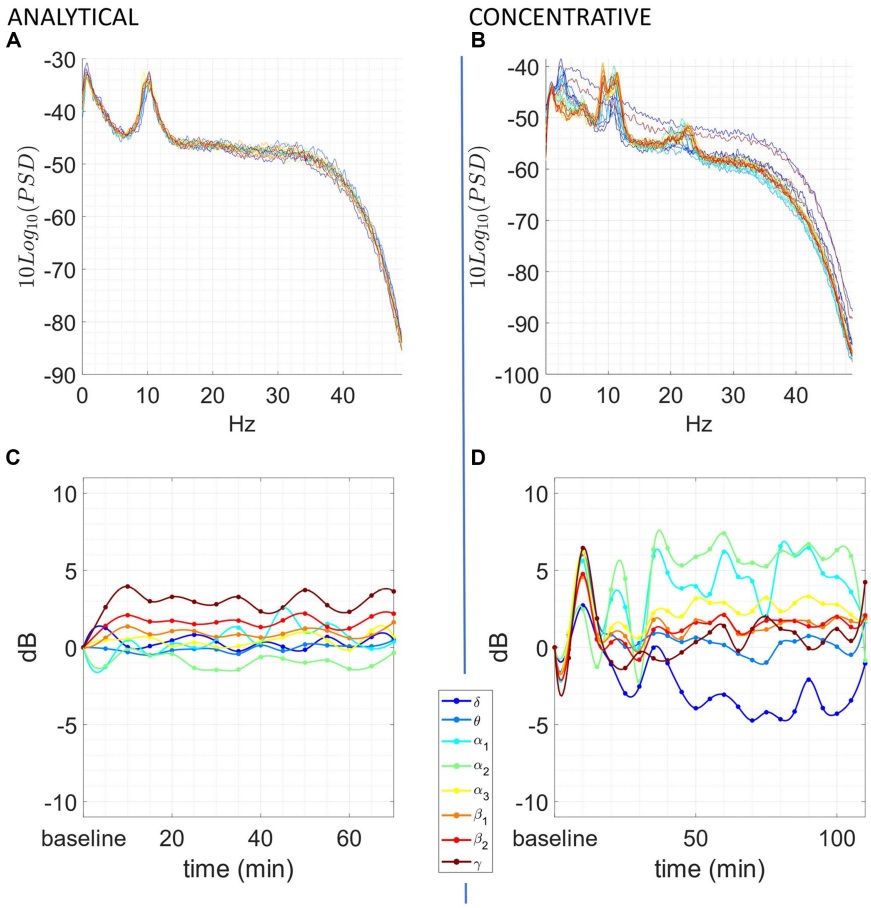

FIGURE 1
Exemplary of an analytical meditation session (left) and concentrative meditation session (right). Top: **(A,B)** tvPSD: each line in the spectrum corresponds to the PSD estimated in a 5-min-long window. Time is encoded in line color, from the beginning of the session (blue) to the end of the session (red). Bottom: **(C,D)** changes in tvPSD compared to baseline. The tvPSD is integrated in each considered frequency band.

marked changes in negative deviations from the baseline were observed for concentrative sessions, mainly in the γ band for frontal regions.

3.2 Neural correlates of analytical and concentrative meditation

Analytical and concentrative meditation were also compared directly, by using LMMs. The aim was to identify the features that significantly differed between the two types of meditation, as well as to provide robust EEG measures that best characterized such differences.

In Figure 3, we report the results of the main effects of the type of meditation performed on each frequency-band deviation in dynamic PSD. We observed that many of these features significantly differed between concentrative and analytical sessions. Interestingly, these differences occurred mainly for the positive deviations from the baseline, $\Delta+_{\delta}$ ($t=2.6883$, df = 33, $p=0.0112$), $\Delta+_{\theta}$ ($t=4.4227$, df = 33, $p=9.993e\text{-}05$), $\Delta+_{\alpha1}$ ($t=5.6642$, df = 33, $p=2.595e\text{-}06$), $\Delta+_{\alpha2}$ ($t=2.962$, df = 33, $p=0.0056$), $\Delta+_{\alpha3}$ ($t=2.5253$, df = 33, $p=0.0165$), $\Delta+_{\beta1}$ ($t=4.2475$, df = 33, $p=1.6581e\text{-}03$), $\Delta+_{\beta2}$ ($t=2.9086$, df = 33, $p=6.4496e\text{-}04$) compared to the negative deviations; $\Delta\text{-}_{\alpha1}$ ($t=-2.2365$, df = 33, $p=0.0322$). Particularly, except for Δ-α1, all these features showed higher values during concentrative meditation compared to analytical meditation. In Figure 4, we separately report the maximum variation of the α peak (i.e., $\Delta_{\alpha\text{-peak}}$). This feature, which is directly observable only in CHR PSD analysis, was significantly different between conditions ($t=4.9434$, df = 33, $p=2.1795e\text{-}05$) and seems to markedly distinguish between the two types of meditation compared to the other considered features.

Overall, since these features represent a variation between the meditation conditions and the resting baseline, this result indicates that concentrative sessions elicited stronger variations in the EEG power compared to analytical sessions.

TABLE 2 Percentage of windows with significantly different tvPSD with respect to baseline for each frequency band.

	Analytical	Concentrative
δ	33.33%	58.33%
θ	50.00%	66.67%
α_1	71.43%	86.36%
α_2	50.00%	66.67%
α_3	28.57%	80.00%
β_1	71.43%	68.18%
β_2	71.43%	77.78%
γ	76.92%	83.33%

3.3 Peaks in PSD in beta frequency range

We found several EEG sessions for which a marked peak (*bump*) in the spectrum in the β range was present. *Bumps*, which sometimes increased up to 6 dB during the session, were clearly observed in 20 sessions out of 35. An exemplary of this phenomenon is reported in Figure 5, while in the Supplementary materials (Table_a_supp_mat.xlsx), we report the presence/absence of *bumps* during baseline and meditation, as well as their PSD difference (Δ_{bump}) and the frequency at which they occurred. The *bump* was more frequent in the advanced meditators (13/16), compared to the beginners (2/9) and more frequent during concentrative sessions (12/16), compared to analytical (8/19).

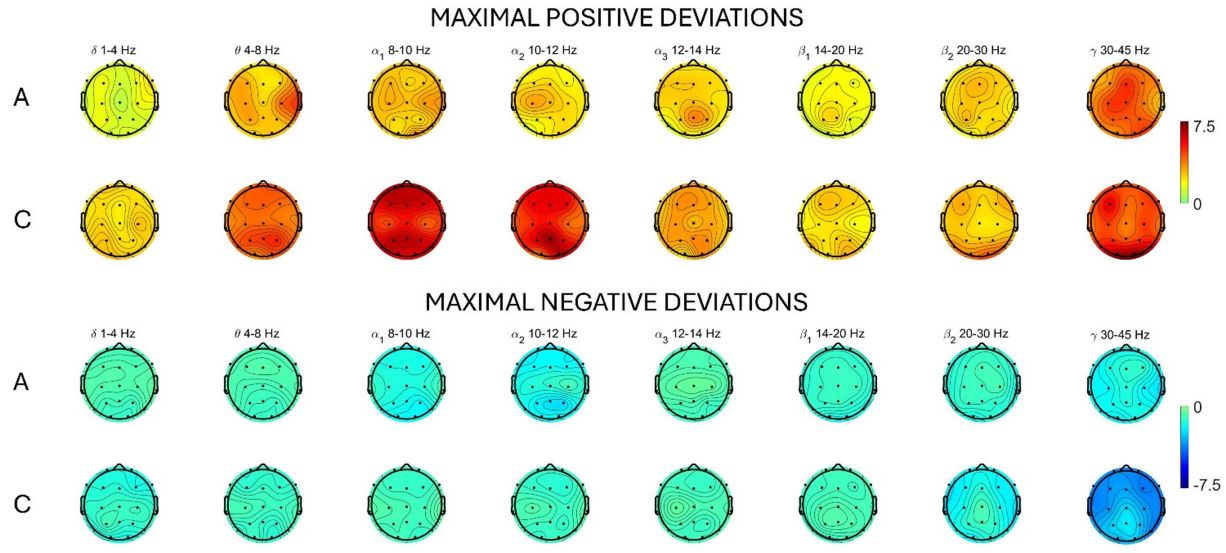

FIGURE 2
Average scalp map distribution for analytical (A) and concentrative (C) meditation. For each frequency band, the maximum difference (dB) (averaged across subjects) between the PSD during the session and the baseline is reported. Top: maximal positive deviations from baseline. Bottom: maximal negative deviations from baseline.

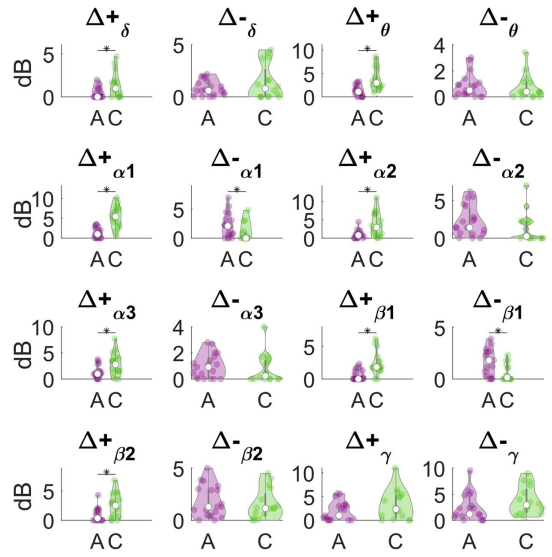

FIGURE 3
Analytical vs. concentrative. Violin plots of frequency-band deviation in dynamic PSD. Statistically significant differences ($p < 0.05$, FDR-corrected) are marked with an asterisk (*).

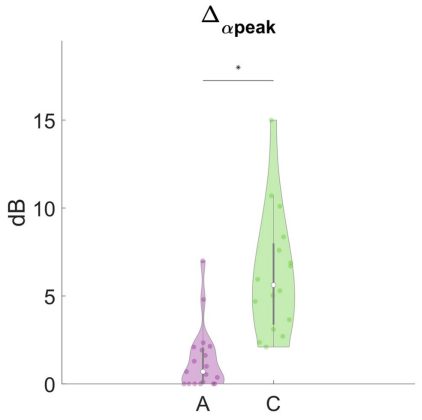

FIGURE 4
Analytical vs. concentrative. Violin plots of $\Delta_{\alpha\text{-peak}}$. This feature was the feature with the most marked differences between analytical and concentrative sessions. Statistically significant differences ($p < 0.05$, FDR- corrected) are marked with an asterisk (*).

3.4 Special cases

In addition to these widespread differences that characterized the two types of meditation, we observed some isolated events, which may be of interest and which, in our opinion, deserve a phenomenological description. These phenomena have been observed only in concentrative sessions. Particularly, we observed that:

(i) In some meditators, the alpha peak in baseline does not exist.
(ii) In 3 cases, the α peak disappears abruptly after 10/15 min of concentration session, and then re-emerges later. This effect is accompanied by an abrupt variation of the spectrum in all bands. An exemplary is reported in Figure 6.
(iii) In other 3 cases, an inverse trend between the variations in the θ/α range and those in the β/γ range. More specifically, we observed that when AFB PSD increases in θ and/or α bands, a decrease in β/γ range is also present, and vice versa. This phenomenon happens just for advanced meditators during concentrative sessions. An example of this phenomenon is reported in Figure 7.

3.5 Effect of years of retreat on the maximum variation of the α peak

The effect of years of retreat of advanced meditators on the variation of the α peak showed a significant effect of "time_in_retreat" factor on such EEG neural correlate ($p = 0.039$). This result indicates that meditators whit more experience may exhibit more marked changes in the EEG signal, compared to less experienced ones.

This last phenomenon has been observed only in the case of intermediate or advanced meditators engaged in the concentrative session. Finally, the same meditator of Figure 6C engaged in an analytical session is reported in Figure 8. As we can see, this session does not show any negative correlation between the behavior of α_1 and θ power with respect to those of β_2 and γ power.

4 Discussion

In this work, we analyzed the neural correlates underpinning analytical and concentrative meditation. We compared several features derived from the EEG to identify the most specific electrophysiological correlates of each type of meditation. Twenty-three monks from the Tibetan Monastery of Sera Jey with different level of experience were analyzed during meditation sessions of variable duration. We showed that concentrative meditation exhibited the most relevant changes in the EEG features compared to the resting baseline. In addition, several significant differences in the EEG power features were observed between analytical and concentrative meditation. We analyzed a total of 35 meditation sessions (19 analytical, 16 concentrative) that allowed to test: (i) Whether the two main types of Tibetan meditation, the analytical and the concentrative one, are characterized by different neuronal correlates; (ii) If there are quantitative features derived from the EEG that can characterize the two types of meditation (i.e., that significantly differ between conditions).

We could exploit the unique opportunity of cooperating with a group of meditators that carried out their studies in the same community and shared the same cultural and social context for their last 10 years at least: i.e., the monks of the Sera Jey Tibetan Monastery in India. Our study provides some potential novel approaches for the study of meditation. Particularly, we aimed at limiting any potential influence of the experiment on the quality of each meditation session by adopting specific choices. Firstly, by acquiring the data inside the Tibetan Monastery of Sera Jey together with the volunteers and scholars of the Monastic University, we could examine the subjects in a more ecological fashion (i.e., without removing them from their own environment). This approach allowed to limit any potential influence of the typical laboratory setting on the meditation sessions, and thus on the acquired data (see Zaccaro et al., 2021 for a similar approach

in a recent Nidra Yoga research). Secondly, we left the meditators to "do their best," without any time limit on the meditation session. This choice was purposely made to account for subject specific differences in reaching the desired mental state or performing the desired meditation during the experiment. This latter aspect did not come without issues, since it heterogenized the nature of the acquisitions. To mitigate such an issue, we purposely set up the double strategy of performing both within session and between session analyses. The within session analysis allowed us to characterize the key aspects of each type of meditation, such as the variations in the spectra underpinning the meditation session. Instead, the between session analysis highlighted the most marked deviations from the resting baseline that, for different meditators, could occur at different instants during the meditation session. Particularly, we exploited not only averaged (i.e., AFB) but also High Resolution (i.e., CHR) PSD features to highlight these deviations that were further used to best discriminate between the two types of meditation. Overall, these choices offer interesting insights in the design of novel experiments that are naturally influenced by subjective differences.

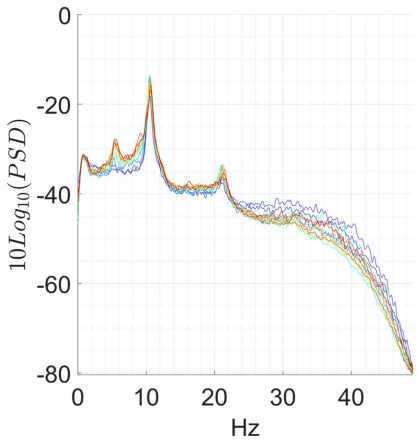

FIGURE 5
Exemplary of *bump*. A marked peak is observed at 21.5 Hz.

4.1 Concentrative vs. analytical meditation

Concentrative meditation elicited variations in the EEG power compared to baseline that differed from those elicited by analytical meditation. Particularly, $\Delta_{+\delta}$, $\Delta_{+\theta}$, $\Delta_{+\alpha1}$, $\Delta_{+\alpha2}$, $\Delta_{+\beta1}$, $\Delta_{+\beta2}$, $\Delta_{-\alpha1}$ and $\Delta_{\alpha\text{-peak}}$ were significantly different between the two practices. Positive deviations from the baseline (i.e., $\Delta_{+\delta}$, $\Delta_{+\theta}$, $\Delta_{+\alpha1}$, $\Delta_{+\alpha2}$, $\Delta_{+\beta1}$, $\Delta_{+\beta2}$), as well as $\Delta_{\alpha\text{-peak}}$ were significantly higher for concentrative sessions, compared to analytical sessions. Conversely, the negative deviation observed for $\Delta_{-\alpha1}$ was significantly lower during concentrative meditation compared to analytical meditation. These results indicate that the most evident changes in the EEG spectral properties between analytical and concentrative meditation happen in the form of an increased EEG power in low frequency range, mainly θ, α_1, and α_2, with respect to baseline, whereas a decrease in gamma range is observable in both type of sessions.

Among these features, $\Delta_{\alpha\text{-peak}}$ is of particular interest, as it also handles the variation in the frequency of the alpha peak, which could vary during the session. $\Delta_{\alpha\text{-peak}}$ corresponds to the maximum positive variation, during the session, of the height of the α peak with respect to the baseline, and it was the feature with the clearest differences between the two types of mediation. In this light, we may suggest that this feature is the most representative for distinguishing between analytical and concentrative meditation. Furthermore, from a visual inspection of the tvPSD, an increased α peak seems to be a hallmark of concentrative meditation that rarely appears in analytic sessions. Indeed, while for analytical sessions changes in PSD rarely exceed ~2 dB, concentrative ones showed much higher variations (up to 15 dB). This feature was further exploited to investigate for an effect of

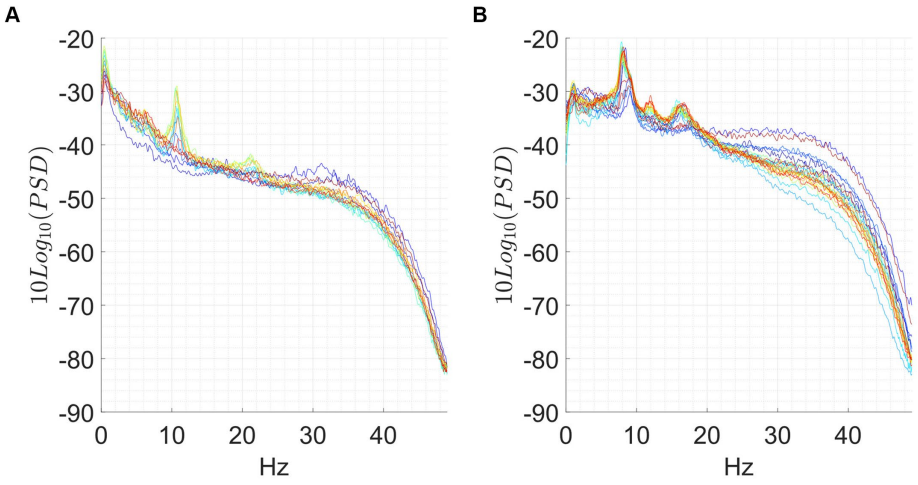

FIGURE 6
(A) In this subject the α peak is absent on the baseline. Then it emerges at frame 55–60 (green line), to turn off abruptly at frame 65–70 and remain off until the end of the session. **(B)** In this subject the α peak, is reduced in the baseline and then there is a first switch in frame 10–15 in which the whole spectrum grows, and the alpha peak is absorbed, then the spectrum returns to the state prior to the switch, and we assist to an increase of the alpha peak for approximately 95 min. In windows ranging from 110 to 115 min the phenomenon happens again and the alpha peak disappears.

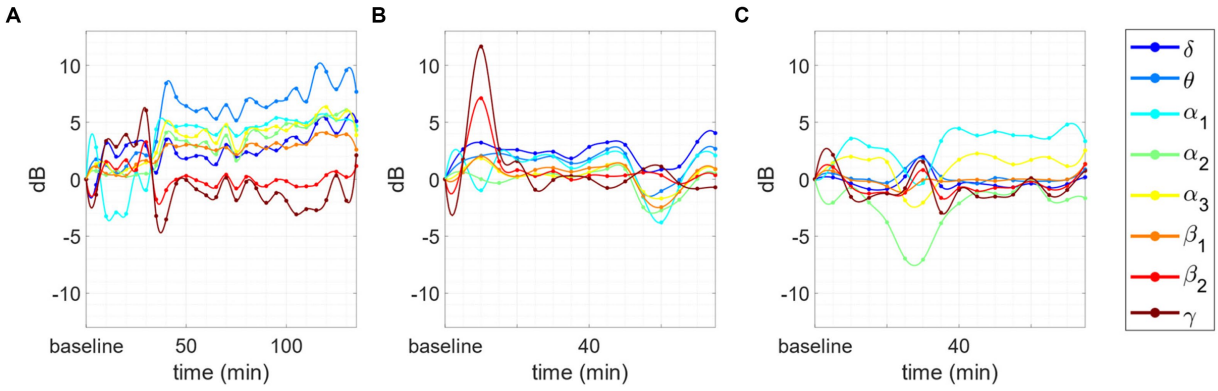

FIGURE 7
Changes in the PSD compared to baseline for 3 subjects. Inverse behavior between $\theta/\alpha_1/\alpha_2$ and β_2/γ AFB PSD. **(A)** After the first part of the session the power in α_1 and α_2 increase with respect to the baseline, whereas β_2 and γ decrease: the phenomenon is evident in the first 7 points (35 min). **(B)** The inverted trend starts after 10 min of meditation and continues for the whole session: the phenomenon is evident in the first 8 points (40 min). **(C)** The inverted trend is clear after at the very beginning of the session (10 to 20 min) and during the las 20 min of meditation: the inverse behavior is evident in the initial and final peaks situated, respectively, between 10 and 20 min and 55 and 70 min.

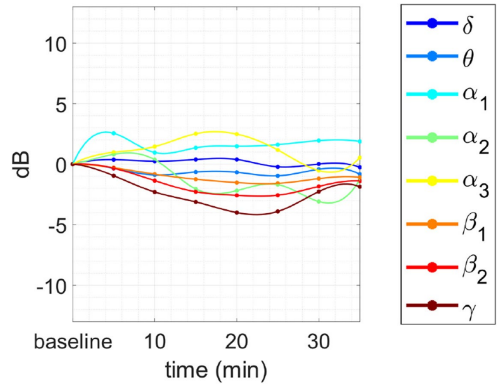

FIGURE 8
Changes in tvPSD compared to baseline. We report changes during an analytical session for the same meditator of Figure 7C.

the years spent in retreat of advanced meditators on the EEG signal. For this subset, meditators are much comparable among them due to the rigorous scheme of their daily practice. Although preliminary, our results indicated a significant effect of years spent in retreat on the maximum variation of the α peak that would merit further investigation by enlarging the sample size used for the analysis.

In the field of Contemplative Neuroscience, the slowing of cortical EEG rhythms, specifically the augmentation of alpha and theta band power, predominantly across frontal regions (Fell et al., 2010), aligns with findings from systematic reviews on contemplative practices (Lomas et al., 2015; Lee et al., 2018). Modulation of alpha and theta band power constitutes a distinctive trait of non-ordinary states of consciousness induced through various means such as slow breathing, relaxation, hypnosis, and psychedelic substances (Aftanas and Golocheikine, 2001; Holroyd, 2003; Fumoto et al., 2004; Jacobs and Friedman, 2004; Yu et al., 2011; Park and Park, 2012; Timmermann et al., 2019), although these states have been effectively distinguished from meditation in numerous studies (Halsband et al., 2009; De Benedittis, 2015; Thompson and Markovic, 2016). At the first-person level, modulations of alpha and theta oscillations have been associated with positive psychological outcomes, including reduced levels of anxiety, depression, anger, and confusion, alongside heightened awareness, perceptual clarity, and introspective attention (Fumoto et al., 2004; Yu et al., 2011; Zaccaro et al., 2018, 2021). Furthermore, the enhancement of theta power has been correlated with the deepening of the meditative state and assumes a critical role in non-ordinary states of consciousness, as evidenced by recent studies on ultra-slow nasal stimulation and slow breathing practices (Piarulli et al., 2018; Zaccaro et al., 2021, 2022). The specific increase of alpha power during concentrative meditation in the present study may be elucidated in light of numerous prior studies exploring the interplay between alpha oscillations and inwardly directed attention regulation, sensory processing, and task performance. While conventionally interpreted as reflective of the brain's "idle" state at rest, alpha oscillations are now acknowledged as active mechanisms in attentional modulation and excitability control (Ben-Simon et al., 2008). Alpha oscillations have been linked with heightened interoceptive attention, observed not only during meditation but also during other attentional tasks where participants internally shift focus, such as toward heartbeat sensations during cardiac interoceptive tasks, hence inhibiting external sources of distraction (Villena-González et al., 2017; Kritzman et al., 2022). Taking previous body of evidences into account (Foxe and Snyder, 2011; Hanslmayr et al., 2011; Diepen et al., 2019; Antonov et al., 2020), heightened alpha-band activity can be here interpreted as an index of an active inhibitory attentional mechanism, suppressing irrelevant and distracting inputs and reflecting the prioritization of task-relevant information (e.g., focusing and sustaining attention on a single object) over irrelevant stimuli, which is specifically required during concentrative meditation.

Of note, from a visual inspection of the tvPSD, we also observed that the most marked differences in the spectra of concentrative sessions occurred for those advanced meditators with more years of retreat. Interestingly, the duration of the session seemed to affect such variations. Indeed, the most marked variations were observed for those sessions whose duration exceeded 45 min. However, considering

the limited size of the sample, we could not properly test the influence of these features in a more rigorous way. In this light, feature improvements would include a larger number of subjects for each group in the analysis.

Although preliminary, our results seem to indicate that expert meditators engaged in concentrative sessions show marked and repeatable modifications of the EEG power to hypothesize a non-ordinary state of consciousness different from wakefulness and sleep at least as far as neural correlates observable by EEG is concerned. This is particularly true in the case of advanced meditators in retreat, whose PSD during the baseline can be completely modified in all the bands during the meditation session (see Figure 1B). Further support to this claim is given by the fact that equally experienced full-time meditators did not show equally significant changes in power during analytical sessions (see Figure 1A and Supplementary materials – single_subject_ranksum_tests_results.zip and single_subjects_tvPSD.zip-). However, we cannot exclude that analytical meditation may induce alterations in brain activity not properly captured by power measures. In this light, future studies involving other measures, such as connectivity and network metrics may help at understanding the underpinnings of this practice.

4.2 Special cases

In some participants, we observed a series of phenomena that may be of particular interest. Probably, the most relevant is the presence of *bumps*: i.e., the presence of a marked peak in the β frequency range observable only from CHR PSD analysis. This phenomenon occurred more frequently for advanced meditators in both analytical and concentrative sessions (13/15) compared to beginners (2/9). In this light, their presence could represent a trait of experience rather than of type of meditation. Yet, considering that experienced meditators performed mostly concentrative sessions, while beginners performed mostly analytical sessions, we cannot completely support this hypothesis that merits further investigation. However, since such a phenomenon has never been reported in the literature of meditation, we provide here a first observational description. Jensen and Mazaheri (2010) suggested that high-α/low-β controls information processing by inhibiting task-irrelevant regions in the brain. In this light, we could hypothesize that experienced meditators are more able to perform such an inhibition compared to beginners.

Another interesting behavior is the abrupt commutation of the PSD trend with abrupt disappearance and subsequent reappearance of the peak in the α band. While this behavior is very common when closing the eyes (i.e., switching from eyes-open to eyes-closed condition), it is less evident in stationary eyes-closed condition. We speculate that this phenomenon may reflect a switching between different mental states. However, more investigation is needed in this direction. For instance, it is suggested to include in the experimental protocol a system for reporting potential switching in mental states experienced by the meditator, as for instance a trigger button manually annotate on the EEG acquisition particular events experienced during the session. Moreover, we cannot exclude that using shorter time windows such changes may be smoother.

Finally, based on the AFB PSD analysis, we observed, in some cases, an opposite behavior between the time-dependent variations of PSD in the θ/α1 bands and those in the β2/γ bands during concentrative sessions, in the sense that when one increased the other decreased and vice versa. Interestingly, this happened for advanced meditators but not for intermediate meditators nor beginners. Considering that concentrative sessions are performed mostly by intermediate or advanced meditators, it may be suggested to include a larger population of advanced meditators for further testing on this phenomenon. In this light, given the coupling properties of θ/γ frequency bands future analysis should focus on the study of brain connectivity which may provide complementary information to the one provided in this work.

4.3 Future developments

Although our results are based on robust statistical testing, they may require further refinements of the data acquisition and processing procedure. Particularly, it will be necessary to increase the number of volunteers, as well as to balance their number among beginners, intermediate and advanced in both conditions (i.e., concentrative and analytical). This aspect is particularly important since, in the investigated sample, there is an intrinsic correlation between the meditator experience and the type of meditation performed. More specifically, advanced meditators tend to perform concentrative sessions, compared to beginners who focused more on analytic meditation. In this light, we cannot exclude that some of the observed differences between concentrative and analytic meditation may be also due to meditator's expertise. However, it is worth noting that from single subject analyses (see Supplementary material) analytic sessions are similar among them, independently from the level of expertise of the meditator. Accordingly, it is reasonable to assume that the observed changes in the neural correlates of concentrative and analytical meditation may derive from intrinsic differences in the type of meditation rather than on meditator's experience.

Additionally, it would be particularly useful to integrate in the analysis the information reported in the questionnaire submitted to the volunteer before and after the meditation session, as well as to include in the analysis the information on the meditator's subjective experience during the various phases of the session. In this work, we assumed that being analytic and concentrative meditation two completely different practices, differences in the EEG neural correlates would be observable even based on such simple distinction. Nevertheless, more sophisticated analysis could include subjective experience of meditators by including specific descriptions of the meditative session and state through the use of structured questionnaires. This latter kind of integration would be beneficial for enhancing the psychophysiological interpretations of our results, which have been left for future studies.

Data availability statement

The datasets presented in this article are not readily available because they contain information that could compromise the privacy of research participants. Requests to access the datasets should be directed to bruno.neri@unipi.it, alejandro.callara@unipi.it.

Ethics statement

The studies involving humans were approved by Ethical Committee of the University of Pisa (n. 0117745/2020). The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study.

Author contributions

BN: Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Software, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing. AC: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Software, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing. NV: Conceptualization, Formal analysis, Investigation, Methodology, Writing – review & editing. DM: Conceptualization, Investigation, Methodology, Writing – review & editing, Formal analysis. AZ: Conceptualization, Formal analysis, Investigation, Methodology, Writing – original draft, Writing – review & editing. AP: Formal analysis, Writing – review & editing. ML: Formal analysis, Software, Writing – review & editing. NN: Conceptualization, Formal analysis, Investigation, Writing – original draft. JK: Conceptualization, Formal analysis, Investigation, Writing – original draft, Writing – review & editing. NS: Conceptualization, Formal analysis, Investigation, Writing – original draft, Writing – review & editing. AG: Conceptualization, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Supervision, Writing – review & editing.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

The author(s) declared that they were an editorial board member of Frontiers, at the time of submission. This had no impact on the peer review process and the final decision.

Publisher's note

Supplementary material

The Supplementary material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fpsyg.2024.1348317/full#supplementary-material

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Taking the edge off: a feasibility randomized controlled trial of an online mindfulness-based intervention to reduce suspiciousness/paranoia in high positive schizotypy

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Positive schizotypy can uniquely predict the development of psychosis with suspiciousness/paranoia having emerged as a key risk factor, pointing to significant worth in reducing this aspect in individuals with high positive schizotypy. Reduced paranoia in the general population following brief online mindfulness training has been previously reported. This study investigated the feasibility of a 40-day online mindfulness-based intervention (MBI) ($n = 12$) in the individuals with high positive schizotypy characterized by high suspiciousness/paranoia and to estimate its effect on paranoia as compared with an active control condition using reflective journaling ($n = 12$). The outcome measures were self-reported trait and VR-induced state paranoia, completed at baseline, after 10 days and post-intervention. The feasibility criteria included retention, adherence, engagement, and acceptability. There was 100% retention, excellent adherence to content and engagement, with an average MBI session completion rate of 91%. Acceptability, indexed by a self-rated motivation to continue practice post-intervention, was also high. No MBI effect on trait paranoia was observed; however, the MBI group showed a reduction in the VR-induced state paranoia with a medium-to-large effect ($d = 0.63$). The findings support conducting larger-scale randomized controlled trials to evaluate the effects of online MBIs on reducing suspiciousness/paranoia to mitigate psychosis risk in individuals with high positive schizotypy.

Clinical Trial Registration: https://www.isrctn.com/, identifier ISRCTN78697391.

KEYWORDS

positive schizotypy, paranoia, virtual reality, randomized controlled trial, mindfulnessbased intervention, suspiciousness

1 Introduction

Schizotypy refers to a set of schizophrenia-like characteristics corresponding to the domains of schizophrenia: positive, negative and disorganized (Raine, 1991; Grant et al., 2018). Factor analytical studies using the self-report measures that are based on three symptom dimensions of schizophrenia have confirmed a three-dimensional factor structure of schizotypy (cognitive-perceptual, interpersonal-negative, and disorganized) in both clinical and non-clinical populations (Fonseca-Pedrero et al., 2018a,b). Viewed within a fully dimensional model, schizotypy is regarded as a normative set of personality traits found in the general population (Claridge, 1997; Grant et al., 2018), which do not necessarily lead to the development of schizophrenia-spectrum disorders. Positive and psychotic-like symptoms are reportedly common in the general population and can be transient in nature, without manifesting as a 'full-blown' psychosis (van Os et al., 2009).

However, schizotypy is also thought to present a latent disposition to schizophrenia (Kwapil and Barrantes-Vidal, 2015; Lenzenweger, 2015), with positive schizotypy (magical thinking, unusual perceptual experiences, ideas of reference, and suspiciousness/paranoia) shown to predict the emergence of schizophrenia-spectrum disorders and symptoms (Kwapil et al., 2013; Debbané et al., 2015; Lenzenweger, 2021). Whilst magical thinking and unusual perceptual experiences may not be pathological *per se* (Lynn et al., 1996) and have been linked with heightened creativity (e.g., Nettle and Clegg, 2006; Nelson and Rawlings, 2010; Badzakova-Trajkov et al., 2011; Acar et al., 2018), suspiciousness/paranoia appears to play a key role in psychosis development. High suspiciousness/paranoia is common in populations at high risk for psychosis (Salokangas et al., 2013), and prospective studies report its significant predictive power for psychosis onset in high-risk individuals (Cannon et al., 2008; Wilcox et al., 2014).

Like other positive-schizotypal experiences, paranoia is not confined to severe mental illness (Freeman et al., 2008a), laying on a continuum in the general population (Freeman, 2007a; Ellett, 2013). Even when fleeting, paranoid thoughts can be distressing and pre-occupying (Freeman and Garety, 2006; Freeman, 2007a) and can lead to problems adapting to the social world (Collip et al., 2013). Threatening appraisal styles toward unusual beliefs/experiences, characteristic of positive schizotypy (Cicero and Kerns, 2010), can lead to distress (Brett et al., 2014). Furthermore, beneficial associations of magical thinking and unusual experiences with creativity may be hindered by high levels of suspiciousness/paranoia (McDonald et al., 2021). There is, therefore, significant worth in reducing suspiciousness/paranoia in individuals with high positive schizotypy to minimize distress and optimize benefits associated with positive-schizotypal traits in the short-term, and to possibly mitigate psychosis risk in the long-term.

Mindfulness-based interventions are promising in this regard. Mindfulness practitioners show significantly lower suspiciousness/paranoia in the presence of higher magical thinking as compared with the general population (Antonova et al., 2016), suggesting that these aspects of positive schizotypy are dissociable with mindfulness practice. Aspects integral to paranoid processes include cognitive and belief inflexibility, rumination (Freeman et al., 2005; Mills et al., 2007; Bebbington et al., 2013), and self-focused attention – specifically, increased experience of the self as a target for others' thoughts and behaviors (Ellett and Chadwick, 2007). Mindfulness, on the other hand, is a process of experiencing mental content, whether it is thoughts, feelings or body sensations, including distressing ones, as passing events in the mind with openness, acceptance and without judgement or elaboration, promoting self-compassion (Woods and Proeve, 2014) and compassion for others (Condon et al., 2013). Trained mindfulness is associated with reduced activation of the Default Mode Network and its connectivity during processing of self-related content (narrative self-referencing) in novices (Farb et al., 2007) and long-term practitioners (Berkovich-Ohana et al., 2012). Finally, rumination is negatively associated with mindfulness (Burg and Michalak, 2011; Hawley et al., 2014).

Mindfulness training has been shown to reduce paranoia in the general population, mediated by increased mindfulness skills (Shore et al., 2018), and can favorably change the relationship with paranoid thoughts in people experiencing psychotic symptoms (Abba et al., 2008). Whilst negatively associating with paranoia, mindfulness skills such as non-judging have been shown to buffer the impact of trait paranoia upon state paranoia (Kingston et al., 2019). This would be particularly valuable for individuals prone to unusual experiences or thoughts, which have potential to cause distress in the presence of high trait suspiciousness/paranoia.

Notably, Shore et al. (2018) and Kingston's (2019) studies utilized mindfulness meditation sessions lasting just 10 min (as compared to the traditional 20–45 min), which is within the remits of what is considered acceptable and safe for individuals experiencing distressing symptoms of psychosis (Chadwick et al., 2005, 2009; Chadwick, 2006, 2014), and could therefore be considered safe for use in a healthy sample from the general population with increased vulnerability to psychosis.

Although typical mindfulness-based interventions (MBIs) are delivered via 8-week in-person programs led by a qualified instructor (Kabat-Zinn, 1982; Teasdale et al., 2002; Kabat-Zinn, 2003), these can be costly, and in-person participation limits deliverability and accessibility (Cavanagh et al., 2014). In contrast, online delivery formats can be relatively inexpensive (Cavanagh et al., 2014) and can greatly increase deliverability and accessibility, particularly since the Covid-19 pandemic has vastly normalized the use of online resources in the general population. Focusing on online formats in mindfulness trials has been recommended due to promising effect sizes upon outcomes (Goldberg et al., 2021) and is thus of particular relevance for this feasibility study, given the reductions in paranoia observed after brief periods of online training (Shore et al., 2018; Kingston et al., 2019).

Commonly used self-report measures of trait paranoia (e.g., Paranoia Scale, Fenigstein and Vanable, 1992) are not suited to assessing state paranoia (paranoid ideation occurring in real time in response to certain situations). Immersive Virtual Reality (VR) has surfaced as an ecologically valid, reliable, and experimentally controlled approach to inducing and assessing state paranoia (Freeman et al., 2008b). VR is safe for use in general population samples (Freeman et al., 2008b), at-risk for psychosis groups (Valmaggia et al., 2007), and individuals with psychosis (Veling et al., 2014, 2016; Pot-Kolder et al., 2018). To the best of our knowledge, the assessment of state paranoia using VR has not yet been conducted in a sample of individuals high in positive schizotypy with high suspiciousness/paranoia or used as an outcome measure of a psychological intervention generally or in this population specifically.

The present study aimed to assess the feasibility of an online mindfulness-based intervention (MBI) and to estimate its effect on

reducing suspiciousness/paranoia in the individuals with high positive schizotypy. The MBI was delivered using *Headspace*, a commercially available meditation app, over the course of 40 days in accordance with *Headspace* package formats. This consisted of daily 10-min meditations, in line with previous studies (e.g., Shore et al., 2018) and safety considerations for psychosis-vulnerable individuals. The feasibility criteria of retention, adherence, and engagement were assessed objectively. Acceptability was assessed using self-rated motivation to continue using *Headspace* post-trial. The MBI effect on suspiciousness/paranoia was assessed using a validated self-report trait measure as well as self-reported state paranoia as induced by a VR environment. Given the general lack of active control designs in MBI trials (Goldberg et al., 2021) and to investigate the MBI effects over and above those related to non-specific factors, a closely matched active control using online reflective journaling via a freely available app *Reflectly* was utilized.

2 Methods

2.1 Participants

The participants were sampled from our earlier online survey study sample ($N = 342$; McDonald et al., 2021) and 93 additional individuals from the general population recruited between May 2019 and March 2020 via London-based universities, Facebook groups, and local forums. All participants completed the same online survey [described in detail in McDonald et al., 2021], which contained the Schizotypal Personality Questionnaire (SPQ; Raine, 1991). They were invited to take part if they met the following inclusion criteria for the feasibility RCT: (i) scoring at least +0.5 *SD* above the mean on the SPQ Positive Schizotypy dimension; and (ii) scoring at least +0.7 *SD* above the mean on the SPQ *Suspiciousness* subscale of the SPQ Positive Schizotypy dimension. The mean was based on normative data from the general population sample ($N = 342$) of McDonald et al. (2021), since this produced comparable SPQ general population means reported elsewhere (e.g., Gibson et al., 2009).

Participants also confirmed (via a checkbox in an online survey) that they met the following general inclusion criteria: (i) fluency in English; (ii) no history or current diagnosis of a mental illness, neurodevelopmental or neurological disorders (as diagnosed by a professional health practitioner, neurologist, psychiatrist or psychologist); (iii) no history of or current substance abuse; (iv) have not engaged in formal, regular mindfulness practice (as defined by an *intentional commitment* of time to practice at least 10 min per day, 4–5 times per week within the past 3–4 months).

The online survey data were inspected for random response patterns by identifying univariate and multivariate (the analysis of Mahalanobis distance) outliers, the survey response times were also examined; no random responders or problematic response times were identified.

Out of all survey completers, 101 expressed willingness to participate in the feasibility study and were therefore assessed for eligibility. The total of 32 participants meeting both feasibility study inclusion criteria were invited for the study.

Twenty-four participants (Mean age = 27.04, $SD = 11.24$, range = 18–58, 83% females) completed the RCT before further recruitment for the study/allocation to the groups ceased prematurely due to the UK government lockdown in response to the COVID-19 pandemic in March 2020, allowing to achieve the recommended minimum of $n = 12$ per group for a feasibility study (Julious, 2005). The total of 77 participants either did not meet the feasibility study inclusion criteria or declined the invitation/were not able to participate (see the consort diagram presented in Figure 1 for the exclusion reasons and the overall flow of the participants through the study).

The study was approved by the King's College London Research Ethics Committee (LRS-17/18–5,604).

Trial registration: ISRCTN78697391 (ISRCTN registry, https://www.isrctn.com/).

2.2 Design and procedures

A randomized, active control, parallel trial design was used. Participants responding to the advertisements completed the online eligibility screening survey. Eligible participants provided informed consent before being randomized by the researcher, in pairs, to either an MBI or active control group using a randomizing algorithm within Microsoft Excel. The trial flow is presented in the consort diagram (Figure 1).

The full assessment battery was administered at baseline (T0), followed immediately by either the MBI or active control, with self-reported paranoia assessed after the initial 10 days (T1), and the full assessment battery re-administered within 2 weeks of intervention completion (T2). All lab-based testing took place at the Institute of Psychiatry, Psychology and Neuroscience, King's College London, UK. Participants were remunerated with £50 (cash), as well as a complimentary 1-month subscription to *Headspace* for taking part and were compensated for travel costs.

2.2.1 Mindfulness-based intervention

The 40-day MBI consisted of daily, formal 10-min guided mindfulness practices provided by *Headspace*.[1] The meditations integrated periods of focused attention (FA; narrowing of attention onto a single object of focus, e.g., breath) and open monitoring (OM) or choiceless awareness (no specific object of focus, but a non-preferential awareness of the flow of perceptions, thoughts, feelings and body sensations). The first 10 days covered the foundations of mindfulness (*Basics* package, available free of charge) to familiarize participants with the main principles or *know-how* of FA and OM meditation practices, after which they were provided with a pre-paid access to the 30-day *Managing Anxiety* package. This package was selected as the most relevant for the aims of the current study from the *Headspace* portfolio, since anxiety has been identified as an antecedent of paranoia and anticipation of threat (Freeman et al., 2008a, 2012).

2.2.2 Active control

The active control condition was reflective journaling using the free online mobile app *Reflectly*, allowing for a reflective engagement with one's experience on a daily basis, but without the 'active' ingredient of explicitly practicing mindful orientation towards the experience (i.e., non-judgmental, non-elaborative, and non-reactive). This app was chosen due to its close similarity to *Headspace*'s graphic user interface to help match the likelihood of engagement between

1 https://www.headspace.com

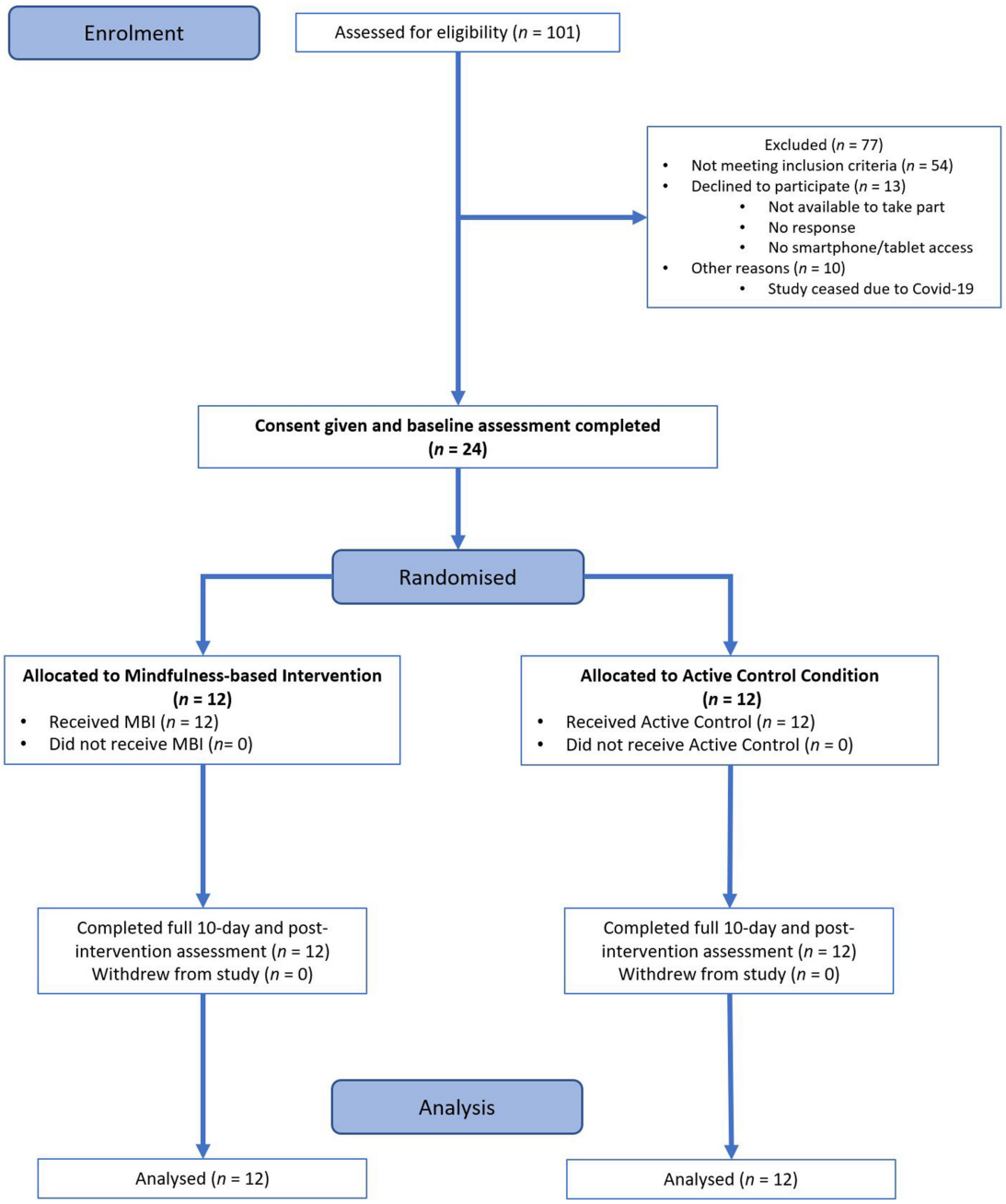

FIGURE 1
Consort diagram of trial profile.

groups as well as the length and regularity of journaling sessions with the MBI format. To reduce the likelihood of negative rumination and to avoid biasing participants' reflections toward either negative or positive aspects of their day based on their habitual tendencies, participants were advised to journal about general themes, such as "daily goals, concerns, relationships, or values."

Participants in both conditions were instructed to complete no more than one session per day and to pick up where they left off in the case of a missed session, even if this meant they would not complete all 40 sessions. All participants were instructed not to engage with any other formal mindfulness-based practices or materials during the trial.

2.3 Protocol to minimize attrition

A common challenge with online interventions is participant retention and engagement (Watson et al., 2018; Elfeky et al., 2020; Pratap et al., 2020). To minimize attrition, regular reminders/supportive emails and text messages were sent to participants at 10-day intervals throughout the intervention (see Supplementary Table A1). Retention may also benefit from personalized enrolment methods (Linardon and Fuller-Tyszkiewicz, 2020), therefore one-to-one app set-up and a detailed program orientation was provided at baseline. All participants were given

information leaflets relevant to their group allocation (see Supplementary Figures A2–A5).

2.4 Trial safety

The study was supervised by qualified mindfulness instructors and clinicians. All participants were invited to contact the researcher at any time during (or after) the trial if they had any concerns or difficulties. At the end of the trial, participants were asked for qualitative feedback regarding any difficulties experienced during the intervention. Signposting to further information and help regarding distressing suspiciousness/paranoia were in place from the start of the trial.

2.5 Feasibility criteria assessment

Retention was defined as the percentage of participants who completed all assessments.

Engagement was objectively monitored via the tracking tools within the apps (total sessions completed) and recorded by the researcher.

Adherence to the content and number of sessions completed per day were tracked within the *Headspace* app. Adherence tracking was not possible for the active control group due to *Reflectly* functionality - whilst the control group app limited one journal entry to be registered per date, it was possible for a user to input journal entries retrospectively, hence it was technically possible for participants to make multiple reflective entries within a single day.

To index acceptability and to account for motivation as a potential confounder, participants were asked to rate how motivated they felt to continue using the app (*Headspace*/*Reflectly*) using a visual analogue scale (1 = '*not at all motivated*' to 10 = '*extremely motivated*') at T1 and T2 assessments.

2.6 Outcome measures for estimating the MBI effect on paranoia

2.6.1 Trait paranoia

Trait paranoia was assessed using the Paranoia Scale (FVPS; Fenigstein and Vanable, 1992). Designed for use in non-clinical populations, this self-report measure comprises 20 items assessing general paranoid beliefs (e.g., *'It is safer to trust no-one'*) using a 5-point Likert-scale (1 = *'Not applicable to me'*, 5 = *'Extremely applicable to me'*), with higher scores reflecting higher paranoia. The FVPS has established reliability and validity (Fenigstein and Vanable, 1992) and has been shown to be sensitive to change following a brief online mindfulness intervention in healthy individuals (Shore et al., 2018).

2.6.2 State paranoia: VR environment and protocol

State paranoia was induced using a previously validated protocol implemented in an inter-personal VR environment (Riches et al., 2019), designed to imitate a nonthreatening everyday scenario (a party in a pub) with computer-generated human avatars of varied gender and ethnicity (Figure 2). The study followed the methods and protocols as reported elsewhere (Riches et al., 2019): participants wore a head-mounted VR display with integrated headphones (HMD; Oculus Rift, Version 2) and used an Xbox (Microsoft) control pad along with physically turning their body direction to move within the environment, giving a fully immersive 3D experience. Upon entering the 'pub', participants were met by a host and then made their way around the room to interact with other guests. The task lasted approximately 5 min and task fidelity was recorded by the researcher. There is no significant habituation or sensitization effects at group level to the VR task with repeated exposure after 40 days (Massaro, 2020, unpublished data).

Upon exiting the VR environment, participants completed the State Social Paranoia Scale (SSPS; Freeman et al., 2007b), which has 20 items rated on a 5-point Likert-scale (1 = *'Do not agree'*, 5 = '*Totally agree*'), with higher scores indicating higher levels of state persecutory thinking in relation to the VR social situation. Only the items for persecutory thinking were included for the analysis (10 items, e.g., '*Someone had bad intentions towards me*'). The SSPS has been shown to have good internal consistency, reliability, as well as convergent and divergent validity (Freeman et al., 2007b).

Following the methods of previous research (Riches et al., 2019), all participants completed the Slater-Usoh Sense of Presence Questionnaire (SUS; Slater et al., 1994) to identify any potential confounding effects of a sense of presence, with items adjusted to apply to the VR environment used in the current study; they were also asked whether they had previously used VR or regularly played video games.

2.7 Data analysis strategy

Statistical analyses were performed using SPSS (v24, IBM).

An independent *t*-test was used to test for baseline group differences in age and chi-square tests for differences in gender, ethnicity and current education level. Independent *t*-tests were also used to test for group differences in baseline schizotypy scores, trait (self-report) and state (as elicited by the VR environment) paranoia. Chi-square tests were used to test for group differences in VR task fidelity. Independent *t*-tests and chi-square tests were conducted to assess baseline group differences in the sense of presence during VR and prior experience of using VR and video games.

Effect sizes (Cohen's *d*) and 95% CIs were calculated for group differences in average motivation to continue with practice at T1 and T2 assessment points.

Effect sizes (Cohen's *d*) were calculated to quantify the effects of group upon score changes in trait and state paranoia from baseline (T0) to post-intervention assessment (T2). Cohen's classification was used to interpret the effect sizes as *small* ($d = 0.2$), *medium* ($d = 0.5$), and *large* ($d \geq 0.8$).

Baseline *SD*s were used for calculation to avoid influence of the allocated intervention/active control (Feingold, 2013, p. 144). The Reliable Change Index (RCI; Jacobson and Truax, 1992; Zahra and Hedge, 2010) was used to examine changes in paranoia on a case-by-case basis. General population norm data, as reported in previous studies (Fenigstein and Vanable, 1992; Freeman et al., 2007b) were used for RCI calculation due to the small size of the current sample.

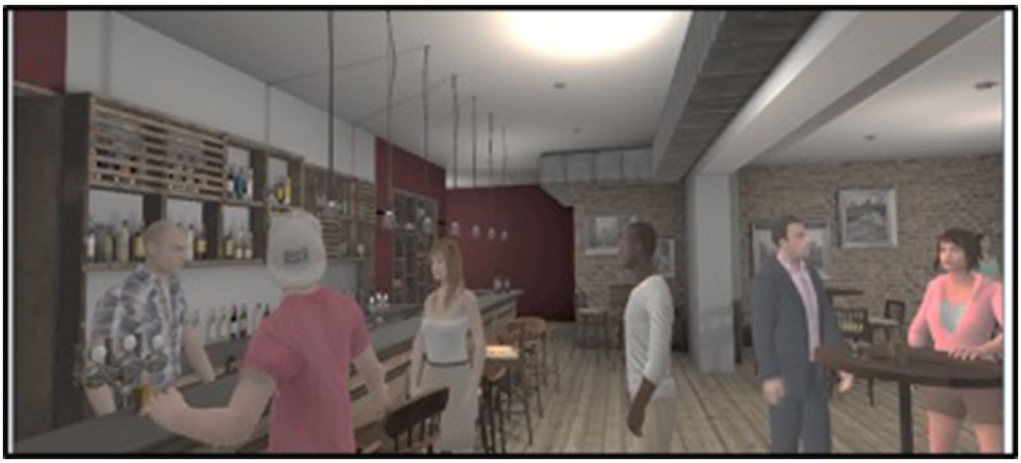

FIGURE 2
Immersive virtual reality environment ('pub') used for the purposes of the state paranoia measure (reproduced with permission from Professor Valmaggia, IoPPN VR Lab, King's College London).

3 Results

3.1 Baseline sample characteristics

Sample characteristics can be found in Table 1. There were no significant baseline between-group differences in demographic characteristics, including age, gender, current level of education, and ethnicity.

There were no significant baseline group differences on total schizotypy scores or the scores on positive, negative or disorganized dimensions, including the *Suspiciousness* subscale of the positive schizotypy dimension.

There were no significant baseline group differences for either trait or state paranoia. Elevated trait paranoia scores were found for the whole sample (FVPS Mean = 54.50, *SD* = 16.01), as compared with other non-clinical population samples (e.g., Freeman et al., 2005). All but two participants (1 MBI, 1 Control) endorsed paranoid items on the SSPS following the VR environment experience, with mean scores for the whole sample (Mean = 18.29, *SD* = 7.06) being similar to those previously reported in a sample of individuals with increased risk of psychosis (Valmaggia et al., 2015).

3.2 Feasibility criteria assessment

Retention rate was 100% in both groups.

All participants in the MBI group adhered to the correct content. Five participants in the MBI group had at least one occurrence of completing more than one meditation session in a single day from the *Managing Anxiety* package, contrary to the instruction.

Engagement rates were high at both 10 and 40 days, with an average of 91% session completion for the MBI group and 82% session completion for the control group across 40 days (Table 2).

Acceptability as indexed by self-rated motivation to continue at T1 was similar in both groups, but was slightly higher for the MBI group at T2 with regards to using the app beyond the study (Table 2).

There were no participant reports of adverse events during the trial.

3.3 VR-task fidelity and sense of presence

All participants completed the full VR task at both T0 and T2. The researcher spoke to 4 participants mid-task at baseline to clarify instructions (2 MBI, 2 Control); however, the data were included in analysis. There were no significant baseline group differences for the sense of presence (immersion), previous VR experience or video game engagement.

3.4 MBI effects on paranoia

Table 3 presents the group means for self-reported trait and state paranoia at each time point, together with the reliable change for each participant in the two groups. Four MBI participants and three active control participants showed reliable reductions in trait paranoia (FVPS) from T0 to T2, with no participants showing a reliable increase over the course of the study. No overall group effect was observed from T0 to T2 for trait paranoia.

The MBI group showed a reduction in state paranoia or persecutory ideation (SSPS) from T0 to T2 with a medium-to-large effect size ($d = 0.63$). Four participants in the MBI group showed reliable reductions of persecutory ideation evoked by the VR social situation following the intervention. SSPS scores for these participants shifted from scores reflecting clinical levels of persecutory ideation to scores reflecting general population means (Valmaggia et al., 2015). In the control group, one participant showed a reliable reduction. One participant in each group showed a reliable increase in SSPS scores; however, there were no qualitative reports of distress as a result of trial participation.

4 Discussion

4.1 Aims and summary of the findings

The aims of this randomized controlled trial were to: (i) investigate feasibility (evaluation criteria included retention, adherence,

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TABLE 1 Baseline means (and standard deviations) for the mindfulness-based intervention (MBI) and active control groups on demographic characteristics, schizotypy and paranoia, with the test statistics for between-group differences.

	Group		Statistic		
	MBI ($N = 12$)	Control ($N = 12$)	t	χ^2	p
	Mean ± SD	**Mean ± SD**			
Age (years) [range]	26.83 ± 10.46 [18–58]	27.25 ± 12.43 [18–57]	0.09	–	0.93
	n (%)	**n (%)**			
Gender			–	<0.00	1.00
Male	2 (16.7)	2 (16.7)			
Female	10 (83.3)	10 (83.3)			
Education level			–	5.21	0.27
GCSE/Equivalent	1 (8.3)	0 (0)			
College, no degree	1 (8.3)	1 (8.3)			
Associate degree	1 (8.3)	0 (0)			
Bachelor's degree	4 (33.3)	9 (75.0)			
Master's degree	5 (41.7)	2 (16.7)			
Ethnicity			–	1.33	0.51
White	4 (33.3)	4 (33.3)			
Asian/Asian Brit	5 (41.7)	7 (58.3)			
Black/African/Caribbean/Black British	3 (25.0)	3 (8.3)			
Schizotypy (SPQ)					
Total SPQ score	38.92 ± 12.41	34.08 ± 9.20	1.08		0.29
Positive schizotypy	16.58 ± 6.05	15.50 ± 4.93	0.48		0.64
Magical thinking	1.58 ± 1.73	1.25 ± 1.66	0.48		0.64
Unusual perceptual experiences	3.08 ± 1.93	2.09 ± 2.31	0.19		0.85
Ideas of reference	5.58 ± 2.78	5.50 ± 2.11	0.08		0.94
Suspiciousness	6.33 ± 1.44	5.83 ± 1.40	0.86		0.40
Negative schizotypy	14.33 ± 4.96	11.83 ± 3.90	1.37		0.18
Disorganised schizotypy	8.00 ± 3.69	6.75 ± 3.11	0.90		0.38
Paranoia					
FVPS	57.92 ± 18.01	51.08 ± 13.63	1.05		0.31
$SSPS^{Persecution}$	19.42 ± 8.73	17.17 ± 8.73	0.77		0.45

engagement, and acceptability) of a 40-day online MBI; and (ii) estimate the MBI effects on self-reported trait and state paranoia in individuals with high positive schizotypy characterized by high suspiciousness/paranoia as compared with an active control intervention.

Retention rate was 100%, with an excellent adherence to content and engagement, as indexed by an average MBI session completion rate of 91%. Acceptability is evidenced by a high motivation to continue using the *Headspace* app after the trial, with the mean motivation ratings being somewhat higher in the MBI as compared with the active control group.

No overall group effect was observed on trait paranoia following the 40-day MBI; however, there was a reduction in state paranoia in the MBI group with a medium-to-large effect size. Additionally, a third of the participants (4 out of 12) in the MBI group demonstrated reliable reductions in state paranoia induced by the VR environment, with only one participant from the active control group showing a reliable reduction.

No serious adverse events or distress reported as a result of the intervention.

4.2 Feasibility

No trial dropouts and high session completion rates are uncommon findings for online mindfulness interventions (e.g., Shore et al., 2018 reported 48% attrition for the mindfulness group; Cavanagh et al., 2013: 57%), including trials using *Headspace* products (Howells et al., 2016: 62%; Champion et al., 2018: 24%; Flett et al., 2019: 17%). Several factors may have contributed to high retention and engagement in the current trial. First, given the time requirements of the trial, volunteers were likely highly committed to taking part in the study. Substantial and consistent in-person contact with the researcher was provided, with opportunities for questions, concerns and clarification about the

10.3389/fpsyg.2024.1380077

TABLE 2 Means (and standard deviations) for the mindfulness-based intervention (MBI) and active control groups for session completion and motivation to continue using the app after 10 days (T1) and 40 days (T2), with effect sizes and 95% CIs.

Feasibility criterion	MBI ($N = 12$)	Active control ($N = 12$)	Statistic	
	Mean ± *SD* (overall %)	Mean ± *SD* (overall %)	*d*	95% CI
Engagement (Avg. rate of sessions completed)				
T1	9.33 ± 1.44 (93.3%)	8.42 ± 1.56 (84.2%)	0.61	[−1.76, 0.56]
T2	36.58 ± 2.81 (91.3%)	33.12 ± 5.61 (82.9%)	0.78	[−1.95, 0.39]
Acceptability (Motivation to continue)				
T1	7.00 ± 1.28	6.75 ± 2.86	0.11	[−1.25, 1.02]
T2	7.83 ± 1.47	6.58 ± 2.97	0.53	[−1.69, 0.62]

TABLE 3 Means (and standard deviations) for the mindfulness-based intervention (MBI) and active control group scores on the Fenigstein and Vanable Paranoia Scale (FVPS) and the State Social Paranoia Scale (SSPS) at each assessment time point: baseline (T0), 10 days (T1), and 40 days (T2), with effect sizes and 95% CIs for group comparisons of score change from T0 to T2.

	Group						Statistic	
	MBI ($N = 12$)			Control ($N = 12$)			*d*	*95% CI*
Timepoint	T0	T1	T2	T0	T1	T2		
Self-reported Paranoia (FVPS)								
Mean ± *SD*	57.92 ± 5.19	56.08 ± 5.51	50.67 ± 5.60	51.08 ± 3.93	44.17 ± 5.71	44.42 ± 4.43	–	–
Total *n* demonstrating reliable reduction (from baseline, T0)	–	1	4	–	3	3	–	–
Overall Change (*Mean* ± *SD*) T0–T2			−7.25 ± 11.89			−6.67 ± 10.54	0.04	[−1.17, 1.10]
VR rating (SSPS)								
Mean ± *SD*	57.92 ± 5.20	–	50.67 ± 5.60	51.08 ± 3.93	–	44.42 ± 4.43	0.63	[−0.53, 1.79]
Overall change (*Mean* ± *SD*) T0–T2			−4.83 ± 9.89			−0.33 ± 4.87		
Total *n* demonstrating reliable reduction			4			1		

interventions, app-use and expectations, supporting rapport-and trust-building. Supplementary information, regular reminders and researcher accessibility in addition to detailed program orientation were provided in the trial, which can enhance retention in smartphone-delivered interventions (Linardon and Fuller-Tyszkiewicz, 2020).

A remunerative incentive (monetary remuneration and *Headspace* vouchers upon trial completion) might have contributed to the 100% retention rate in the trial; other studies compensated participants for their time with vouchers (e.g., Champion et al., 2018; Economides et al., 2018), whilst it is not clear whether trial incentives were offered in the other trials (e.g., Shore et al., 2018; Flett et al., 2019). However, remuneration is unlikely to explain high session completion rates, since remuneration did not apply to any 'minimum' number of sessions to be completed throughout the intervention. High self-rated motivation upon trial completion is also indicative of acceptability of and engagement with the intervention contributing to retention rates.

All participants adhered to the correct content; however, 5 participants completed >1 mindfulness session per day at least once, contrary to instruction. This is most likely due to an app log artefact when two meditation sessions are completed within a 24-h period (e.g., a meditation completed before sleep with the following meditation completed the next morning), as was noted by some participants. Another possibility is the participants completing two session in 1 day to catch up with a missed session the day before. Continued use of pragmatic tracking of practice is recommended for future research, as well as investigating whether disrupted regularity of practice may affect outcomes.

4.3 MBI effects on paranoia

There was no effect on trait paranoia unique to the MBI in the present study after 40 days. The previous study using a brief (2-week) online mindfulness intervention (Shore et al., 2018)

observed a significant reduction in trait paranoia after 2 weeks; however, the study was well-powered with 56 participants in the treatment group. Furthermore, the current sample was recruited on the basis of having high suspiciousness and had higher trait paranoia scores at baseline in comparison to the sample to Shore and colleagues' study (2018). Finally, the current study used an active rather than a wait-list control condition (as used by Shore et al., 2018), which can reduce the unique effects (Goldberg et al., 2021).

However, state paranoia as elicited by the VR environment, and self-rated using SSPS, showed a reduction in the MBI group with a medium-to-large effect size, with more participants demonstrating reliable reductions in persecutory ideation in the MBI group than the active control group. Mindfulness encourages non-judgmental, non-elaborative, and non-reactive orientation to thoughts and other experiences, no matter their salience and/or valence (Kabat-Zinn, 1990), facilitating an experiential insight that thoughts are not an accurate reflection of reality, but rather passing events in the mind (Williams and Kuyken, 2012). Bringing an open and accepting attitude to the present-moment experience may thus reduce evaluative reactivity and increase adaptive responding to and reduce distress of perceived social threats (Brown et al., 2008; Jankowski and Holas, 2014). This could lead to a more neutral and less distressing (or 'triggering') experience within the VR environment by the individuals with high levels of positive schizotypy who may have an increased tendency for state paranoia as elicited by unusual thought content (e.g., jumping to conclusions; Hua et al., 2020) or unusual experiences, which could be distressing when accompanied by threatening appraisals (Brett et al., 2014).

Further, mindfulness is positively associated with metacognitive insight and decentered awareness (Teasdale et al., 2002; Chadwick, 2006), which may have contributed to noticing and adaptively managing 'here and now' evaluations and cognitions in relation to the VR social situation. These findings provide encouraging evidence for the use of mindfulness to buffer against everyday distressing experiences of persecutory thinking, given the negligible changes observed in the active control group. This highlights the worth of using experimentally controlled digital environments for the assessment of paranoia - this MBI effect would have otherwise been missed through the use of traditional self-reported trait paranoia assessment.

4.4 Limitations and future research directions

We note the small sample size of the study; however, the study reached the recommended minimum $n = 12$ per group for pilot/feasibility trials (Julious, 2005). The feasibility of the intervention, in addition to the observed medium-to-large effect size found for reduction in state paranoia, warrants larger-scale randomized control trials evaluating online MBIs aimed at reducing suspiciousness/paranoia in individuals with high positive schizotypy to mitigate psychosis risk. Better-powered trials would also provide opportunity to investigate underlying mechanisms which are specific to online mindfulness training (e.g., whether improvements are mediated by specific mindfulness skills), as have been reported previously for trait paranoia reduction (Shore et al., 2018).

Future trials might consider using alternative self-report measures for the assessment of trait paranoia – it has been suggested that the FVPS items, used in the current trial, may tap into themes of depression rather than paranoia (Green et al., 2008). Also, rumination, associated with maintenance of both depression (e.g., Li et al., 2022) and paranoia (Martinelli et al., 2013) and identified as a barrier of psychological engagement with mindfulness training (Banerjee et al., 2018), was not assessed in the current study. Future trials would benefit from assessing psychological engagement and factors by which it may be influenced, such as rumination, to gain a better insight into the mechanisms promoting positive outcomes.

Further, recent research has identified bodily self-disturbances as the shortest paths from childhood trauma to schizotypal experiences in both schizophrenia patients and healthy individuals (Torregrossa et al., 2024), using the network approach to understanding the multifaceted nature of schizotypy and its relationship to schizophrenia (Fonseca-Pedrero et al., 2021). Future research investigating the applications of MBI for reducing risk factors for conversion to psychosis and schizophrenia in the individuals with high positive schizotypy should include bodily self-disturbances related to childhood trauma as one of the outcome measures.

Finally, the current results provide insight into short-term effects of the intervention on paranoia; follow-up assessments in future trials are necessary for insight into longer-term effects, particularly in the context of trajectory toward development of psychosis associated with high positive schizotypy generally and suspiciousness/paranoia specifically.

5 Conclusion

Ten minutes of daily mindfulness practice over the course of 40 days, delivered online via a mobile app, has been shown to be feasible and acceptable in a sample of individuals with high positive schizotypy characterized by high suspiciousness/paranoia. A medium-to-large effect size for reductions in state paranoia, as induced by VR environment, was found in the MBI group as compared with an active control group. The MBI was largely self-directed, with no face-to-face interaction with a trained instructor or clinician, suggesting that such interventions can be delivered at relatively low cost. However, in-person contact prior to the intervention and practical support throughout the trial, including intervention/app orientation, reminders and informational resources, may be important for achieving high retention and engagement. There were no serious adverse effects of the intervention, indicating that the MBI is a safe method to alleviate experiences of state paranoia in individuals with increased vulnerability to psychosis development.

Overall, the findings are consistent with the proposal that mindfulness training could safely mitigate psychosis risk associated with higher levels of positive schizotypal traits and call for larger-scale randomized controlled trials evaluating the effects of online MBIs on reducing suspiciousness/paranoia in individuals with high positive schizotypy. Finally, the results support the VR use for assessing change in state paranoia following interventions generally and the MBIs specifically.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

The study was approved by the King's College London Research Ethics Committee (LRS-17/18-5604). The study was conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study.

Author contributions

HM: Writing – original draft, Visualization, Methodology, Formal Analysis, Data curation, Conceptualization. LV: Writing – review & editing, Supervision, Resources, Methodology. EA: Writing – review & editing, Supervision, Methodology, Funding acquisition, Conceptualization. PC: Writing – review & editing, Supervision, Methodology, Funding acquisition, Conceptualization.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

Supplementary material

The Supplementary material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fpsyg.2024.1380077/full#supplementary-material

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Can sensory and semantic priming enhance the effects of guided self-compassion meditation? A proof-of-concept study

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Introduction: Self-compassion is a fundamental aspect of psychological health and well-being that can be cultivated through self-compassion meditations, but it remains unclear how to facilitate this most effectively. This study is the first to explore whether sensory and semantic priming introduced prior to a guided self-compassion meditation could enhance the effects of meditation in comparison with a control condition.

Methods: The study was conducted with 3 × 3 repeated measures between-group design, including three groups (sensory priming, semantic priming and control group), and three assessment time points of state self-compassion, self-criticism, and positive and negative affect (at baseline, after priming, and after guided meditation). Additionally, a meditation appeal questionnaire was used. The total sample size included 71 students who underwent a 3-min priming intervention followed by a 15-min self-compassion guided meditation session.

Results: First, prior to guided meditation, sensory priming significantly decreased state self-criticism more than the control condition or semantic priming, although some reliability issues of the applied self-criticism scale must be taken into consideration. Second, neither sensory nor semantic priming changed state self-compassion, positive affect or negative affect. Third, neither semantic nor sensory priming significantly enhanced the effects of guided self-compassion meditation either in positive and negative affect, self-compassion states, self-criticism states, or in the appeal of the meditation experience.

Discussion: Although this study is underpowered (estimated post hoc power ranges from 0.20 to 0.42), the findings provide preliminary insights into the potential priming has as a tool to enhance meditation effects and provide guidelines for future studies.

KEYWORDS

self-compassion, sensory priming, semantic priming, meditation, self-criticism

1 Introduction

Clinical and research interest in self-compassion has gained popularity in the past decade due to its vast array of positive outcomes that are relevant to public health, including reduced psychopathology (MacBeth and Gumley, 2012; Kirby et al., 2017), increased well-being (Zessin et al., 2015), and coping with stress (Ewert et al., 2021). Self-compassion can be defined as a "cognitive, affective, and behavioral process" directed toward the self that includes five elements: recognizing suffering, understanding its universality, feeling empathy and emotional resonance, tolerating uncomfortable feelings and motivation to act to alleviate suffering (Strauss et al., 2016). The capacity for self-compassion varies among individuals and it is not fixed; instead, it remains flexible throughout the lifespan (Neff, 2003). As such, self-compassion training is a crucial component of several evidence-based therapeutic modalities, such as a Compassion Focused Therapy (Gilbert, 2009) or Mindful Self Compassion (Neff and Germer, 2013), which are effective for mental health across non-clinical, clinical, and subclinical populations (Kirby et al., 2017; Wilson et al., 2019). This transdiagnostic effectiveness is not surprising, given that self-compassion targets maladaptive mechanisms contributing to psychopathology such as self-criticism (Clark et al., 1994; Gilbert and Procter, 2006; Gilbert, 2009; Wakelin et al., 2022) and enhances emotion regulation (Porges, 2017; Inwood and Ferrari, 2018). As one of the pioneering clinicians in the field of compassion mentioned, "The field of self-compassion in therapy is currently in its adolescence" (Germer, 2023). In other words, until now the majority of studies have focused on validating compassion-based interventions in a specific context (e.g., population or disorder), while little is known about how to optimize the effectiveness of this practice.

Self-compassion practice typically includes guided meditation, which directs attention inward while using mental imagery to induce feelings of warmth, nurture and benevolence towards the self (Gilbert, 2020). Indeed, self-compassion meditations can be categorized as the constructive type of meditative practices (Dahl et al., 2015) where the quality of the meditation practice can be influenced by the practitioner's ability to generate mental imagery (Navarrete et al., 2021; Wilson-Mendenhall et al., 2023), and by the activation of the somatosensory component to elicit and sustain compassion (Navarrete et al., 2021). Although mental imagery plays an important role in the self-compassion meditation practice, finding different ways to enhance the somatosensory component by evoking an inner sense of safety that arises from the soothing system is another crucial factor that influences the quality of this meditation practice (Gilbert, 2009; Navarrete et al., 2021). The soothing system, one of the three emotion regulation systems as conceptualized by Gilbert in Compassion-Focused Therapy, is characterized by the activation of the parasympathetic nervous system, fostering feelings of safety, warmth, and comfort (Gilbert, 2009, 2020). By cultivating this system, individuals can effectively regulate their emotions and navigate challenges (Gilbert, 2009, 2020; Porges, 2017; Inwood and Ferrari, 2018). Discovering new ways to activate the soothing system, especially its somatosensory component, might further improve the effectiveness of self-compassion practice and of compassion-based therapeutic modalities. However, to the authors' knowledge, the only existing attempts to trigger the soothing system in the context of self-compassion meditation have been done pharmacologically. For instance, Kamboj et al. showed that 3,4-Methylenedioxymethamphetamine (MDMA, commonly known as ecstasy) can enhance the effects of self-compassion meditation by further increasing self-compassion and decreasing self-criticism (Kamboj et al., 2015, 2018). On the other hand, Rockliff and her colleagues (Rockliff et al., 2011) showed that intranasal oxytocin can increase the ease of compassionate mental imagery, but this effect was smaller in people with low attachment security and high self-criticism. Since the use of pharmacological interventions in combination with meditation as a regular enhancement tool for meditation could be problematic due to its possible adverse effects (especially in the absence of medical guidance), its temporary action, and still not well-understood long-term consequences (Buchert et al., 2003), other ways to activate the soothing system should be considered a priority.

Drawing from social psychology, one non-pharmacological approach to activating the soothing system could be performed through priming. Indeed, priming consists in modifying the quality, intensity or duration of emotional responses in an implicit way (i.e., without explicit intentions). This implicit activation (i.e., priming) refers to the activation of mental representations through exposure to stimuli, which then influences subsequent experiences (Shalev and Bargh, 2011; Molden, 2014).For instance, semantic priming via exposure to words such as "wrinkles" or "Bingo" (i.e., stimulus) can activate the elderly stereotype (i.e., mental representations), leading to behavior changes such as walking more slowly upon exiting the laboratory (Bargh et al., 1996). Despite failed replication attempts of many priming studies (Cesario, 2014; Molden, 2014), some are supported by a substantial body of research, including numerous meta-analyses (Zessin et al., 2015; Kirby et al., 2017; Ewert et al., 2021), affirming the robustness of priming effects. However, the effects of priming on self-compassion meditation have not yet been studied. Applying priming within self-compassion interventions could increase readiness to practice self-compassion techniques, boost their effectiveness, or increase adherence to intervention instructions (Shalev and Bargh, 2011). As such, priming could be a valuable tool to enhance the effects of guided self- compassion meditation by activating the soothing system and creating a sense of safety, warmth, and comfort. For individuals who struggle to activate the soothing system, such as those with interpersonal trauma or an avoidant attachment style, finding the means to activate the soothing system is necessary so that they can gain benefits from self-compassion meditation that they might otherwise perceive as difficult, ineffective, or even threatening.

To our knowledge, only one study directly tested the effects of priming on outcomes of meditation (Rowe et al., 2016). While they did not specifically evaluate self-compassion meditation nor how priming influences the immediate effect of meditation, they tested and confirmed that semantic priming prior to mindfulness meditation can increase the willingness to commit to regular mindfulness practice (Rowe et al., 2016). Our study is the first to examine the potential benefits of priming and its enhancing effect on immediate outcomes of self-compassion meditation. By priming individuals with stimuli related to the soothing system through sensory or semantic cues, it is hypothesized that guided self-compassion meditation will be more effective than it is when priming is not present. Here we use two priming modalities, one that can be defined as a "bottom-up" priming (activating the

soothing system in response to a sensory stimulus), and one that can be defined as "top-down" (activating the soothing system in response to an explicit cognitive stimulus) (Strauss et al., 2016). The first priming modality is sensory priming, which includes holding a warm therapeutic pad in a fluffy cover and this type of warmth-based priming has been used previously in other studies related to pro-sociality (Neff, 2003) and trust (Gilbert, 2009), but not in mediation research. The second priming modality is semantic priming, which includes an unscrambled sentence task and has also only been used in different research areas related to emotion regulation until now (Neff and Germer, 2013). The specific objectives of this study are twofold: (1) to test whether sensory and semantic priming on its own is effective (i.e., can increase self-compassion state and positive affect, and decrease self-criticism state and negative affect), (2) to test whether sensory and semantic priming introduced prior to a guided self- compassion meditation can enhance the effects of meditation and lead to greater increases in self-compassion state and positive affect, decreases in self-criticism state and negative affect, as well as greater appeal to meditation in comparison with a control group that does not receive any priming prior to meditation instructions. The choice of the outcome measures is based on Social Mentality Theory that differentiates between self-compassion as a state that involves caregiving and care-seeking, and between self-criticism as a state that has a function to protect us from social threats (Wilson et al., 2019). Both self-compassion and self-criticism can be considered as "complex cognitive, emotional, motivational, and behavioral responses to the self" that have a particular temporal relationship which has been rarely studied together (Wakelin et al., 2022). The choice of positive and negative affect as outcome measures stems from a meta-analysis that found significant small indirect effects of self-compassion on health behaviors through both positive and negative affect (Sirois et al., 2015), which is also in line with Neff's model (Neff, 2003) that posits that self-compassion is linked to positive affect and it underscores the importance of examining affective states as outcomes in self-compassion interventions. Investigating the combined effects of priming and self-compassion meditation in this study contributes to a deeper practical understanding of how to facilitate self-compassion effectively. The findings of this study not only have important implications for clinical practice, but also set the foundations for future research on priming and meditation.

2 Materials and methods

2.1 Participants

A total of 71 students (75.4% female; mean age of 26.64 years, SD = 5.67) recruited from the University of Amsterdam participated in the study and were awarded 5€ for study participation. Additionally, a lottery of 50 € coupon among all participants was performed. Inclusion criteria included English-speaking adults between 18 and 45 years old with no history of severe psychiatric disorders nor previous experience in self-compassion meditation. Informed consent was obtained from all participants prior to their participation in the study.

2.2 Procedure

The study employed 3x3 repeated measures between-group design, with three assessment time points (baseline, after priming, and after guided self-compassion meditation) and three groups (sensory priming, semantic priming and control group). Testing was done during one individual lab session (in closed independent cubicles without the presence of the researcher) that lasted approximately 35 min per participant (see Figure 1). Following the arrival at the lab, participants were informed about the study procedures and aims (i.e., studying how different priming modalities affect the meditation experience). The participants signed the consent form and completed questionnaires that examined their baseline state (self-compassion and self-criticism states, and positive and negative affect). Participants were then randomly allocated to one of the three conditions: semantic priming, sensory priming, or a control condition. The sensory priming group received a 3-min sensory priming intervention, which involved holding a warm therapeutic pad in a fluffy cover based on previous research (Kang et al., 2011; Storey and Workman, 2013). The semantic priming group received a 3-min priming intervention, which involved an unscrambled sentence task based on previously tested methodology (Williams et al., 2009) where participants had to construct 10 sentences from four scrambled words (e.g., "*The sand is warm*", "*Her touch is tender*"), in which 6 sentences included affiliative system activating word such as (warm, tender, loving). The control group did not receive

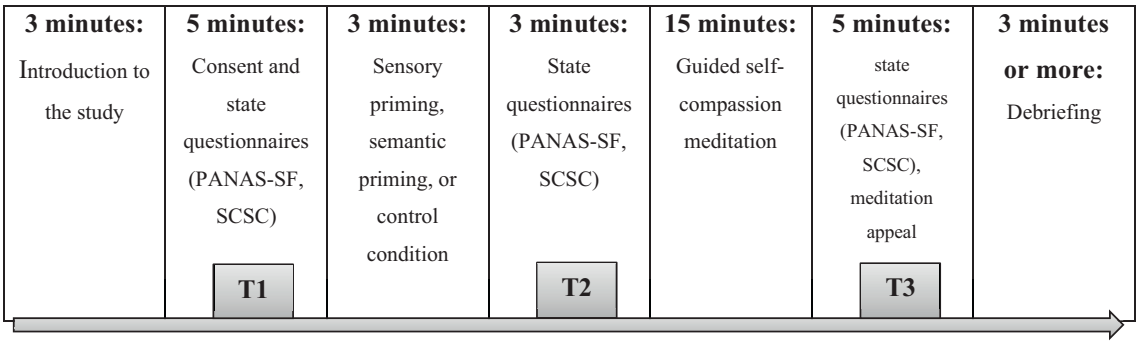

FIGURE 1
A graphical representation of the lab visit including three timepoints of measurements (T1, T2, T3).

any priming, but instead, participants did a set of simple hand mobility and strength exercises for the same duration as the priming conditions to control for factors such as engagement in a task, duration of time spent alone in a cubicle and physical activity comparable to writing or holding a pad. Following the priming intervention, participants again completed the measures of self-compassion state, self-criticism state, and positive and negative affect. They then listened to a recording of a 15-min guided self-compassion imagery meditation suitable for beginners (i.e., Compassionate Friend from the MSC program) (Neff and Germer, 2013). After the guided meditation, participants completed the final set of questionnaires. Additionally, a meditation appeal questionnaire was administered to assess participants' subjective experience of the meditation session. At the end of the lab session, participants were thanked and debriefed. Finally, participants were examined for any suspicions regarding the experimental objectives, a recommended procedure in priming (Bargh and Chartrand, 2000). None of the participants expressed any suspicion regarding the intentions behind the priming and task procedures.

3 Outcome measures

3.1 Demographics

A brief questionnaire included standard demographic questions including age, gender and ethnicity.

3.2 Positive and negative affect

The Positive and Negative Affect Schedule Short Form (PANAS-SF) consists of two 10-item scales developed to assess positive and negative affect (Thompson, 2007). This version contains five items for positive affect ("active/determined/attentive/inspired/alert") and five items for negative affect ("afraid/nervous/upset/hostile/ashamed"). For each item participants are instructed to indicate on a scale of 1 ("Very slightly or not at all") to 5 ("Extremely") how well the item described their current state. The results provide separate scores for positive affect and negative affect. Both positive and negative scales of the PANAS-SF have shown adequate reliability (Cronbach's alpha of 78 and 0.76, respectively) and it is a valid measure of affect across countries (Thompson, 2007). In this study the scales were equally reliable (positive affect: T1: $\alpha = 0.89$, T2: $\alpha = 0.92$; T3: $\alpha = 0.90$. and negative affect T1: $\alpha = 0.76$, T2: $\alpha = 0.90$, T3: $\alpha = 0.81$). The measure was selected as a traditionally used self-report emotional experience outcome, previously used in the priming studies (Yuan et al., 2015).

3.3 State self-compassion and self-criticism

The Self-Compassion and Criticism Scale (SCCS) is a scenario-based trait measure and its adapted state measure (Falconer et al., 2015). The state measure consists of three items (self-reassurance, self-soothing, self-compassion) that correspond to self-compassion subscale, and three items (self-contempt, self-criticism and self-harshness) that correspond to the self-criticism subscale, that are rated on a 1 ("Not at all") to 7 ("Highly") Likert scale. The SCCS has shown good reliability of.87 and.91 for self-criticism and self-compassion subscales, respectively (Falconer et al., 2015). In our study, while the self-compassion subscale has shown adequate reliability in all three time points (respectively: $\alpha = 0.67$, $\alpha = 0.98$, $\alpha = 0.84$), the self-criticism obtained low reliability in the first time point, but not in the second and third (respectively: $\alpha = 0.41$, $\alpha = 0.75$, $\alpha = 0.78$).

3.4 Meditation appeal questionnaire

A meditation appeal questionnaire was adapted from two previous studies (Rockliff et al., 2011; Rowe et al., 2016). It contains ten items (answered on a scale from 1 to 10) that assess participants' subjective experience after the meditation, including their perceived easiness, resistance, difficulties, emotionality, mind wandering, and intention to practice again. Psychometric properties are not available, thus we used this questionnaire for exploratory purposes only.

4 Data analyses

Non-parametric analyses were conducted using IBM SPSS Statistics (Version 22 for Windows) because the assumption for parametric group comparisons were not met (i.e., deviations from normal distribution and violation of homogeneity of variance assumption in several variables). First, we tested for outliers using the Mahalanobis distance that showed two participants were outliers, and these participants were excluded from all the analyses. Second, baseline differences between the three randomized groups were checked with Kruskal-Wallis to test if randomization was successful before continuing with further analysis. Next, to investigate the combined effect of priming and self-compassion meditation (T3) on state self-compassion, self-criticism, and positive and negative emotions across different priming conditions (sensory, semantic, and control), we conducted multiple Kruskal-Wallis tests. We calculated change scores by deducting the final score on each scale from the first, baseline score (T3–T1) and compared all groups. To investigate solely the effect of priming on state self-compassion, self-criticism, and positive and negative emotions across different priming conditions, we again conducted multiple Kruskal-Wallis tests and in this case, we calculated the change scores between priming and baseline conditions (T2–T1). Whenever the Kruskal-Wallis tests found significant differences between the three groups (i.e., p-values adjusted for multiple comparisons were smaller than 0.05), pairwise comparisons were done to detect between which two groups the detected difference occurred.

5 Results

Below we show the results of our analyses that should only be considered as preliminary and hypotheses generating due to

TABLE 1 The effects of priming on main outcome measures.

Change score (T2−T1)	H	p^a	Median	IQR	η2 b
Self-compassion	7.892	0.019*	0.333	−0.333–1.167	0.089
Self-criticism	12.044	0.002*	0.333	0.000–0.750	0.152
Positive affect	0.140	0.933	0.000	−0.200–0.200	0.028
Negative affect	5.686	0.058	0.000	−0.200–0.000	0.056

[a]Adjusted *p*-values (multiple comparisons, Bonferroni adjustment), * < 0.05 is considered significant. [b]Partial eta square represents effect sizes [η^2 = (H–k + 1)/(n−k)].

TABLE 2 The combined effect of priming and self-compassion meditation on main outcome measures.

Change score (T3– T1)	*H*	$_p$a	Median	IQR	$_\eta$2 b
Self-compassion	4.726	0.094	0.000	−1.000–1.000	0.041
Self-criticism	4.747	0.093	0.000	−0.083–0.833	0.042
Positive affect	1.528	0.466	0.000	−0.225–0.500	0.007
Negative affect	0.929	0.628	0.000	−0.400–0.000	0.016

[a]Adjusted *p*-values (multiple comparisons, Bonferroni adjustment), < 0.05 is considered significant. [b]Partial eta square represents effect sizes [η^2 = (*H*–*k* + 1)/(*n*– *k*)].

limited sample size and thus insufficient statistical power (post hoc power was calculated in GPower using effect sizes based on the two most relevant meta-analyses (Lucas, 2000; Gillath et al., 2022), and showed the power in our study ranges from 0.20 to 0.42). There were no differences between the three groups at baseline (T1) in self-compassion (H = 1.700, df = 2, p = 0.428) self-criticism (H = 0.027, df = 2, p = 0.987), positive affect (H = 0.849, df = 2, p = 0.654) and negative affect (H = 0.253, df = 2, p = 0.881) (see Supplementary Table 1 in the Supplementary materials), hence we could continue with further analysis. The results of the analysis that tested the first study aim—whether sensory and semantic priming on their own is effective—suggested that there was an increase in state self-compassion with a medium effect size, a decrease in state self-criticism with a large effect size, and no significant changes in positive or negative affect (see Table 1). To explain the observed significant group differences in self-compassion and self-criticism, pairwise comparisons were run and suggested that a significant difference in self-compassion occurred between sensory and semantic priming groups (H = 16.512, SE = 5.973, η^2 = 0.220, $p < 0.05$[1]), where sensory priming increased self-compassion more than semantic priming (Mean Rank Sensory = 43.58, Mean Rank Semantic = 27.07, Mean Rank Control = 33.35). However, sensory priming did not increase self-compassion more than the control group. On the other hand, when it comes to self-criticism, pairwise comparisons suggested a significant difference between sensory priming and the control group (H = −15.104, SE = 5.733, η^2 = 0.199, $p < 0.05$)—sensory priming decreased self-criticism more than the control group and the effect size is large. There was also a significant difference between sensory priming and semantic priming (H = −19.292, SE = 5.935, η^2 = 0.262, $p < .05$[i]), but semantic priming was not significantly more effective than the control group (Mean Rank Sensory = 23.88, Mean Rank Semantic = 43.17, Mean Rank Control = 38.98; see Supplementary Figure 1 in the Supplementary materials). Together, these results suggest that neither sensory nor semantic priming is more effective than the control group in terms of changing state self-compassion, but that sensory priming can effectively decrease state self-criticism.

The results of the analysis that tested the second study aim, which is the combined effects of priming and self-compassion meditation across all three groups, suggested no significant results on either state self-compassion, self-criticism, positive affect, or negative affect (Table 2). When testing the differences between T3 and T1 in the control group alone, there were no significant results in any of the tested variables self-compassion (z = −0.437; p = 0.662), self-criticism (z = −1.543, p = 0.123), positive affect (z = −0.163; p = 0.871), and negative affect (z = −0.425, p = 0.671). These results suggest that sensory or semantic priming introduced prior to a guided self-compassion meditation does not enhance the effects of meditation, and also show that independent effects of self-compassion were not significant because there were no changes in the control condition that was exposed to hand exercises instead of priming. Finally, we expected that the appeal to the meditation would be significantly greater in both semantic and sensory priming groups compared to the control condition. For this, we used an ad hoc and non-validated questionnaire, so we provided analyses on each item from this questionnaire. As can be seen in Table 3, none of the results are significant therefore there are no differences between groups.

6 Discussion

This proof-of-concept study aimed to investigate whether sensory and semantic priming could enhance the effects of guided self-compassion meditation and yielded several findings. However, due to low statistical power, all findings must be considered preliminary until they are replicated in larger studies because there is a higher probability that non-significant findings could be due to an insufficient sample size rather than the absence of a true effect. First, sensory priming had a significant and large effect on reducing state self-criticism compared to semantic priming and the control group. Second, sensory priming did not significantly increase self-compassion or positive affect compared to the other conditions, nor decrease negative affect. Finally, neither sensory nor semantic priming significantly enhanced the effects of guided self-compassion meditation in terms of positive and negative affect, self-compassion states, self-criticism states, or the appeal of the meditation experience.

The finding that sensory priming reduced self-criticism suggests that sensory priming may be a more promising tool for reducing self-critical thoughts instead of directly targeting self-compassion. This goes in line with previous studies emphasizing the importance of experiencing internal scripts based on warmth, compassion and forgiveness when targeting self-criticism (Gilbert et al., 2006; Gilbert, 2009). For instance, holding a warm and fluffy pad during therapeutic work might implicitly facilitate these warmth-based internal scripts that have an impact on self-criticism, which remains to be tested in future studies. As mentioned above,

TABLE 3 Group differences in exploratory per-item analysis of the mediation appeal questionnaire.

	H	*p*	Median	IQR	$_{\eta}2$
Easiness receiving compassion	1.179	0.555	6.000	4.000–7.500	0.012
Wanting to resist	0.747	0.688	5.000	3.000–8.000	0.019
Tension during meditation	0.615	0.735	3.000	2.000–6.000	0.021
Trying to create a visual image	2.382	0.304	7.000	6.000–8.000	0.006
Clearness of image	2.151	0.341	7.000	6.000–8.000	0.002
Moved by image	1.975	0.372	7.000	5.000–8.000	0.000
Intention to practice	1.148	0.563	7.000	5.000–8.000	0.013
Sadness feelings during meditation	1.775	0.412	4.000	1.000–7.000	0.003
Mind wandering	0.996	0.608	6.000	4.000–7.000	0.015
Evaluation of experience	1.688	0.430	2.000	1.000–3.000	0.005

the finding that sensory priming decreases state self-criticism is not robust because the reliability of the self-criticism subscale was low in our sample at the first time point (T1, baseline assessment). Previous studies using the SCCS scale reported only the reliability from the original paper (Falconer et al., 2015), without reporting reliability based on their data (Kamboj et al., 2015; Falconer et al., 2016; Serpell et al., 2020; Hidding et al., 2024). Therefore, because the low reliability of the self-criticism subscale was observed in our study in one out of the three timepoints, the results might not accurately represent the true relationship between sensory priming and self-criticism, instead the observed effect could be influenced by measurement error. For this reason, future studies should directly test this relationship on a larger sample and with a more reliable instrument, pre-registration, and open data sharing, until then precise clinical recommendations cannot be made.

The finding that neither sensory nor semantic priming enhanced the effects of guided self-compassion meditation is inconsistent with previous research suggesting that priming can enhance the effects of psychological interventions (Shalev and Bargh, 2011) and that priming can enhance willingness to practice mindfulness meditation (Rowe et al., 2016). This lack of significant effects on positive and negative affect, self-compassion states, self-criticism states, and the appeal of the meditation experience could be due to various factors. First, the duration of priming was 3 min long, which may not have been sufficient to produce significant changes in the soothing system and induce a feeling of inner safety and inner warmth. Longer priming sessions or other types of priming might be more effective in boosting the effects of self-compassion. Second, it might also be that neither semantic nor warmth-based priming influences the internal scripts related to the soothing system. In this line, although not directly related to the meditation outcomes, a recent meta-analytical review shows little support for the temperature (i.e., warmth-priming) effect on pro-sociality (Serpell et al., 2020). Additionally, we must also note that the brief self-compassion meditation that was employed in this study was not effective, which is seen through non-significant changes in outcome variables in the control group that had hand exercises instead of priming. This ineffectiveness of the self-compassion meditation itself could have prevented any priming effects from emerging, thus limiting the generalizability of our results. Even though the implemented short meditation was extracted from a validated protocol (Mindful Self Compassion) it is only a 15-min meditation that might not induce expected outcomes in novice meditators (i.e., a decrease in self-criticism and negative affect, and increase in positive affect and self-compassion). According to recent meta-analytic results (Schumer et al., 2018) short-term meditations present some potential for decreasing negative affect, however the authors also suggest that given the presence of publication bias in this research field more published studies are needed. Thus, the non-significant results in this manuscript also contribute to decreasing the publication bias in this research area, and applying different meditations in future priming studies might lead to different results. Furthermore, as mentioned earlier, this study did not manage to recruit a sufficient number of participants to achieve sufficient statistical power to detect smaller effects, which could be one of the reasons of non-significant results that were observed. Another important limitation of this study is the exclusive use of self-report measures in this study. While self-report measures are commonly used in self-compassion and in priming research, they are subject to biases and may not fully capture the nuanced changes in the soothing system when they occur. Including physiological measures such as heart rate variability; and/or implicit self-report measures such as the implicit version of the positive and negative affect scale (Quirin et al., 2009) could provide additional data on the effects of priming and guided self-compassion meditation in future studies. Especially since other priming studies demonstrated that the effect of semantic priming of emotional regulation was effective only on the implicit, physiological level (Yuan et al., 2015). However, even with optimal research design and methodology, there is a possibility that there will be inconsistencies across future studies that examine either the effects of priming on state outcomes or the combined effect of priming and self-compassion meditation on state outcomes. Overall, the robustness and generalizability of priming effects have been questioned because priming studies are often not replicated or replication studies find different effects (Cesario, 2014; Molden, 2014). The field has also grappled with the lack of standardized methodologies, leading to variability in experimental designs and difficulty in comparing findings across studies (Cesario, 2014; Molden, 2014).

Nevertheless, priming holds promise as a means to activate the soothing system, and potentially also in enhancing the effects of guided self-compassion meditation and other types of meditation. Further research is needed to understand how to use priming and under what conditions it can boost the effects of meditation. First, we can expect there will be differential effects of priming

on beginner and experienced meditators. Beginners may require more explicit and prolonged priming interventions to establish a sense of safety, as they may lack the internal resources and familiarity with meditation practices to readily access this state. On the other hand, experienced meditators may benefit from more subtle and brief priming interventions, as they have already developed a certain level of proficiency in cultivating a sense of safety during meditation. Moreover, individual differences such as type of attachment style and level of social safety, that could not be tested due to the sample size in this study, could also influence the practice. Understanding these differential effects can inform the development of tailored priming interventions based on the personal characteristics of the participant. Second, the optimal type and dosage of priming necessary to boost the effects of meditation remains unknown. This study tackled sensory and semantic priming that targets the soothing system and is 3 min long, while other types of priming or longer duration might be more effective in boosting the effects of self-compassion meditation. Should priming be a one-time event before meditation, or would multiple sessions yield more sustained effects? Should the duration of priming be prolonged to allow for a deeper sense of safety to be established, or would shorter bursts be equally effective? Answering these questions will provide valuable insights into the practical implementation of priming techniques in meditation practices. Finally, exploring different ways in which individuals activate their soothing system outside of the laboratory to inform future interventions could also be an interesting path. For instance, methodologies based on ecological momentary assessment [e.g., Gilbert et al., 2006] or social media post analysis (Ziemer, 2022) could bring more insights into possible ecological mechanisms of action. Overall, this proof-of-concept study provides valuable insights into the potential of priming modalities to enhance the effects of guided self-compassion meditation. However, it did not find significant effects of priming on self-compassion or the enhancement of guided self-compassion meditation, which could be due to a lack of statistical power to detect these effects. Future research should build upon these findings by conducting larger and more refined studies to further explore the effects of priming modalities on self- compassion and identify the most effective strategies for combining priming and meditation.

Data availability statement

The datasets presented in this study can be found in online repositories. The names of the repository/repositories and accession number(s) can be found below: https://osf.io/gznp9.

Ethics statement

The study received ethical approval from the Ethics Review Board of the Faculty of Social and Behavioral Sciences of the University of Amsterdam (2016-CDE-7472). The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study.

Author contributions

IB: Writing—review and editing, Writing—original draft, Visualization, Formal analysis. MW: Writing—review and editing, Resources, Project administration, Methodology, Investigation, Funding acquisition, Conceptualization. JM: Writing—review and editing, Software, Formal analysis, Data curation. AR: Writing—review and editing, Methodology, Investigation, Conceptualization. ED: Writing—review and editing, Supervision, Methodology, Investigation, Conceptualization. SB: Writing—review and editing, Supervision, Methodology, Investigation, Conceptualization.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

Supplementary material

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fpsyg.2024.1385799/full#supplementary-material

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The greatest challenge in contemplative science: tailoring meditative practices

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The practice of meditation has grown in popularity around the world in recent decades. However, standard and untailored meditative practices are recommended for all practitioners, regardless of their personality traits or characteristics. No scientific attempts have been made to match specific meditation types with personality. This paper summarizes the limited proposals relevant to this subject in contemplative traditions such as Buddhism and schools of humanistic and transpersonal thought, including the Enneagram. We also discuss future research directions in this field.

KEYWORDS

meditation, Buddhism, tailoring, personality, enneagram

Tailoring meditation in ancient times

Interest in contemplative practices has grown inexorably over the last few decades (Garcia-Campayo et al., 2021).

According to various studies, the lifetime prevalence of meditation in Western countries, such as the United States, is 5.2%. Compared to non-meditators, the profile of meditators was more likely to be aged 40 to 64 years, female, non-Hispanic White, residing in the West, at least college-educated, not in a relationship, diagnosed with one or more chronic conditions, smokers, consumers of alcohol and physically active. Meditation was mainly used for general wellness (76.2%), improving energy (60.0%), and aiding memory or concentration (50.0%) (Cramer et al., 2016). Recent studies demonstrate that meditation practice extends to other population groups such as indigenous Americans, individuals ages 65 years and older, and individuals experiencing moderate or severe psychological distress (Davies et al., 2024). Similar findings have been reported in Australia (Lauche et al., 2019) and Iceland (Orlygsdottir et al., 2021).

One of the most challenging tasks for a meditation teacher is to match different forms of meditation with the personality types of meditation practitioners. Which meditative practices are more effective or useful for each individual? What kind of meditation do different people prefer? Is there any connection between meditation styles and personality traits, and which classification would be more reliable for this purpose? Finding answers to these questions is one of the greatest challenges in the field of contemplative practices.

Traditionally, masters of meditation in past centuries, who possessed deep insights into the mind of their disciples, would recommend the most suitable kind of meditation according to the specific characteristics of each individual. The permission and qualification to practice a particular tantric deity is called an 'empowerment', as it enables the recipient to engage in the practice of the generation and completion stages of that particular deity, ultimately leading to its accomplishment. The first 'empowerment' that one receives also constitutes one's entrance to Vajrayana Buddhist path (Tulku, 1995). These complex processes, combined with the

unwavering faith that disciples had in their masters, would enhance the effectiveness of meditation practice, regardless of type.

Most meditators in today's modern societies no longer have a guru – a person invested with faith who advises practitioners on which specific form of meditation to follow. Instead, they practise on their own and choose for themselves the type of meditation that best suits their preferences and intuition. Even when such masters of meditation are available, the reality of our overcrowded world means that they have hundreds or even thousands of disciples, ruling out a close personal relationship and individual supervision in most cases. Rather than giving any specific advice on the best form of meditation for the particular individual, they will provide general teachings on certain practices. Only when gurus have a more limited number of followers can they devote the necessary time to tailor a meditation practice to their needs. In such cases, they endeavor to align the meditation techniques with the meditator based on advice from sacred texts while also relying on their intuition or wisdom. However, is this the best method, or could it be improved by modern personality psychology?

Personality traits and meditation

Assessing personality is one of the most difficult tasks for mental health professionals, and inter-rater reliability tends to be low (Vernon, 2015). Currently, one of the most widely accepted assessment models for personality in psychiatry and psychology is the Big Five Personality Traits model, also known as OCEAN (Roccas et al., 2002), which stands for the five factors included in this theory: Openness to experience, Conscientiousness, Extraversion, Agreeableness and Neuroticism.

There are some research studies on the relationship between personality and meditation. A meta-analysis by Buric et al. (2022) studied the characteristics of meditators in relation to their response to meditation. It reported that higher levels of psychopathology or depression in subjects were associated with a decline in their mental health experienced after a meditation intervention. In contrast, interpersonal variables, motivation, medical conditions and mindfulness showed higher levels of positive meditation outcomes. Finally, demographics, self-concept, length of meditation practice and psychological traits – the object of this paper – did not significantly influence their response to meditation. The authors argue that their findings indicate that personality traits, as defined by frameworks such as the Big Five theory, do not significantly affect how participants respond to meditation. A similar conclusion was reached by Nyklicek and Irnischer (2017), who found no moderating effects of personality factors when controlling for baseline mood, with the exception of neuroticism, which was shown to be associated with delayed benefit. Tang and Braver (2020) suggest that Openness to Experience is the OCEAN trait most associated with positive outcomes and engagement in mindfulness meditation; however, there are no studies on specific meditation techniques. Another study on personality and type of meditation found that individuals with high neuroticism tend to benefit more from concentration and observing thoughts, while those with high extroversion obtain more positive responses from humming and walking meditation (Matko and Sedlmeier, 2023)."

Personality typologies can be found that are related to meditation. Several such classifications exist in Buddhism, such as: (a) personalities associated with the jhana practice and (b) the five Buddha families. The Enneagram is another personality classification associated with contemplation that has been used.

Personalities associated with jhanas

Jhanas are states of one-pointed absorption characterized by a reduced awareness of one's surroundings. The Pali Canon describes four progressive states known as *rūpa jhāna* ('form *jhāna*') and four additional meditative attainments that are referred to as *arūpa* ('without form') (Buddhaghosa, 1956). To attain these states, forty objects of meditation can be utilized, of which the chosen object should be appropriate to one's character and temperament. Buddhist teachings mention a total of six character types, and a meditator may identify with any one of these types or a combination of them (Buddhaghosa, 1956).

It is essential to have a qualified and experienced meditation teacher, ideally a personal teacher who can be considered a good friend (*kalyanamitta*), to assist the meditator in choosing an appropriate meditation object. The teacher can explain the meditation process and guide the practitioner's progress. Table 1 summarizes the recommended types of meditation for attaining jhana based on the meditator's personality characteristics.

We can see a tailoring of meditation followed by thousands of meditators over the centuries.

The five Buddha families

In Mahayana and Vajrayana Buddhism, the five Buddha families, frequently depicted in mandalas, are considered emanations or representations of the five qualities of the first Buddha, known as Adi-Buddha. This figure is not the historical Shakyamuni Buddha but represents the Dharmakaya, the unmanifested, inconceivable aspect of a Buddha out of which Buddhas arise and to which they return after their dissolution (Rockwell, 2002).

These qualities are represented by five couples, each comprising a masculine and a feminine Buddha; according to Buddhist mythology, they are associated with different directions (north, south, east, west or centre), colors (blue, yellow, red, green, or white), *mudrā* (the Sanskrit word for gesture) and symbols. Furthermore, they each embody a different aspect, type of evil and cosmic element, and they each have a spiritual son, as well as different animal vehicles (elephant, lion, peacock, garuda or dragon).

There are many more characteristics associated with each Buddha family, but for the purposes of this paper, we will focus only on the personality traits and identify them using the name of the masculine Buddha. The most common names for these Buddhas are Vairocana, Akshobhya, Ratnasambhava, Amithaba, and Amoghasiddhi. These five males Buddhas are also considered a classification of human psychological subtypes. All individuals, including meditators, are believed to belong to one of these categories, and a specific meditation should be tailored to each (Table 2).

The Vairocana family is characterized by the delusion of ignorance and dullness, for which meditation on wisdom (the awareness of the true nature of reality, i.e., impermanence, suffering and emptiness) and non-duality (a way of living life, whereby one feels the interconnection with everything in each moment) is recommended for meditators who belong to it. The Akshobya family is primarily

TABLE 1 Relationship between personality and the object of meditation to attain jhanas (Buddhaghosa, 1956).

Character	Recommended meditation
Lustful character (*lobha carita*): a person with strong feelings of sexual desire	Foulness of the body (it is a practice to break the illusion that the body is a permanent part of a permanent self. It brings attention to the temporary nature of the physical body)
Hateful character (*dosa carita*): an individual filled with hatred	The four brahmaviharas – loving-kindness, compassion, empathetic joy and equanimity – and the four color kasinas. Kasinas are basic visual objects of meditation. The four color kasinas are blue, yellow, red and white.
Deluded character (*moha carita*): a person believing something that is not true	Impermanence, or the fact that the existence of all objects and beings lasts for only a limited time. It is considered one of the main teachings of Buddhism
Faithful character (*saddha carita*): a character steadfast in affection or allegiance	The three jewels: Buddha, dharma or Buddhist teachings, and sangha or assembly of Buddhist practitioners. Or two qualities: morality (principles concerning the distinction between right and wrong) and generosity (the quality of being kind and generous)
Intellectual character (*panna carita*): a person possessing a highly developed intellect	Contemplation on death (meditation on the process of death and dying). Analysis of the four elements (the meditator sees the body as composed of the same material as everything else in nature: earth, water, fire and wind)
Speculative character (*vitakka carita*): an individual with a trend to conjecture	Mindful breathing (to focus our attention on our breath)

TABLE 2 Shows the types of meditation suggested by Dhiravamsa (2011) based on the main ego fixation of each enneatype.

Enneatype	Main ego fixation	Meditation
Type 1. Perfectionist: self-controlled and rational	Resentment	Acceptance of imperfections and self-compassion
Type 2. Helper: generous and caring	Flattery	Loving-kindness and modesty
Type 3. Achiever: success-oriented and pragmatic	Vanity	Self-reflection on happiness as an inner experience
Type 4. Romantic: sensitive and dramatic	Melancholy	Gratitude for life
Type 5. Observer: cerebral and isolated	Stinginess	Mindfulness and sharing with others
Type 6. Loyalist: committed and responsible	Cowardice	Courage and Self-confidence
Type 7. Enthusiast: versatile and scattered	Planning	Sobriety and avoidance of compulsive searching of new experiences
Type 8. Challenger: dominating and self-confident	Vengeance	Surrendering and openness
Type 9. Peacemaker: easygoing and agreeable	Indolence	Mindful movement and action and presence

associated with the delusion of anger, so peace meditation is suggested for its members. Meditators whose main delusion is pride belong to Ratnasambava family and should practise equanimity (the quality that allows us to remain open and balanced in the midst of any changes). Individuals dominated by desirous attachment, the main trait of Amitabha family, benefit from meditation on impermanence. Finally, meditators characterized by jealousy, the mark of the Amoghasiddhi family, should focus on loving-kindness meditation.

While both Buddhist classifications – personalities associated with jhanas and the five Buddha families – are quite distinct, they have been in use for centuries without assessment by modern scientific methods.

The Enneagram

The Enneagram is a model of human mind typologies described by Oscar Ichazo that draws on theories by different humanistic psychology authors. It describes nine interconnected personality types, referred to as enneatypes (Naranjo, 1995). While there are different schools of thought and authors who may not always agree on certain aspects, these nine types are generally accepted. The lack of scientific evidence supporting this classification may be due to limited research; however, its validity appears promising (Alexander and Schnipke, 2020). The Enneagram has been employed by therapists to enhance their understanding of object relations, prominent defences, core motivations and self-awareness.

There are currently no studies regarding the usefulness of this classification; however, the Enneagram has been associated with traditional Buddhist teachings (Piver, 2022), although Piver does not present an academic overview of correlations between the systems. Instead, her book offers a personal exploration of Buddhist teachings on liberation from suffering and their relationship to the Enneagram, illustrating through Buddhist teachings for each of the nine enneatypes that Enneagram is able to offer support for a compassionate and cognizant life, regardless of spiritual path (including the path of no path).

Future suggestions

Tailoring meditation is a fascinating area of research that deserves further exploration. While some tentative proposals have been made, there is currently no solid evidence regarding its effectiveness. Two of the most significant attempts to tailor personality to mediation type are the work by Jagielski et al. (2020), a health-related study on women with breast cancer, and the work by Nyklicek and Irnischer (2017), an analysis of the effect of personality on the outcomes of meditation in the workplace.

We have identified three classifications of personality based on different traits, each one emphasizing distinct aspects of human psychism. Given the difficulty of comparison, they should be assessed independently. One of the challenges is developing reliable questionnaires to measure the different personality subtypes outlined in the three taxonomies. Another is accurately defining the meditations to be assessed. Finally, there must be agreement on what constitutes improvement in meditation. An important limitation of this paper is that we focus only on participant characteristics as sources of variability in responses to meditation, although we acknowledge that contextual factors, such as characteristics of the meditation teacher or group processes, can also play a role. Our aim has been to review the current state of research in this area and reflect on future directions to advance this field.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Author contributions

JG-C: Conceptualization, Methodology, Writing – original draft, Writing – review & editing. RW: Conceptualization, Writing – original draft, Writing – review & editing. RH-A: Conceptualization, Writing – original draft, Writing – review & editing.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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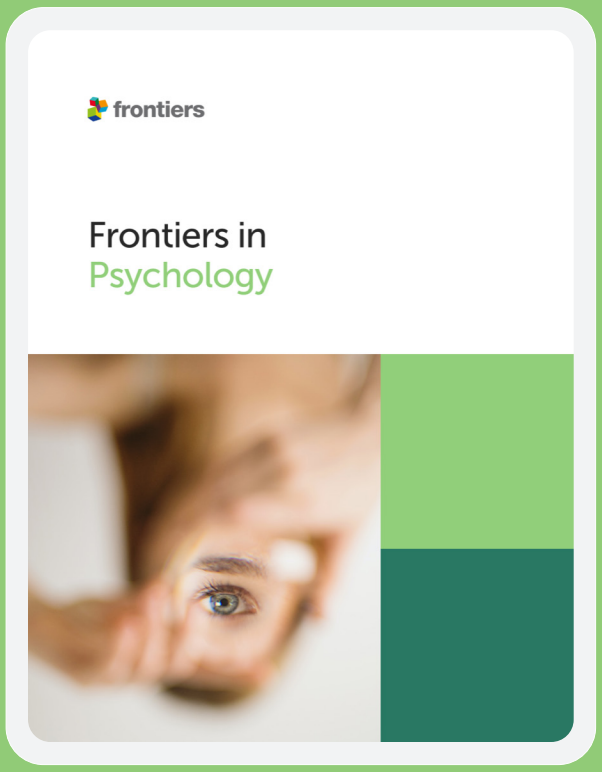

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