Archival Report

Biological Psychiatry: GOS

Shedding Light on Changes in Subjective Experience During an Intensive Contemplative Retreat: The Lyon Assessment of Meditation Phenomenology Questionnaire

Oussama Abdoun, Arnaud Poublan-Couzardot, Stéphane Offort, Giuseppe Pagnoni, and Antoine Lutz

ABSTRACT

BACKGROUND: A significant share of meditation research relies on trait psychometric measures of mindfulness, which neglect the complex and dynamic unfolding of experiential processes entailed by meditation over time. However, there have been a few attempts to capture ongoing changes in experience during meditation. In this study, we integrated and expanded on 3 of these previous approaches to create a novel instrument, which we called the Lyon Assessment of Meditation Phenomenology (LAMP). This questionnaire encompasses contextual, conative, affective, somatic, attentional, cognitive, and metacognitive domains.

METHODS: Fifty-three experienced meditators completed the LAMP after each meditation session during an intensive 10-day retreat. We modeled the time courses of the individual answers to each question using generalized additive modeling and automatically clustered participants using group-based trajectory modeling.

RESULTS: Over 60% of the dimensions assessed by LAMP exhibited significant change during the retreat across the group, following distinct temporal trajectories. These trajectories reflected differences between meditation types (chiefly, focused attention and open monitoring) and individual expertise, supporting a previously proposed multidimensional phenomenological model of mindfulness-related practices. We also identified 3 clusters of individual temporal trajectories associated with prior meditative experience and difficulties experienced during the retreat. Finally, we replicated and extended core findings from mindfulness research on pain regulation.

CONCLUSIONS: The proposed multidimensional experience-sampling approach provides a rich characterization of the dynamic aspects of meditative experience and may be used to deepen our knowledge of the phenomenology and mechanisms of meditation and meditation-based interventions.

https://doi.org/10.1016/j.bpsgos.2025.100474

In recent years, there has been a surge in literature examining the effects of various mind-body training regimes that fall under the umbrella of contemplative practices. This research field is still in its infancy, and various practices are studied (1); however, a significant focus has been placed on mindfulness practices, which are conceptualized as attention-based, regulatory, and self-inquiry training regimes cultivated for purposes such as well-being and psychological health (2–4). This surge of interest reflects the growing recognition of the positive impact of mindfulness meditation (MM) on mental well-being (3,4), cognitive processes (5), and overall psychological health (4). Evidence from meta-analyses indicates that mindfulness-based interventions (MBIs) have beneficial effects in specific areas of psychopathology, including depression, anxiety, chronic pain, and substance abuse (3). Although key mechanisms of action of MBIs, such as decentering (6,7), have been identified, in the current study, we aimed to further refine our understanding of the mechanisms that underlie their clinical benefits.

A substantial portion of this research has relied on trait psychometric measures of mindfulness (8–10), which typically refer to a generic class of events (e.g., "In difficult situations, I can pause without immediately reacting") or even to self-concepts ("I am easily distracted"). Although clinically relevant, some of these measures have problematic construct validity (2,11). Furthermore, conceiving mindfulness as a fixed state or trait is likely to oversimplify the complex dynamic processes that unfold with regular practice (2) and can lead to spurious findings (12). In contrast, the current study is aimed at specifically investigating the very specific and fresh experience—namely a meditation session that has just ended—so as to characterize the temporal dynamics of meditative experience that unfold across several days of practice. It also aims to showcase the effectiveness of using

© 2025 THE AUTHORS. Published by Elsevier Inc on behalf of the Society of Biological Psychiatry. This is an open access article under the CC BY-NC-ND license (http://creativecommons.org/licenses/by-nc-nd/4.0/).

ISSN: 2667-1743

fine-grained first-person data to probe the cognitive mechanisms that underlie MM.

A few authors have proposed different conceptual frameworks to capture changes in experience during meditation. Our study integrates and extends 3 prominent existing frameworks, among others, into a novel psychometric instrument that was used during an intensive 10-day meditation retreat. The phenomenological matrix of mindfulness (PMM) by Lutz *et al.* (2) views MM as a continuum of practices that involve states and processes that can be mapped into a multidimensional phenomenological space. This space consists of 7 features: 3 primary dimensions (object orientation, dereification, and meta-awareness) and 4 secondary qualities (aperture, clarity, stability, and effort). While providing a theoretical foundation for characterizing the fundamental structural features of mindfulness phenomenology, empirical validation is currently lacking.

Kok and Singer (13) proposed measures reflecting meditation-related shifts in experiential contents related to temporality, self-relevance of thoughts, and the valence and conative dimensions of feeling states. Complementing these approaches, Lindahl *et al.* (14) focused on underreported, challenging meditation-related experiences and identified a taxonomy of 59 experiences across 7 domains.

Based on these frameworks, as well as teachings and experiences that diversely shaped our personal understandings of meditative processes, we designed the Lyon Assessment of Meditation Phenomenology (LAMP) questionnaire, which comprises 37 questions across several phenomenological and psychological domains. The questionnaire also includes questions that probe relatively infrequent meditative phenomenology such as perceptual distortions, alterations in the sense of self, as well as adverse or blissful experiences of unusual intensity. We aimed to capture dynamic shifts in the contents of experience (i.e., the "what") and qualities of experience (i.e., the "how") during meditation retreats. In contrast to most self-report questionnaires, the LAMP questionnaire requires specific methodological considerations due to the phenomenological nature of many of its items. Investigating the "how" of experience often necessitates first- and second-person qualitative methods because these aspects of consciousness (e.g., quality of attention, affective tone) are typically lived prereflectively and intransitively. These methods are aimed at helping participants become more reflectively attentive to experiential qualities to accurately report them (15,16). Here, MM itself is assumed to function as a first-person method that cultivates an explicit attitude of attentive self-awareness (16). We also conducted a 1.5-hour training session to introduce the questionnaire and provided concrete examples to ensure that participants engaged with it both cognitively and experientially.

We anticipated that this multidimensional questionnaire would reveal rich insights into the phenomenology of mindfulness. Firstly, we hypothesized that the sustained meditation regime of an intensive residential retreat, where participants dedicate most of their time to practice, often in silence, for days and weeks (17), would be associated with significant changes in most dimensions of contemplative experience. We also predicted that these changes would be consistent with distinctions between meditative states (focused attention [FA] and open monitoring [OM] meditation) and the participants' prior meditation experience, as initially proposed for the PMM (2). Secondly, we anticipated that this framework would replicate and expand previous findings about the effect of mindfulness on pain regulation (18,19). MM has a well-documented history of efficacy in chronic pain management (20,21) and has been shown to modulate acute pain perception among regular practitioners (19,22). Notably, a defining feature of MM is to engage fully with the pain experience while reducing reactivity. This process primarily influences the affective aspect of pain, as opposed to its sensory dimension, a phenomenon that we termed sensory-affective uncoupling (19). In this study, we aimed to test whether participants' proficiency in meditation, as acquired over the course of the retreat, would lead to increased pain uncoupling. We also aimed to identify the active principles of this regulation. These principles, such as attentional control, acceptance/nonreactivity, metacognitive insight, adaptive self-beliefs, and motivation, have been the focal points of previous psychotherapeutic interventions for pain (23,24).

METHODS AND MATERIALS

Participants and Ethics Statement

We recruited 54 participants with variable meditation experience (see demographics in Table 1). Inclusion and exclusion criteria are detailed at length in the clinical trial record of the study (ClinicalTrials.gov ID: NCT04449913), which received approval from an independent ethics committee on human research (CPP Est IV 2020-A00669-30). The main inclusion criteria were ages between 18 and 67 years, speaking French fluently, having been trained in a formal meditation practice (mindfulness, mindfulness-based stress reduction [MBSR], Buddhist traditions), having a regular practice of at least 20 minutes per day 3 times a week for at least 1 year, and having already participated in a silent meditation retreat of at least 2 days with a minimum of 6 hours of meditation per day.

Table 1. Demographic Characteristics of the Retreat Participants

Characteristic	*N* = 53
Gender	
Women	33 (62%)
Men	20 (38%)
Age, Years	49 (38–55)
Socioprofessional Category	
Farmers	0 (0%)
Craftsmen, shopkeepers, and business owners	1 (1.9%)
Executives and intellectual professions	21 (39.7%)
Intermediate occupations	7 (13.2%)
Employees	5 (9.4%)
Workers	0 (0%)
Retirees	3 (5.7%)
Others without professional activity	13 (24.5%)
NA	3 (5.7%)

Values are presented as *n* (%) or mean (range). The socioprofessional category is an official index of socioeconomic status developed by the French National Institute of Statistics and Economic Studies. Here we used the 2003 classification.

NA, not available.

Exclusion criteria were a history of neurological or psychiatric conditions, chronic pain or any other medical condition that caused acute pain or increased sensitivity to pain, motor or sensory deficit in the hands, severe auditory loss, and regular use of opioids or drugs that act on the central nervous system. During their first visit to the laboratory, inclusion and exclusion criteria were strictly assessed, with the participants also receiving a detailed explanation about the study and its measurements before signing an informed consent form. They were then interviewed by the experimenter, who quantified their history of daily and retreat meditation.

Experimental Design

For detailed information regarding the retreats' setting and structure, the meditation instructor, and meditation practices, see Supplemental Section 1.

Retreat Information. Data collection was organized in 3 waves, each one involving a 10-day MM retreat, which took place between fall 2020 and spring 2021 at the IZARIAT retreat center (Le Poizat-Lalleyriat, France). All retreats followed the same structure, but due to initial difficulties in recruitment and COVID-19 restrictions, they varied in the number of participants: 11 (8 women and 3 men) took part in the first one, 23 (15 women, 8 men) in the second, and 19 (10 women, 9 men) in the third retreat. The first retreat stopped 1 day earlier due to the announcement of a COVID-19 lockdown in France. The daily schedule included approximately 7 hours of formal group meditation, divided into eight 45- to 60-minute sessions. All retreats were supervised by co-author SO, a qualified meditation instructor trained in Tibetan Buddhism and MBSR (see Supplemental Section 1.2).

The meditation retreats arranged for the current study were secular and followed a sequence of mindfulness and compassion practices as described in meditation manuals (25,26). The retreat started with FA meditation on bodily sensations and extended to external sensations, thoughts, and emotions, with the aim of calming the mind and fostering concentration and meta-awareness. The practices gradually shifted into OM meditation, characterized by an equanimous acceptance of anything that spontaneously enters the field of consciousness (see Figure 1 and Supplemental Section 1.3).

Meditation Experience and Psychometric Questionnaires. Participants' previous meditation experience was assessed by multiple metrics (see Supplemental Section 2.1 and Table S1). In the current study, we focus on total lifetime practice. Participants completed a battery of standard psychometric questionnaires (see Supplemental Section 2.3) during their first visit to the laboratory and again 3 weeks after the retreat. For the purposes of the current report, we only use the Drexel Defusion Scale (DDS) (27) and the Pain Catastrophizing Scale (PCS) (28) scores collected before the retreat. The PCS is a 13-item questionnaire used to measure the extent to which individuals have exaggerated negative thoughts and feelings about their pain. The DDS is a 10-item questionnaire designed to measure cognitive defusion, the ability to achieve psychological distancing from distressing thoughts and view them as mere mental events rather than truths.

LAMP Questionnaire

The latest version of the questionnaire is available for reuse at https://osf.io/e2fud. The versions used for the retreats had some minor differences, which are described in detail in Supplemental Section 2.2.

Development. The LAMP was designed to capture aspects of the subjective experience of a meditation session in a quantitative fashion. One driving motivation for LAMP was to

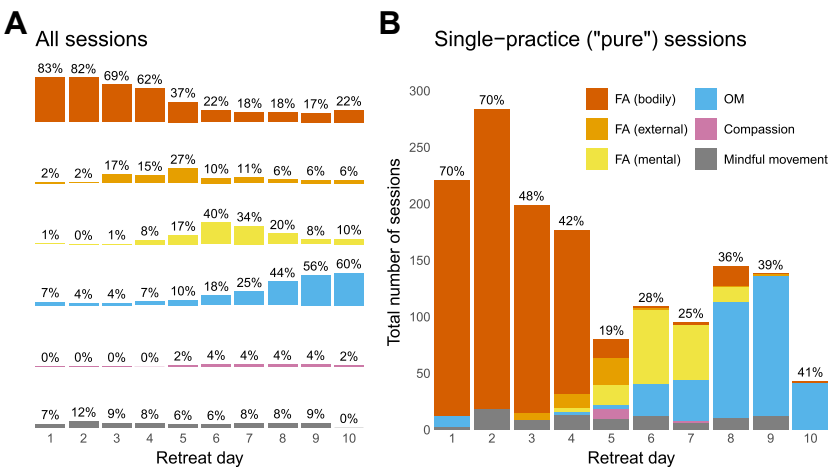

Figure 1. Average timeline and frequency of meditation practice styles during the retreat across all participants, as reported by participants on the postmeditation questionnaire. See Figure S1 for the timeline of each retreat. **(A)** Overview of all meditation sessions for each day of the retreat. Percentages indicate the prevalence of a practice style among all sessions on that day. For sessions with multiple practices reported, prevalence was weighted so as to sum to 1. The most frequently practiced techniques were focused attention (FA) (67.2% of overall practice time) on either bodily sensations, external sensations, or mental events and open monitoring (OM) (23.5%), predominating during the first and second half of the retreat, respectively. Mindful movement sessions were incorporated (7.3%) from the beginning, while compassion meditation started midway through the retreat (2% overall). The specific timing of these practices slightly varied by 1 or 2 days across retreats, reflecting the instructors' efforts to tailor the teachings to the evolving needs and progress of each group (see Figure S1). **(B)** Total number of sessions using a single meditation technique (pure session) over the 3 retreats performed in the study. In contrast to manualized interventions, practitioners had the flexibility to gradually select 1 or 2 techniques to practice preferably during a session. Percentages indicate the proportions of pure sessions among all sessions. It is maximal in the first 2 days and then declines sharply with the introduction of new practices. Description of practice types: FA (bodily), attention on the breath or bodily sensations; FA (external), attention on external stimuli, typically sights or sounds; FA (mental), attention directed toward thoughts, feelings, and emotions; OM, open monitoring and open awareness practices; and mindful movement, practices based on movement, such as walking meditation and exercises inspired by yoga or qi gong.

explore the multidimensional PMM (2), initially designed to map states and processes across various mindfulness-related practices. The version of LAMP presented here measures 6 of the 7 core dimensions and 2 of the 4 contextual features of PMM (see Supplemental Section 2.2 for details).

The LAMP adopted 1 question on the distractibility of thoughts from Kok and Singer (mental stickiness), as well as 4 questions that pertain to the temporal orientation and self/other orientation of spontaneous thoughts (13). We refined the characterization of thoughts by adding a present orientation option, questions on their temporal depth, and a question on the thematic orientation toward spiritual and/or material concerns. Our approach to probing feeling states departed from Kok and Singer's 2-dimensional affect grid (valence and arousal). Instead, we implemented a multiselect approach with a list of affective states inspired by the Positive and Negative Affective Schedule (29).

We also included items that probe aspects of experience that feature prominently in some Buddhist traditional phenomenological accounts of meditation, either as supportive or adverse factors (30) (see Supplemental Section 2.2 for details). We also collect contextual information about the meditation session, such as the practices that the participants followed during the session and whether they kept their eyes open or closed.

Finally, the last section of the LAMP allows participants to report remarkable experiences. One special class of such experience is insight, defined as "the impression of gaining some novel understanding" about the meditative practice; the teachings; and/or one's own mind, life, or something else. Other unusual experiences can be described in free text and/or assigned to one or more categories. The list of options was drawn from the categories of meditation-related effects that emerged from the thematic content analysis of the phenomenological interviews of Buddhist meditators by Lindahl *et al.* (14). These unusual experiences will be analyzed and reported in a future publication.

The items were written collectively by all authors, who have experience in various contemplative traditions (Zen, Vipassana, Tibetan, mindfulness) and are acquainted with Buddhist psychological theories. A preliminary version of the questionnaire was first tested by author OA during a 10-day Vipassana retreat, as well as by experienced practitioners at an MM retreat led by the meditation instructor SO. The questionnaire was revised after each piloting phase.

In the remainder of the article, the probed dimensions are organized into 6 domains for the benefit of communicating findings: conative, affective, somatic, attentional, metacognitive/reflexive, and cognitive (see Figure 2 for an overview of the questions foci and the complete questionnaire for a detailed list of the questions).

Data Collection and Preprocessing. Participants completed the LAMP on individual tablets available for the duration of the retreat. A training session about the use of the tablets and the questionnaire was organized the evening before each retreat, which allowed the participants to clarify any ambiguity or misunderstanding with the experimenters. Thereafter, participants were invited to complete the questionnaire after every meditation session of the retreat. Although this was not compulsory, the completion rate was very high at 98% and resulted in 3603 data points.

Some of the variables reported in the current report were preprocessed or derived from the original responses (see Supplemental Section 3.1).

Data Analysis

Generalized Additive Mixed Modeling. We investigated the dynamics of phenomenological ratings using generalized additive mixed models (GAMMs). GAMMs allow for nonlinear relationships between predictors and the response variable, incorporating smooth functions of covariates, and can account for the multilevel structure that arises from within-subject sampling using (nonlinear) random effects. We modeled each response variable as a nonlinear smooth function of time-into-retreat (day) and within-day time (session). By-subject day and session random factor smooths were included to model nonlinear individual variability from the group means. Thin plate regression splines were used for both fixed and random effects. There was no need to model residual autoregression because it was low in all models (maximum 0.14). The R package *mgcv* was used to specify and fit the models using the fast restricted maximum likelihood algorithm (31,32).

For the model testing the predictions of PMM, we used a linear mixed model with a by-subject random intercept. Model fitting and inference were conducted with the *lme4* and *lmerTest* packages, respectively (33,34).

Group-Based Trajectory Modeling. Group-based trajectory modeling (GBTM) is a type of finite mixture model that uses maximum likelihood estimation to identify homogeneous subgroups in a heterogeneous collection of time series (35). It assumes a finite number of subgroups, each described by a polynomial function of time, and estimates both the parameters of the generative functions and the group membership. GBTM is very useful to unravel the structure of variability in temporal trajectories, such as the time courses of dimensions of meditation experience. We used the *gbmt* package in R (36). This implementation requires prespecification of the degree of polynomial functions as well as the maximum number of clusters. We chose fourth-degree polynomials because the average effective degrees of freedom estimated by the GAMMs was close to 4. To determine the optimal number of clusters, we ran the algorithm on a range of cluster numbers and chose an optimal value that balanced model parsimony and goodness of fit, as indexed by information criteria.

To identify homogeneous subgroups of participants across the 6 dimensions of PMM (2), we used a multivariate extension of GBTM implemented in *gbmt* (37).

Correlations. All correlations reported in the current study are Spearman coefficients, which are equivalent to Pearson correlations of rank-transformed data. They assess the strength and direction of the monotonic relationship between variables. For correlations between variables of the questionnaire, we adopted a multilevel approach, which effectively provides a group-level estimate of the association within participants (38).

RESULTS

Exploratory Analysis of the Dynamics of Phenomenological Dimensions

Figure 2 presents the average time courses of ratings for each phenomenological dimension observed throughout the entire retreat. Among the 39 phenomenological variables examined, 24 exhibited consistent patterns of day-to-day variation changes across individuals, with an additional 4 showing trends toward significance (see Figure 2).

These changes encompassed shifts in both experiential content—the "what" of experience (e.g., pain intensity)—and

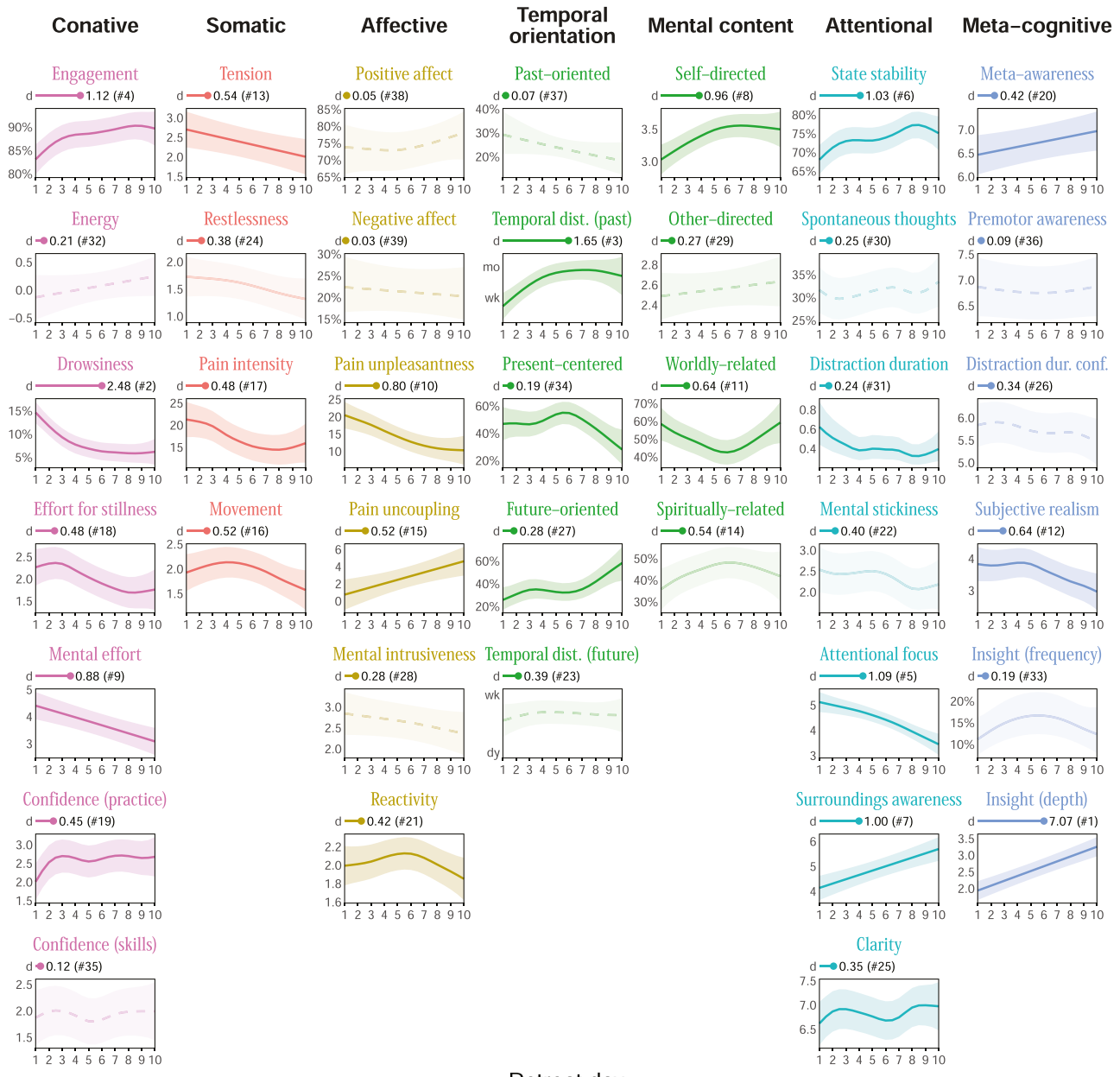

Figure 2. Time courses of the ratings of each phenomenological dimension across the entire retreat. For convenience, the cognitive domain has been divided into 2 subdomains laid out over 2 columns, time orientation and mental content. Curves are model predictions, and confidence bands are 95% CIs. Significance is indicated by the style of the curves: $p < .05$ after false discovery rate correction for solid and opaque curves, $.05 < p < .10$ for solid pale curves, $p > .10$ for dashed pale curves. Above each curve, an approximation of Cohen's d is displayed together with the effect size rank of the variable (see Supplemental Methods 3.2). Thus depth of insight is the dimension with the highest effect size ($d = 7.07$, #1), and negative affect has the lowest one ($d = 0.03$, #39). The colors of each graph represent 6 psychological domains of inquiry: conative, affective, somatic, mental contents (including time orientation), attentional, and metacognitive. dist, distance.

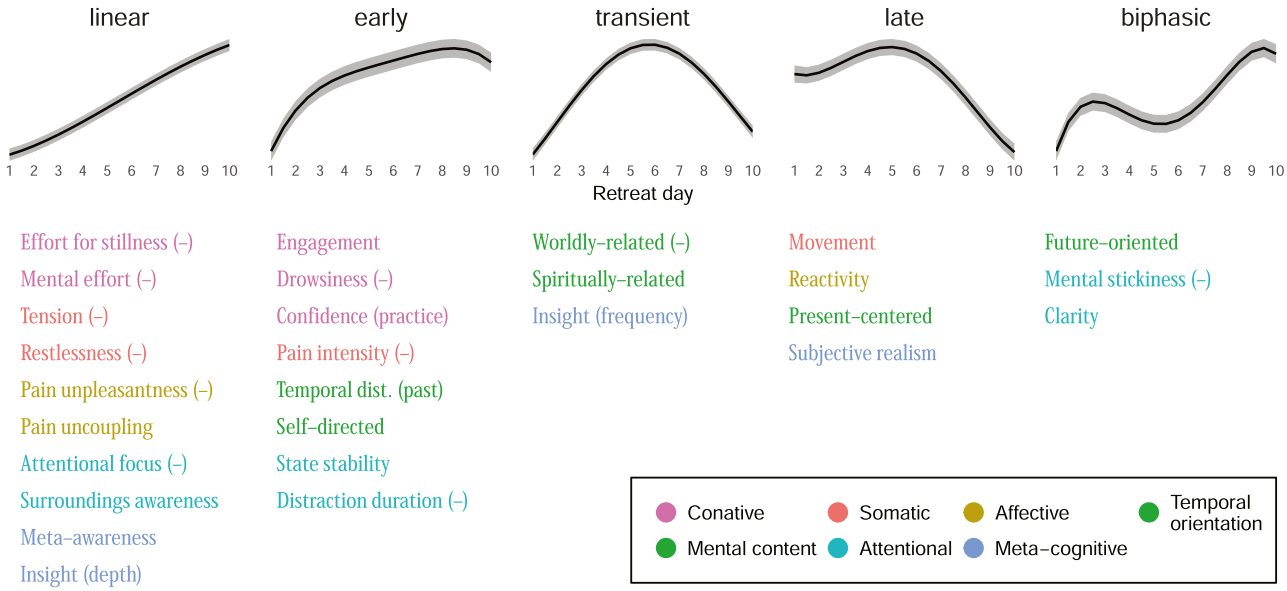

Figure 3. Classes of phenomenological temporal evolution identified by group-based trajectory modeling. This data-driven clustering procedure on the significant and nearly significant ($p < .1$) dimensions identified 5 distinguishable temporal evolution classes for the collected phenomenological dimensions, showing how both cumulative practice time across the retreat and daily changes in the content of the meditative program differently impacted the dynamics of these dimensions. The most populated class comprises dimensions that evolved linearly throughout the retreat (linear). The second-largest class gathers dimensions that quickly increased or decreased in the first 3 days before slowing down (early). Three dimensions, pertaining to the thematic orientation of spontaneous thoughts and intensity of insight, had similar levels at the beginning and end of the retreat but reached a peak around days 5 and 6 (transient). Four dimensions increased slightly in the first half of the retreat before decreasing sharply (late). Finally, 3 dimensions had a more complex temporal pattern, featuring both an early and a late change (biphasic). Phenomenological dimensions that evolve opposite to the patterns illustrated at the top are followed by the (−) sign. dist, distance.

structural features—the "how" of experience (e.g., subjective realism). In particular, the strongest effects were observed in depth of insight, drowsiness, engagement, stability, pain unpleasantness, and mental effort (see Figure 2).

Over the course of the retreat, past-oriented thoughts shifted to events progressively more distant in the past (see temporal dist. (past) in Figure 2), while general thoughts tended to be more future-oriented during the final 4 days (see future oriented in Figure 2). There was also a gradual transition toward thoughts being more self-directed and spiritually related, particularly during the middle phase of the retreat. Experiential changes over the course of the retreat followed specific time courses that could be categorized into 5 clusters of distinguishable temporal evolution (Figure 3 and Figure S2). The most prevalent patterns included linear changes (10/28 dimensions), rapid early changes (8/28), transient effects peaking at the midpoint of the retreat (3/28), late delayed effects (4/28), and biphasic effects (3/28).

On a finer time scale, within a day, consistent changes across individuals were also observed for 18 dimensions, with an additional 5 showing trends toward significance (see Figure 4). Having followed a bottom-up descriptive approach in the first part of this report, now we shift our focus to a targeted investigation of a subset of phenomenological dimensions to test specific theoretical hypotheses. Our objective is 2-fold: to explore predictions based on a previously developed model of MM and to expand on previous findings about pain perception during meditation.

Predictions of the PMM

The PMM [Lutz *et al.* (2)] provides a theoretical framework to understand the richness of meditation-induced changes in the structure of subjective experience. It also makes predictions about the effects of different styles of practices and levels of expertise on the following dimensions: meta-awareness, deeification (the reverse of subjective realism), object orientation, clarity, stability, aperture, and effort. We tested predictions from the PMM regarding the effects of mindfulness styles (FA vs. OM) and expertise (except for object orientation, which was not adequately measured in the version of the LAMP used for study retreats). For each dimension of the PMM, we tested both the practice style and expertise effects in a single model controlling for age. All dimensions except for clarity were significantly different in FA at the beginning of the retreat compared with OM at the end (all $ps < .001$) (Figure 5A; see Table S2 for detailed statistics) in the directions predicted by PMM. However, because the temporal order of the practice styles in the retreat was confounded with time into retreat, with a larger prevalence of FA and OM during the first and the second half of the retreat, respectively (see Figure 1), we cannot exclude the possibility that part of the observed effects are due to time into the retreat.

Consistent with the PMM model, meta-awareness, deeification, and aperture increased (and mental effort decreased) significantly with expertise, as indexed by cumulative lifetime practice (all $ps < .01$) (Figure 5B). The slopes for stability and clarity as a function of expertise were also in the

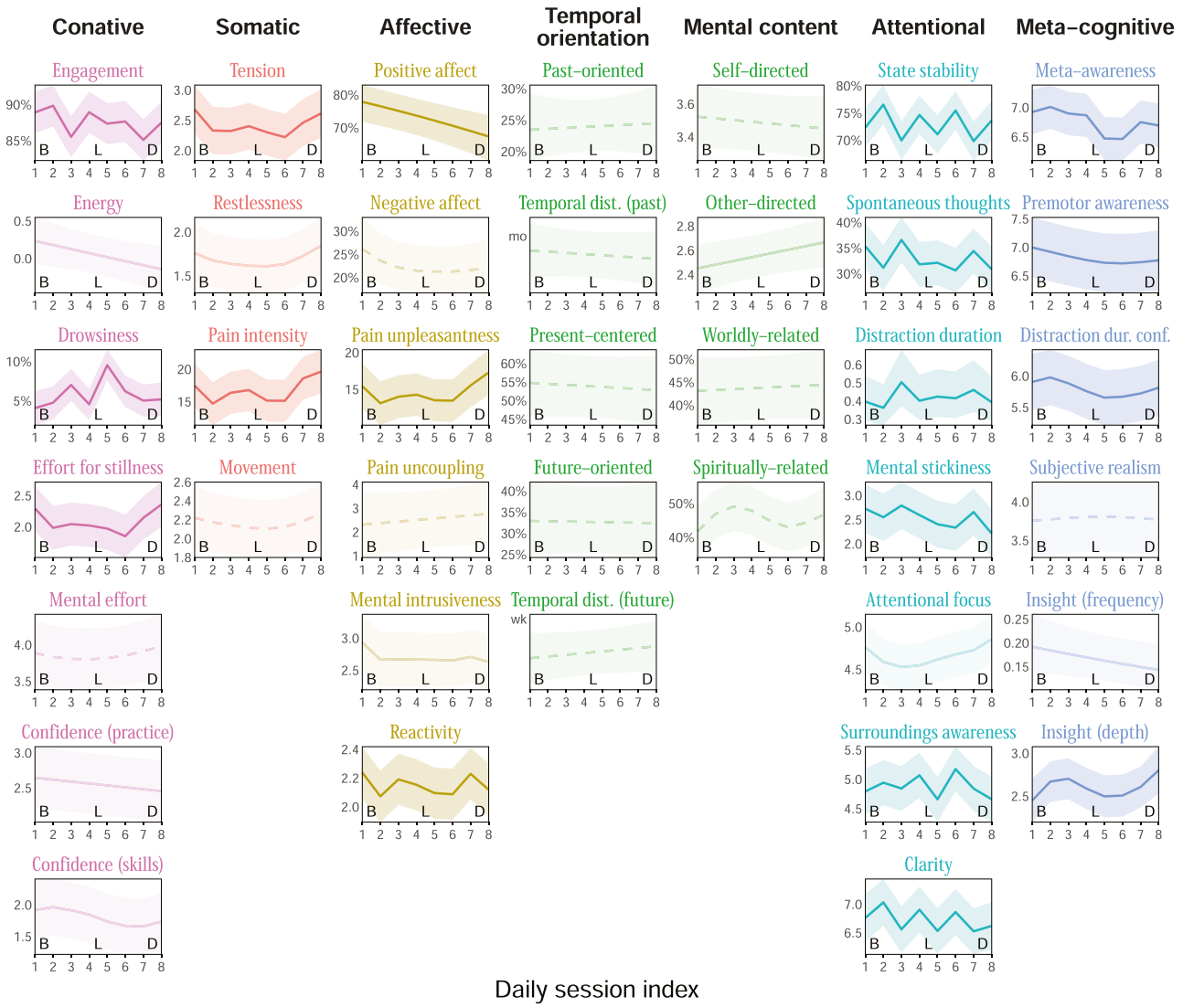

Figure 4. Time courses of the ratings of each phenomenological dimension within a retreat day. One type of change most likely corresponds to a postprandial effect (e.g., drowsiness, awareness of the surroundings). Another dynamic pattern reflects a gradual increase in physical and mental discomfort throughout the day, as indicated by rises in tension, restlessness, pain intensity, pain unpleasantness, and effort for stillness, coupled with a decline in energy, positive affect, and confidence in both the efficacy of the practice and one's own meditative competence. Interestingly, this discomfort experienced toward the end of the day was accompanied by an increase in depth of insight. Additionally, an oscillatory pattern for what concerns the perceived stability and clarity of mental state was observed, whereby an increase during one session was frequently followed by a decrease in the following one. Curves are model predictions, and confidence bands are 95% CIs. Significance is indicated by the style of the curves: $p < .05$ after false discovery rate correction for solid and opaque curves, $.05 < p < .10$ for solid pale curves, $p > .10$ for dashed pale curves. The colors of each graph represent 6 psychological domains of inquiry: conative, affective, somatic, mental contents (including time orientation), attentional, and metacognitive. Meal times are indicated at the bottom of each graph: B, breakfast; L, lunch; D, dinner. Note how the highest peak in drowsiness occurs following lunchtime and thus likely reflects postprandial somnolence. dist, distance.

predicted direction, although not statistically significant, possibly due to the restricted range of meditation experience in our sample. Figure 5C graphically illustrates the differences in dynamic trajectories as a function of meditation experience. More experienced practitioners (>2000 hours of meditation in life) improved only on dereification. They began and remained at high values on other dimensions during the retreat. By contrast, less experienced practitioners started from lower values on these dimensions than more experienced ones and showed a different temporal evolution. They reported a gradual increase in all dimensions of interest until the end of the retreat, with values nonetheless being lower on average than those of the experienced practitioners.

To further explore the interindividual variability in the dynamics across the PMM, we next applied group-based multivariate trajectory modeling to the subset of 6 phenomenological

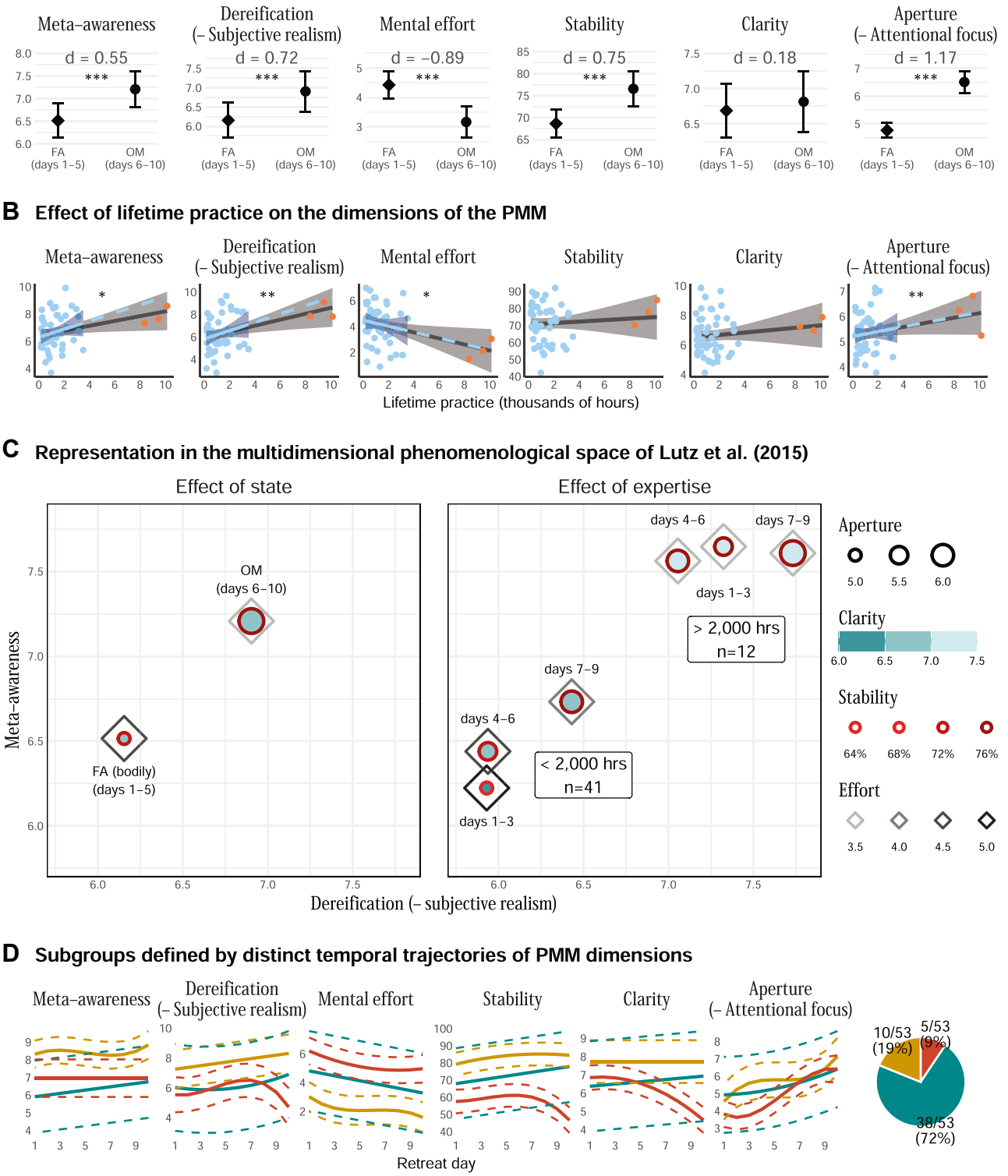

Figure 5. Testing the predictions from the phenomenological matrix of mindfulness (PMM) (2). **(A)** Effect of practice on the PMM dimensions. Except for the dimension of clarity, focused attention (FA) and open monitoring (OM) practices differed following these predictions. To simplify the interpretation of this analysis, we used only sessions for which participants reported practicing either only bodily FA or only OM. Note that the observed effect is confounded by a practice order effect during the retreat (FA was prominent in the first half of the retreat and OM in the second half). In particular, the observed increases in

dimensions. This data-driven approach qualitatively confirmed and refined the findings displayed in Figure 4C. Three clusters emerged (Figure 5D and Figure S3). A small group (n = 10/53, orange cluster) started high on all dimensions and remained stable across the retreat, except for a linear increase in dereification; the practitioners in this group were also significantly more experienced than the rest of the sample (mean = 3320 hours vs. 1299 hours, Wilcoxon rank-sum test: W = 113.5, p = .023). A second group, which included most participants (n = 38/53, green cluster), progressed linearly over the time course of the retreat in all dimensions. Finally, the smallest group (n = 5/53, red cluster) included participants who decreased on some dimensions, especially toward the end of the retreat; these low scores were associated with personal difficulties that arose toward the end of the retreat (physical, e.g., toothache, tinnitus, and motivational struggles).

Replicating and Extending Findings on Pain Sensory-Affective Uncoupling During MM

Consistent with our prediction, we found that pain sensory-affective uncoupling, operationally defined as the difference between pain intensity and unpleasantness ratings, increased over time, reaching statistical significance from day 3 onwards (Figure 6A, left). After orthogonalization of the 2 pain dimensions, the effect appeared to be driven by a specific decrease in pain unpleasantness (Figure 6A, right).

Building on our earlier work (39), we tested whether trait cognitive defusion (DDS) was a better predictor of pain uncoupling than trait pain catastrophizing (PCS) scores. Confirming these findings, we found that preretreat scores on DDS, but not on PCS, negatively correlated with retreat-averaged pain unpleasantness after orthogonalization with pain intensity (r = −0.34; 95% CI, −0.56 to −0.08; p = .012) (Figure 6B). This correlation persisted even after controlling for pain catastrophizing (r = −0.29; 95% CI, −0.52 to −0.02; p = .034).

Next, we investigated the potential active contributions to pain regulation (23,24) of dimensions of subjective experience probed by LAMP. We tested whether the changes in these dimensions across the retreat could predict variations in pain ratings at the individual level (Figure 6C). We found that confidence in practice and skills, engagement, mental intrusiveness, reactivity, state stability, mental stickiness, premotor awareness, and subjective realism were associated with changes in pain unpleasantness after orthogonalization with pain intensity. These associations were highly specific for confidence in one's own skills, reactivity to experiences, meta-awareness, and premotor awareness. None of the tested dimensions correlated with pain intensity after orthogonalization with pain unpleasantness.

DISCUSSION

In this study, we aimed to develop a measurement tool to assess the fine-grained structure and changes in subjective experience of meditation practitioners. We demonstrated it by describing in detail the temporal evolution of various dimensions of contemplative experience reported by a sample of experienced practitioners during a 10-day intensive meditation retreat. The architecture of the retreat mirrored a natural progression in many contemplative traditions from concentrative practices (FA) to a broader scope of attention to any arising phenomenon (OM). We identified meaningful statistical regularities and found that phenomenological dimensions could be grouped into a small number of temporal evolution classes. Many dimensions, including physical relaxation, mental ease, and metacognitive insight, showed an approximately linear progression during the course of the retreat, suggesting that they are general outcomes of meditation practice. Among the experiential features that showed marked increases early in the retreat, some indicated a shift of mindset and adaption to the retreat setting (engagement, confidence, and self-directedness of thoughts), while others are widely considered specific targets of FA practices (attentional stability, alertness). Two core dimensions of contemplative experience, equanimity and dereification, changed only later, possibly reflecting the specificity of OM practices and/or the requirement for cumulated practice.

Furthermore, our findings are largely consistent with predictions about the average locations occupied in a phenomenological space during FA and OM practices (2). Participants with more extensive accumulated lifetime experience rated higher in meta-awareness and dereification, suggesting the accrual of practice-related effects over time. Finally, we examined how the phenomenon of pain uncoupling—whereby the affective (unpleasantness) and the sensory (intensity) component of pain can partially dissociate in an individual's experience—would be affected by the retreat, given our previous work (39) and traditional claims about the effects of meditation (40). We observed that pain uncoupling increased linearly with time into retreat and was significantly predicted by the individual scores on a scale assessing individual trait capacity for achieving psychological distance from mental

meta-awareness, stability, and dereification and the decrease in mental effort during the course of the retreat could have occurred not only due to the gradual introduction of the OM practice but also by practitioners becoming more proficient in meditation as the retreat progressed. **(B)** The relationships between the phenomenological scores averaged across retreats and participants' total lifetime practice are also congruent with the PMM model for meta-awareness, dereification, mental effort, and aperture. We used only sessions with FA or OM practices in this analysis. While the estimation of the regression lines (black lines) may seem to be driven by the 3 outlier participants (with more than 8000 hours of practice), slopes in fact remain similar when these points are removed (blue lines). **(C)** For an easier comparison, we replicated the graphical scheme used in Figure 1 in Lutz *et al.* (2). **(C)** Left: Group-averaged data for pure bodily FA and OM sessions. **(C)** Right: Group-averaged data for 2 subgroups of low and high meditation experience at different stages of the retreat. The cutoff between the subgroups was arbitrarily chosen to illustrate the effect of experience on the baseline and temporal evolution. **(D)** Data-driven clusters of participants based on the joint temporal trajectories across the 6 dimensions of the PMM, where different colors identify different subgroups of participants as detailed in the main text, and dashed lines represent 95% confidence bands. In particular, the red cluster consists of 5 participants who exerted high effort in their meditation practice but reported low stability; unlike others, these participants exhibited a decrease in dereification, stability, and clarity during the second part of the retreat. Significance: $^{*}p < .05$, $^{**}p < .01$, $^{***}p < .001$.

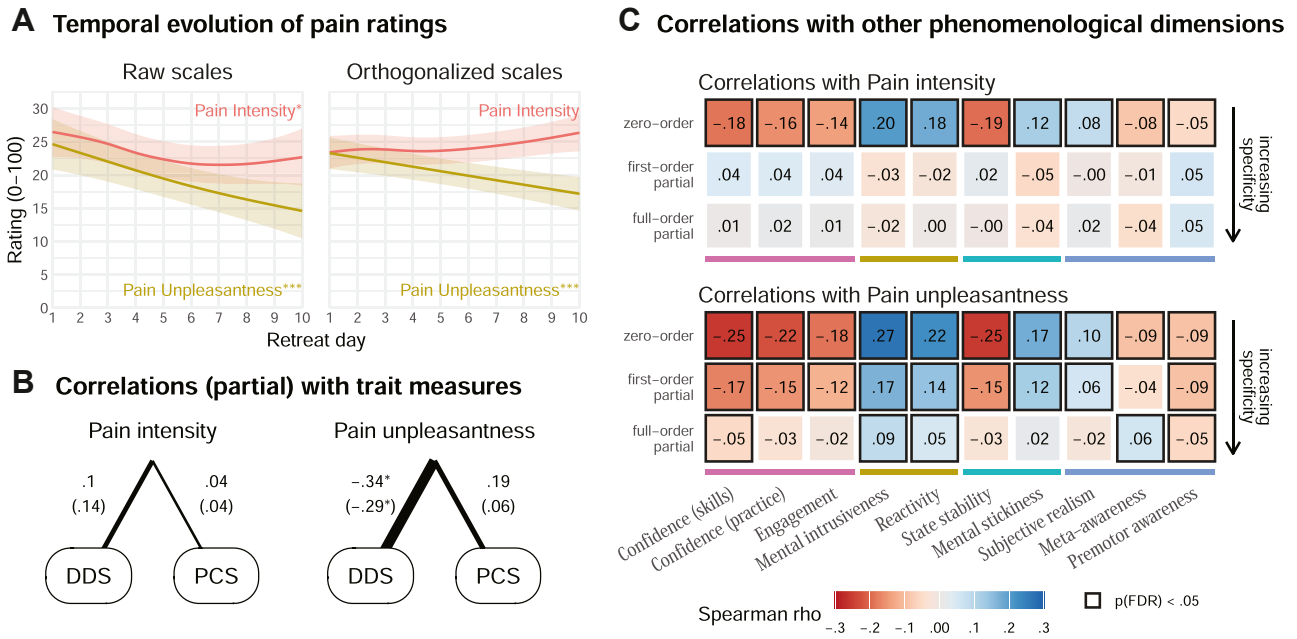

Figure 6. Evolution and regulatory mechanisms of the sensory-affective uncoupling of pain during meditation. **(A)** Both the sensory and affective components of pain (indexed by ratings of intensity and unpleasantness, respectively) appeared to decrease significantly over the course of the retreat. However, after orthogonalization of the 2 scales, only the decrease of pain unpleasantness remained significant. **(B)** Trait cognitive defusion (Drexel Defusion Scale [DDS]) predicted retreat-average orthogonalized pain unpleasantness, but not pain intensity, an effect that remained significant after partialling out Pain Catastrophizing Scale (PCS) scores (values within parentheses). Trait pain catastrophizing was not associated with any measure of pain. Line widths are proportional to the corresponding partial correlation coefficients, and asterisks mark significant correlations at the $p < .05$ level. **(C)** Spearman, multilevel, within-subject correlations between pain ratings and hypothesized phenomenological dimensions implicated in pain regulation. To account for potential confounds arising from shared temporal patterns, all correlations were adjusted for time into retreat. Significant correlations ($p < .05$) are denoted by a black square. False discovery rate (FDR) correction for multiple comparisons was applied to each family of correlations, corresponding to a row of values in the plot. The zero-order correlations, reflecting direct associations with pain ratings, were found to be uniformly highly significant. However, upon orthogonalizing pain ratings—partialling out pain unpleasantness from correlations with pain intensity and vice versa—only correlations with pain unpleasantness remained significant (first-order partial correlations). This dissociative pattern suggests that the active processes and factors cultivated through meditation practice target the affective, rather than sensory, dimension of pain. Even after fully accounting for shared covariance among variables, in addition to the variance of the complementary pain scale, confidence in self-efficacy, reactivity to thoughts, and premotor awareness remained significantly correlated with pain unpleasantness (full-order partial correlations).

events. Processes such as acceptance, meta-awareness, and self-belief—but, interestingly, not attentional capacities—influenced pain uncoupling, highlighting their role in successful pain management. These findings provide novel hypotheses regarding the regulatory mechanisms that underlie the clinical effects of MBIs on chronic pain and mood disorders.

While the study is, to our knowledge, the first one to investigate the changes in subjective experience during an intensive meditation retreat in such detail, it has limitations. First, the depth and precision of phenomenological insight, as well as the understanding of questions and labels, may be affected by meditative expertise (11,41,42); therefore, caution should be exercised in using the instrument to contrast novices and more adept practitioners in cross-sectional studies [but see (43) for a promising approach]. Second, our retreats featured a gradual progression from FA to OM practice, favoring a naturalistic approach at the expense of controllability. This precluded us from unambiguously assessing the effect of time and common factors versus the effect of a specific meditative technique/style and warrants investigation into retreats where the same practice is adopted throughout (e.g., Zen Soto sesshin). Third, the potential influence of participants' expectations and social desirability on their subjective reports deserves careful consideration. While we took special care to minimize these effects by framing the questionnaire as a tool for self-investigation and by assuring anonymous processing of the data, we cannot rule out the possibility that some of the observed effects are partially affected by demand characteristics. However, several properties of the data suggest that practitioners were genuinely tracking their variations in experience: the presence of distinct and complex temporal evolution trajectories (especially nonmonotonic ones, such as the transient and biphasic patterns of Figure 4), the lack of statistically significant change in dimensions that are commonly viewed as primary targets of meditation practice (e.g., negative affect, frequency of spontaneous thoughts), and large temporal and interindividual variability. Fourth, the presence and guidance of the meditation instructor might have had a moderating effect on some of the participants' responses, especially where it overlapped semantically with the questionnaire. Finally, our sample size allowed us to detect only medium effect sizes, so that our findings may underestimate the changes associated with the meditation retreat.

To the best of our knowledge, the LAMP is the most comprehensive and refined phenomenological questionnaire on meditation experience available. However, it has important gaps that should be filled in future versions. These shortcomings include items that probe the motivations and goals that underlie practice, the consistency of thoughts, the awareness of the transient nature of experiences, and tools that capture the fine-grained dynamics of a meditation session (44).

Conclusions

We offer a proof of concept for the fine-grained study of the plasticity of subjective experience induced by intensive meditative practice. Our phenomenological instrument enables investigation of causal relationships among variables, population heterogeneity, and individual variability, as well as predictive factors of retreat effects such as prior experience, personality, etc. Such an approach could serve as a blueprint for guiding clinical and neurophenomenological investigations of mental health (45) and meditation practices (46), as well as providing diversified and rich data for testing computational models of subjective experience (47).

ACKNOWLEDGMENTS AND DISCLOSURES

This work was supported by a European Research Council Consolidator Grant (project BRAIN and MINDFULNESS) (Grant No. 617739 [to AL]), by the LABEX CORTEX of Université de Lyon (Grant No. ANR-11-LABX-0042), and within the program Investissements d'Avenir (Grant No. ANR-11-IDEX-0007).

We thank Kacylia Pistoia, Thalia Doumengine, and Malo Renaud for their assistance with the recruitment of the participants, logistics of the retreats, and data collection. We also thank Rael Cahn for his useful suggestions at an initial stage of data analysis.

OA was responsible for validation and visualization. OA and AP-C were responsible for data curation, software, and formal analysis. OA, AP-C, GP, and AL were responsible for methodology, writing the original draft of the article, and reviewing and editing the article. OA, AP-C, SO, and AL were responsible for investigation. OA, GP, and AL were responsible for supervision. AP-C and AL were responsible for project administration and funding acquisition. All authors were responsible for conceptualization.

The LAMP questionnaire is available for reuse on OSF (https://osf.io/e2fud). The R code used to perform the analyses and generate the figures is openly accessible on GitHub (https://github.com/ousabd/LAMP_BPGOS2025). Access to the dataset is available upon request on OSF (https://osf.io/4wbk3; requires an OSF account).

The authors report no biomedical financial interests or potential conflicts of interest.

ClinicalTrials.gov: Study of the Longitudinal Changes in Perception and Cognition Occurring During a Meditation Retreat; https://clinicaltrials.gov/ct2/show/NCT04449913; NCT04449913.

ARTICLE INFORMATION

From the Université Claude Bernard Lyon 1, CNRS, INSERM, Centre de Recherche en Neurosciences de Lyon CRNL U1028 UMR5292, EDUWELL, Bron, France (OA, AP-C, AL); Institut Euthymia de formation à la méditation, Fleurac, France (SO); and Department of Biomedical, Metabolic and Neural Sciences, University of Modena and Reggio Emilia, Modena, Italy (GP).

OA and AP-C are co-first authors.

Address correspondence to Oussama Abdoun, Ph.D., at oussama.abdoun@pm.me, or Antoine Lutz, Ph.D., at antoine.lutz@inserm.fr.

Received Mar 20, 2024; revised Jan 4, 2025; accepted Jan 24, 2025.

Supplementary material cited in this article is available online at https://doi.org/10.1016/j.bpsgos.2025.100474.

REFERENCES

1. Dahl CJ, Lutz A, Davidson RJ (2015): Reconstructing and deconstructing the self: Cognitive mechanisms in meditation practice. Trends Cogn Sci 19:515–523.
2. Lutz A, Jha AP, Dunne JD, Saron CD (2015): Investigating the phenomenological matrix of mindfulness-related practices from a neurocognitive perspective. Am Psychol 70:632–658.
3. Wielgosz J, Goldberg SB, Kral TRA, Dunne JD, Davidson RJ (2019): Mindfulness meditation and psychopathology. Annu Rev Clin Psychol 15:285–316.
4. Galante J, Friedrich C, Dawson AF, Modrego-Alarcón M, Gebbing P, Delgado-Suárez I, *et al.* (2021): Mindfulness-based programmes for mental health promotion in adults in nonclinical settings: A systematic review and meta-analysis of randomised controlled trials. PLoS Med 18:e1003481.
5. Whitfield T, Demnitz-King H, Schlosser M, Barnhofer T, Frison E, Coll-Padros N, *et al.* (2022): Effects of a mindfulness-based versus a health self-management intervention on objective cognitive performance in older adults with subjective cognitive decline (SCD): A secondary analysis of the SCD-well randomized controlled trial. Alzheimers Res Ther 14:125.
6. Moore MT, Lau MA, Haigh EAP, Willett BR, Bosma CM, Fresco DM (2022): Association between decentering and reductions in relapse/recurrence in mindfulness-based cognitive therapy for depression in adults: A randomized controlled trial. J Consult Clin Psychol 90:137–147.
7. Segal ZV, Anderson AK, Gulamani T, Dinh Williams L-A, Desormeau P, Ferguson A, *et al.* (2019): Practice of therapy acquired regulatory skills and depressive relapse/recurrence prophylaxis following cognitive therapy or mindfulness based cognitive therapy. J Consult Clin Psychol 87:161–170.
8. Baer RA, Smith GT, Hopkins J, Krietemeyer J, Toney L (2006): Using self-report assessment methods to explore facets of mindfulness. Assessment 13:27–45.
9. Lau MA, Bishop SR, Segal ZV, Buis T, Anderson ND, Carlson L, *et al.* (2006): The toronto mindfulness scale: Development and validation. J Clin Psychol 62:1445–1467.
10. Walach H, Buchheld N, Buttenmüller V, Kleinknecht N, Schmidt S (2006): Measuring mindfulness—The Freiburg Mindfulness Inventory (FMI). Personal Individ Dif 40:1543–1555.
11. Belzer F, Schmidt S, Lucius-Hoene G, Schneider JF, Orellana-Rios CL, Sauer S (2013): Challenging the construct validity of mindfulness assessment—A cognitive interview study of the Freiburg mindfulness inventory. Mindfulness 4:33–44.
12. Leigh J, Bowen S, Marlatt GA (2005): Spirituality, mindfulness and substance abuse. Addict Behav 30:1335–1341.
13. Kok BE, Singer T (2017): Phenomenological fingerprints of four meditations: Differential state changes in affect, mind-wandering, metacognition, and interoception before and after daily practice across 9 months of training. Mindfulness 8:218–231.
14. Lindahl JR, Fisher NE, Cooper DJ, Rosen RK, Britton WB (2017): The varieties of contemplative experience: A mixed-methods study of meditation-related challenges in Western Buddhists. PLoS One 12:e0176239.
15. Depraz N, Varela FJ, Vermersch P (2000): 6: The gesture of awareness: An account of its structural dynamics. In: Velmans M, editor. Investigating Phenomenal Consciousness: New Methodologies and Maps. John Benjamins Publishing Company, 121–137.
16. Depraz N, Varela FJ, Vermersch P (2003): On becoming aware: A pragmatics of experiencing. John Benjamins Publishing Company.
17. King BG, Conklin QA, Zanesco AP, Saron CD (2019): Residential meditation retreats: Their role in contemplative practice and significance for psychological research. Curr Opin Psychol 28:238–244.
18. Zeidan F, Baumgartner JN, Coghill RC (2019): The neural mechanisms of mindfulness-based pain relief: A functional magnetic resonance imaging-based review and primer. Pain Rep 4:e759.
19. Zorn J, Abdoun O, Bouet R, Lutz A (2020): Mindfulness meditation is related to sensory-affective uncoupling of pain in trained novice and expert practitioners. Eur J Pain 24:1301–1313.
20. Kabat-Zinn J, Lipworth L, Burney R (1985): The clinical use of mindfulness meditation for the self-regulation of chronic pain. J Behav Med 8:163–190.

21. Hilton L, Hempel S, Ewing BA, Apaydin E, Xenakis L, Newberry S, *et al.* (2017): Mindfulness meditation for chronic pain: Systematic review and meta-analysis. Ann Behav Med 51:199–213.
22. Nicolardi V, Simione L, Scaringi D, Malinowski P, Yordanova J, Kolev V, *et al.* (2024): The two arrows of pain: Mechanisms of pain related to meditation and mental states of aversion and identification. Mindfulness 15:753–774.
23. Jensen MP (2011): Psychosocial approaches to pain management: An organizational framework. Pain 152:717–725.
24. Day MA, Thorn BE (2014): Using theoretical models to clarify shared and unique mechanisms in psychosocial pain treatments: A commentary on McCracken and Morley's theoretical paper. J Pain 15:237–238.
25. Bodhi B (2017): The Suttanipata: An Ancient Collection of the Buddha's Discourses Together With Its Commentaries. Sommerville, MA: Wisdom Publications.
26. Karmapa WD (2017): Mahamudra, the ocean of true meaning. In: Havlat H, editor. Books on Demand.
27. Forman EM, Herbert JD, Juarascio AS, Yeomans PD, Zebell JA, Goetter EM, Moitra E (2012): The Drexel defusion scale: A new measure of experiential distancing. J Context Behav Sci 1:55–65.
28. Sullivan MJL, Bishop SR, Pivik J (1995): The Pain Catastrophizing Scale: Development and validation. Psychol Assess 7:524–532.
29. Watson D, Clark LA, Tellegen A (1988): Development and validation of brief measures of positive and negative affect: The Panas scales. J Pers Soc Psychol 54:1063–1070.
30. Bodhi B (2000): A Comprehensive Manual of Abhidhamma: The Abhidhammattha Sangaha of Acariya Anuruddha. Available at: https://www.saraniya.com/books/meditation/Bhikkhu_Bodhi-Comprehensive_Manual_of_Abhidhamma.pdf. Accessed March 29, 2025.
31. Wood S (2017): Generalized Additive Models: An Introduction With R, Second edition. Available at: https://www.crcpress.com/Generalized-Additive-Models-An-Introduction-with-R-Second-Edition/Wood/p/book/9781498728331. Accessed March 29, 2025.
32. Wood SN (2011): Fast stable restricted maximum likelihood and marginal likelihood estimation of semiparametric generalized linear models. J R Stat Soc B 73:3–36.
33. Bates D, Mächler M, Bolker B, Walker S (2015): Fitting Linear Mixed-Effects Models Using lme4. Journal of Statistical Software 67:1–48.
34. Kuznetsova A, Brockhoff PB, Christensen RHB (2017): lmerTest package: Tests in linear mixed effects models. J Stat Soft 82:1–26.
35. Nagin DS (2010): Group-based trajectory modeling: An overview. In: Piquero AR, Weisburd D, editors. Handbook of Quantitative Criminology. New York, NY: Springer, 53–67.
36. Magrini A (2022): gbmt: Group-Based Multivariate Trajectory Modeling: R package version 0.1.3. Available at: https://CRAN.R-project.org/package=gbmt. Accessed March 29, 2025.
37. Nagin DS, Jones BL, Passos VL, Tremblay RE (2018): Group-based multi-trajectory modeling. Stat Methods Med Res 27:2015–2023.
38. Makowski D, Ben-Shachar M, Patil I, Lüdecke D (2020): Methods and algorithms for correlation analysis in R. J Open Source Softw 5:2306.
39. Zorn J, Abdoun O, Sonié S, Lutz A (2021): Cognitive defusion is a core cognitive mechanism for the sensory-affective uncoupling of pain during mindfulness meditation. Psychosom Med 83:566–578.
40. Bhikkhu T (1997): Sallatha sutta: The arrow. Samyutta Nikaya. Available at: https://www.dhammatalks.org/suttas/SN/SN36_6.html. Accessed March 29, 2025.
41. Dunning D (2011): The Dunning–Kruger effect. Adv Exp Soc Psychol 44:247–296.
42. Van Dam NT, Earleywine M, Danoff-Burg S (2009): Differential item function across meditators and non-meditators on the Five Facet Mindfulness Questionnaire. Personal Individ Dif 47:516–521.
43. Abdoun O, Zorn J, Poletti S, Fucci E, Lutz A (2019): Training novice practitioners to reliably report their meditation experience using shared phenomenological dimensions. Conscious Cogn 68:57–72.
44. Jachs B, Garcia MC, Canales-Johnson A, Bekinschtein TA (2022): Drawing the experience dynamics of meditation. bioRxiv https://doi.org/10.1101/2022.03.04.482237.
45. Kyzar EJ, Denfield GH (2023): Taking subjectivity seriously: Towards a unification of phenomenology, psychiatry, and neuroscience. Mol Psychiatry 28:10–16.
46. Timmermann C, Bauer PR, Gosseries O, Vanhaudenhuyse A, Vollenweider F, Laureys S, *et al.* (2023): A neurophenomenological approach to non-ordinary states of consciousness: Hypnosis, meditation, and psychedelics. Trends Cogn Sci 27:139–159.
47. Sandved-Smith L, Bogotá JD, Hohwy J, Kiverstein J, Lutz A (2024): Deep computational neurophenomenology: A methodological framework for investigating the how of experience. OSF. https://doi.org/10.31219/osf.io/qfgmj.