Pain regulation during mindfulness meditation: phenomenological fingerprints in novice and expert practitioners

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AUTHORS VERSION

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Abstract

Background: The way people respond to pain is based on psychological mechanisms, beliefs and expectations. Mindfulness meditation (MM) has been shown to regulate pain and mental suffering through different mechanisms such as positive reappraisal, attentional and emotional regulation. Yet, subjective experience and meaning of pain in connection with MM are still largely unexplored.

Methods: The present mixed-methods study combined an interpretative-phenomenological qualitative approach with an experimental thermal pain paradigm to explore and compare the meaning of experiencing pain in 32 novices who received short meditation training and 30 experts in meditation practice (more than 10, 000 hours in life). We collected the qualitative data during in-depth semi-structured interviews where we probed participants' response strategies. During the pain task, we collected self-reports of intensity and unpleasantness, while after the task we collected self-reports of avoidance, openness, vividness and blissfulness.

Results: Five phenomenological clusters (PhC) emerged from the interviews, including three which described pain as an unpleasant sensation calling for: 1) experiential avoidance-suppression, 2) volitional agency-distanciation, or 3) a positive cognitive reappraisal and flexibility. Two additional clusters (4-5), containing mostly expert meditators, thematized pain sensation as an opportunity to gain metacognitive insights about mental processes, and to deconstruct one's suffering through these insights. PhC5 further integrates these insights with the recognition that suffering is part of the shared human experience and with the aspiration to relieve others from suffering. Each PhC was correlated to a unique profile of self-reports during the pain paradigm.

Conclusion: These findings need to be replicated in patients with severe and chronic pain and practicing MM. They also warrant the integration of this mixed-method approach with brain imaging data to refine the experiential neuroscience of pain.

Significance: We compared the meaning of experiencing and regulating pain in novices and expert meditators using qualitative interviews. We identified five phenomenological clusters describing relevant features implicated in pain response strategies and meditation. These clusters were organized along a pseudo-gradient, which captured meditation

expertise and predicted self-reports related to a pain paradigm and psychometric scales associated with pain and its regulation. These findings advance our understanding of the metacognitive mechanisms and beliefs underlying mindfulness meditation and can inform pain treatment strategies

Keywords: Mindfulness meditation, metacognitive models of pain, coping styles, phenomenological clusters, mixed-methods

1 Introduction

Pain is a multifaceted phenomenon that includes a mixture of sensory, cognitive, behavioral and affective patterns. Although the International Association for the Study of Pain states how “pain is always subjective” (IASP, 1994) its “lived experience” remains an elusive phenomenon (Rysewyk 2017; Smith, Osborn 2014).

During a phenomenological interview, an interviewer guides a participant through open questions so that he/she can become aware and report features of experience that he/she was initially not spontaneously aware of. Through this dyadic process novel knowledge can eventually arise, which refines the descriptions of a specific lived experience and its experiential meaning (Hoffding, Martiny 2016). This approach can bring forward aspects of highly embodied, and socio-culturally embedded dimensions of experience which are difficult to capture with psychometric scales (Bitbol & Petitmengin 2017; Smith et al. 2009). Phenomenological interviews can shed new light for instance on the subjective experience of chronic pain (Osborn and Rodham 2010) or on the narrative built around these chronic conditions (Osborn, Smith 2015). These qualitative data consist not only of patients’ accounts about their clinical conditions but also their pictorial representations of them (Kirkham et al. 2015; Osborn and Rodham 2010).

This framework has not yet been used to describe the way long-term expert meditators relate to pain. A refined description of how expert meditators relate and give meaning to

pain could inform our understanding of pain regulation and of the mechanisms of Mindfulness-Based Interventions (MBI; Kabat-Zinn et al. 1992) which are routinely used in hospitals as adjunct pain therapies with reliable effects on pain (Zeidan et al. 2019; Hilton et al. 2017). Mindfulness Meditation (MM) makes affective states available to explicit processing, improving emotional regulatory processes (Chambers 2009; Wielgosz et al. 2019) and facilitating perspective-taking, cognitive reappraisal, and self-inquiry (Lutz et al. 2015). Sustained, present-centered MM develops nonjudgemental meta-awareness which supports the metacognitive monitoring and deconstruction of automatic mental schemes (Dunne et al. 2019; Hussain 2015). MM also fosters sensory-affective uncoupling of pain (Zorn et al. 2020) and adaptive self-schema (Dahl et al. 2015). Metawareness may also result in metacognitive insight, which means becoming aware of thoughts instead of being fused with their contents (Jankowski & Holas, 2014) and regulates the response to nociceptive pain signals (Zeidan et al. 2016). Different MM practices regulate nociceptive stimuli through specific processes (Perlman et al. 2010). Metacognitive styles, expectation and beliefs can moderate pain and Pain Catastrophizing (PC, Schütze et al. 2017; Ziadni et al. 2018) as exemplified by placebo and nocebo effects (Tracey 2010).

Recently, we explored the effects of MM on sensory and affective pain experience in expert and novice meditators (Zorn et al. 2020a). We found that experts compared to novices reported a lower score on the Pain Catastrophizing Scale (PCS, Sullivan et al. 1995) which predicted larger sensory-affective uncoupling of pain (driven by specific reductions in unpleasantness) (Zorn et al. 2020a). PCS measures cognitive tendencies to amplify the threat value of pain developing aversive expectations and negative affect (Edwards et al., 2016; Gatchel et al., 2007) and correlates with depression and anxiety (Quartana et al., 2009). It is still unclear how differences in PCS between expert and novice practitioners are reflective of subjective differences in pain regulatory strategies, beliefs and expectations about pain, and meditation practices' impact on pain perception. To shed light on these points, we here used a phenomenological approach (Smith, Osborn 2014) interviewing the same sample of participants, asking them to describe their experience of pain and its meaning in connection with MM. First, we explored individual spontaneous pain-regulative strategies in novice and expert meditators and how meditation techniques affected them so as to identify different Phenomenological Clusters (PhC) which could possibly extend and refine existing knowledge on pain regulation strategies. Secondly, we

tested the hypothesis that these clusters could significantly account for unexplained variances in the self-report data collected during the pain paradigm previously described (Zorn et al. 2020a). Besides providing novel qualitative information about these self-report data, testing this hypothesis could also enrich knowledge claims through the corroboration of multiple sources of evidence (Gallagher, Zahavi 2008).

2 Material and Methods

2.1 Participants

Novice and long-term meditation practitioners were recruited for the *Brain and Mindfulness* ERC-funded project through multiple screening stages (see the *Brain & Mindfulness Project Manual*: <https://osf.io/dbwch>, Abdoun et al., 2018; Zorn et al. 2020a). Eligibility criteria were: age between 35–65 years, no psychotropic drug use, no neurological or psychiatric disorder, Beck Depression Inventory (BDI) score below 20, no family history of epilepsy, no severe hearing loss, health insurance coverage, no chronic pain under treatment. Pregnant and breastfeeding women were excluded. Experts had at least 10.000 hours of practice in the Kagyu or Nyingma school of Tibetan Buddhism, one traditional 3-year meditation retreat, and regular daily practice. Novices did not practice meditation or mind-body techniques prior to their participation in the study. A total of 32 novices and 30 expert practitioners were included and interviewed. Of them, 25 novices and 25 experts participated in the experimental task described below. The final sample included 32 novices and 30 expert practitioners. No significant group differences were present in age, gender or education (Table 1). Experts had an average lifetime meditation experience of 40453 hours (± 17873 SD; range: 13110–94535, $n=30$). All participants priorly provided written informed consent. The study was approved by the regional ethics committee on Human Research (CPP Sud-Est IV, 2015–A01472–47).

	n	Sex	Age	Education
Novices	33	15F/18M	55.1 (6.3)	3.7 (2.2)
Experts	30	13F/17M	51.6 (8.1)	3.0 (2.6)
<i>p</i>		>.99	.065	.26

TABLE 1. Group characteristics. Continuous variables (Age, Education) are presented as mean (standard deviation), and associated *p*-

values were calculated using Welch's t-test. Education is indexed in years of higher education. A chi-squared test was used for Sex.

2.2 Meditation training of novices and experts

An important aim of the *Brain and Mindfulness* project was to have a high-quality control group for expert practitioners (see Abdoun et al. 2019 for detailed information on the novice training protocol). Eligible novices participated in a training protocol, where they were extensively trained and familiarized with MM and compassion meditation, a specific practice characterised by the wish to relieve others' suffering. The training was derived from the secular meditation program *Joy of Living*, designed by Yongey Mingyur Rinpoche, a Tibetan monk in the Nyingma and Dzogchen Buddhist traditions.

Eligible novices were instructed in the practice of Focused Attention (FA) and Open Monitoring (OM), both styles of meditation that were well-known by eligible experts (Lutz et al., 2008). These practices are found in several Buddhist traditions as well as in secular mindfulness-based interventions. The task-set of FA involves the sustaining of attention on a selected object (e.g. the sensation of the breath at the nostrils), noticing when the mind becomes distracted, and systematically bringing attention back to the intended object. This practice is said to increase the monitoring capacity and to stabilize the mind. The increased monitoring capacity can then be used as a transition point to OM, which involves a task-set that consists of the cultivation and maintenance of a non-reactive, open and accepting awareness of present moment experience (Lutz et al., 2008). After the training weekend, we invited novices to keep up a daily practice of minimum 20 minutes a day until the day of the last experiment, spread equally between FA, OM and compassion meditations and to keep track of their practice with a logbook.

With expertise, the capacity to sustain an OM state becomes increasingly effortless, at which point it becomes possible to make awareness an object of meditation itself (Dunne, 2011). Expert practitioners in this study were intensively trained in this advanced style of OM labelled Open Presence (OP, Tibetan, "rig pa cog gzhag", pronounced "rigpa chok shak", literally "freely resting in what consciousness manifests") (Namgyal et al., 2004). They were explicitly asked to do it during the pain paradigm. In this state, theoretically at least, the phenomenological qualities of effortlessness, openness and acceptance are vividly

experienced and control-oriented elaborative processes reduced to a minimum. A suspension of subject-object duality (non-duality) is also reportedly involved (Lutz et al, 2006) where perceptual phenomena are experienced with more saliency and clarity, without acting upon them or avoiding them. As this state is considered a relatively advanced one, even expert practitioners might not be able to sustain it for more than a short time. For the sake of simplicity, we will use the term OM for both novices and experts below, acknowledging that for experts actual meditation might also have qualified as OP.

2.3 Interview procedures and explored themes

In-depth, semi-structured interviews explored different aspects besides pain. First, each participant was asked to describe their motivation to take part in the study. Then each participant was invited to give a short autobiographical overview: this invitation was meant as a way for the participant to gain confidence in sharing personal or even difficult aspects of their life while becoming acquainted with the setting and the interviewer. Then we invited participants to describe their personal way to relate to pain by answering four principal questions:

Meaning: *What does it mean for you to experience pain?*

Coping: *How do you usually handle it?*

Living: *Could you give some meaningful examples throughout your life?*

Meditating: *Did meditation change your way to experience pain? If yes, how?*

We chose these questions in order to reach a high experiential level of significance (Smith 2018). Besides these areas, interviews addressed other topics related to higher-order metaphysical worldviews, axiological systems of values, epistemological and ontological beliefs. These aspects exceed the purpose of this study and will be treated in future publications.

The interviewer explored each participant's idiosyncratic construct about pain as a significant life experience which emerges as a combination of perspectives, experiences, beliefs and narratives. Therefore, to detail their account, participants were invited to distinguish psychological suffering from sensory-discriminative pain, describing their

interaction and eventually providing biographical experiences. This interview was then used to explore the personal meaning of pain as well as beliefs about one's way to relate to it. Finally, participants were invited to question its connection with MM.

At the beginning of this interview, experts were invited to avoid using theory-driven terminology stemming from Buddhist psychology and philosophy, and instead to use their own words and experiences.

Interviews were collected using a digital voice recorder and subsequently transcribed verbatim. We asked each participant to check/validate the transcription of their interview. Ten interviews were in English, 52 in French, and 1 in Italian. All were coded in English. We eventually translated portions of text to provide quotes.

2.4 Coding procedures

We analyzed the transcripts with the Interpretive-Phenomenological Approach methodology (Smith & Osborn 2008, 2015) using the Atlas.ti 7 software. In the field of health psychology, IPA aims to provide insights into how a given person makes sense of a given phenomenon, such as pain (Osborn, Smith 2015; Kirkham et al. 2015). Structural-hermeneutic approaches uncover subjective meanings and their latent structure through multiple-step interpretative procedures. IPA enables integration of meanings by systematically revising the understanding of subjective details with respect to the entire picture (Smith 2019). A teamwork reflection upon the meaning of critical contents enabled their connection with scientific literature about pain and MM. Complying with Pietkiewicz and Smith guidelines (2014) the coding procedures adhered to the following phases and are summarized in Figure 1:

1) *Making notes and coding*: after multiple readings, notes were organised into meaningful codes extending over greater portions of text. Codes incorporated notes in a consistent narrative and were synthesized when possible by taking into account their relation to common constructs.

2) *Transforming codes into metacodes and emergent themes*: subjective specificity was enhanced synthesizing all relevant information in rich Meta-Codes (MCs). MCs were

further incorporated in subthemes. Subthemes were critically compared generating descriptive general themes.

3) *Seeking relationships and clustering themes*: themes were compared revealing a thematic interdependent structure. Themes were grouped into PhCs showing counterposed polarities. PhCs were consistently distributed along this axis.

FIGURE 1. Coding procedures. Coding started subject-by-subject gathering all within-subject relevant information and structure. The meaning of this structure is progressively synthesized and all codes attributed to each subject were associated with an MC. A circular comparison between MCs generated a subthematic structure progressively simplified through the Atlas.ti network view manager, until reaching semantic saturation of common relevant themes. These themes were then gathered in PhCs. MCs enabled to assign each subject to a primary, and eventually a secondary PhC.

To provide an illustrative example:

- 1) MC1 “cognitive-emotional-behavioral avoidance of pain” was characterised by a tendency to develop catastrophic thoughts and negative emotions about pain and an urge to actively solve physical pain by taking drugs.
- 2) Based on similar cognitive, emotional and behavioral patterns, MC1 was associated and then merged with the MC2 “suppressive control and denial of pain”, characterised by an internal model of pain based on passive tolerance and downplaying of pain expression.
- 3) These MCs were combined under the broader theme “control of pain based on avoidant and suppressive strategies”, which was associated with five participants. This theme was gathered with 4 similar ones to give rise to PhC1.

Reliability criteria

The interviewer (SP), who also led the analyses, is acquainted with Buddhist contemplative practices, but quite unfamiliar with the Tibetan schools in which expert participants were trained. The authors are trained in cognitive neuroscience, clinical psychology, phenomenology and meditation and are familiar with the conceptualisation of pain regulation in these various domains.

2.5 Experimental pain paradigm and measures

We developed a paradigm designed to amplify the cognitive-affective aspects of pain experience by the manipulation of pain anticipation and uncertainty of stimulus duration (Zorn et al. 2020a).

Experimental design

Pain research calls for further integration of qualitative and quantitative data to produce a deeper understanding of pain and its mechanisms (Rysewyk 2014). Quantitative data were acquired by having participants perform a novel fMRI-scanner acute pain paradigm that has been designed to amplify the cognitive-affective aspects of pain experience and has been extensively described elsewhere (Zorn et al., 2020a). Briefly, participants received short (8s) and long (16s) painful stimuli (calibrated at a subjective pain level of 7/10

corresponding to moderate pain) or 16s warm and nonpainful control stimuli (6 degrees cooler); applied to the palmar side of the left wrist. During reception of thermal stimuli, participants performed one of two task conditions: OM or Distraction. Participants received a total of 10 thermal stimuli for each combination of trial type (short hot; long hot; long warm) by task condition (OM; Distraction): 60 thermal stimuli in total. During OM, participants were instructed to keep an open and accepting meditative awareness using the thermal stimuli as support. During Distraction, subjects were instructed to mentally add simple-digit numbers (1-3), that were presented for 1s every 3-5 s, starting 12-8 before stimuli delivery until presentation of the rating scale (5-8 s after thermal stimulation).

Pain ratings

After each thermal stimulation, participants received two 1-9 Item Likert scales, including on pain intensity and unpleasantness (see Supplementary information for all rating scales presented and frequency of presentation).

Psychometric scales

Before the experiment, participants completed the Pain Catastrophizing Scale (PCS) (Sullivan et al., 1995), the Drexel Defusion Scale (DDS) (Forman et al., 2012) and the Cognitive Fusion Questionnaire (CFQ) (Gillanders et al. 2014), three trait questionnaires for which we have demonstrated that they specifically predict pain unpleasantness as opposed to pain intensity in the context of the experiment (Zorn et al., 2020a; Zorn et al., 2020b under review). In addition, we obtained participants' trait scores on several questionnaires measuring common negative cognitive-emotional constructs including anxiety, depression, and worry, respectively assessed by the State-Trait Anxiety Inventory (STAI) (Spielberger et al. 1970), Beck Depression Inventory (BDI) (Beck et al. 1961), and Penn State Worry Questionnaire (PSWQ) (Meyer et al. 1990), as well as several meditation-relevant constructs including mindfulness, well-being and interoceptive awareness, respectively assessed by the Five Facet Mindfulness Questionnaire (FFMQ) (Baer et al. 2006), the Psychological Well-Being Scale (PWBS) (Ryff 1989) and the Multidimensional Assessment of Interoceptive Awareness (MAIA) questionnaire (Mehling et al. 2012).

Post-experiment interview

After the experiment, we conducted a brief semi-structured interview, during which participants were asked to retrospectively indicate for each condition (OM, Distraction) the degree to which they had experienced each of four phenomenological dimensions: Avoidance, Openness, Vividness and Bliss/Felicity, on a 1–7 item Likert-scale, for the long painful stimuli specifically (out of time constraints and as presumably being the most salient trial type). The presented dimensions were identified during a phenomenological pilot during which the PI, two-postdoctoral researchers, and a long-term meditation practitioner engaged in an open-ended inquiry during which they alternately received long painful stimuli in an OM state and interacted to discuss and mutually agree on the most salient phenomenological dimensions characterizing the experience.

2.6 Methodological triangulations

Triangulation of PhCs with trait questionnaires

We assessed the relationships between these phenomenological clusters and pain-related constructs (i.e. PCS score), as well as of broader constructs relevant but not specific to pain perception (DDS, CFQ, STAI, PSWQ, BDI, PWBS, MAIA, FFMQ). Because these trait questionnaires are sensitive to meditation expertise, we assessed their relationship with PhCs beyond the stratification in groups of expertise. More specifically, we modelled individual scores on each of these questionnaires as a function of expertise (novice or expert), phenomenological cluster, or both. We compared those three models using the fraction of variance explained adjusted for model complexity (adjusted R^2).

Experiential signature: Triangulation with experimental self-reports

We explored the congruence between qualitative accounts of pain and self-reports during a pain task, i.e. the degree of phenomenological inter-reliability of these outcomes. First, we used a one-vs-rest logistic regression model to assess whether participants' self-reports during the task could predict their primary PhC assignment. Second, we systematically tested for each of the 5 PhCs whether it was significantly different from all other clusters on each of 13 variables: 6 phenomenological features (pain Intensity, pain

Unpleasantness, Avoidance, Openness, Vividness and Felicity/Bliss) in 2 experimental conditions (OM and DIStraction), as well as moderate pain calibration temperature. We used permutation location tests. The false discovery rate was controlled at 0.25 using the Benjamini–Hochberg procedure (Benjamini & Hochberg 1995).

3 Results

The open coding procedure generated 434 codes, summarized in 52 Meta-Codes (MCs) across 62 participants. We then gathered MCs in five phenomenological clusters (PhCs). Table 2 describes the number of MCs for each PhC as a function of groups of participants. PhC1, 2, and 3 are principally composed of novices while PhC4 and 5 are exclusively populated by experts.

PhC	Number of MC	% of text	Primary assignment			Secondary assignment		
			Novices	Experts	Total	Novices	Experts	Total
1	10	24.5	11	2	13	5	1	6
2	13	26.5	15	2	17	2	0	2
3	11	9.1	6	5	11	5	9	14
4	11	23.9	0	13	13	0	4	4
5	6	16.0	0	8	8	1	1	2
Total	51	100.0	32	30	62	15	13	28

TABLE 2. Description of samples. Number of metacodes (MC), percentages of text and number of participants per phenomenological cluster (PhC).

Below we provide a short summary of each PhC:

PhC1 is characterised by avoidant-controlling strategies and self-evaluative patterns. A combination of pessimistic beliefs supports anticipatory worry to hinder the contact with the incoming sensation, resulting in its magnification: unavoided pain hence makes one feel completely out of control. Intense pain is perceived as a threat and avoided through diverting activities.

PhC2 is characterised by perceiving pain as a challenging opportunity to control it and develop pain self-efficacy. While focusing on the physical sensation of pain, participants distance affective-emotional feelings by suppressing pain unpleasantness.

PhC3 aggregates different ways to positively reappraise pain by adjusting oneself to it and welcoming it. Participants report no experience of intense pain, but adjust their attitude to mild pain by cultivating a flexible awareness of its psychosomatic components, shortly describing cognitive or emotional ways to relativise it, often supported by bodily awareness.

PhC4 analyses pain and its unpleasantness through non-preferential awareness. Pain offers the opportunity to gain insight about one's own mental processes, and to become aware of one's sensory, emotional or cognitive reactivity. Afflictive patterns are observed neutrally and examined analytically for what they are, dissecting their functioning, deconstructing their components and approaching pain with curiosity.

PhC5 integrates the previous deconstructive strategy with altruistic aspirations. Pain becomes an opportunity to integrate deep contemplative insights with the recognition that existential suffering is part of the shared human experience and with the aspiration to relieve others from it. Through specific techniques, pain is thus more actively altered by accepting, rather than reflexively acting on, thoughts and emotions.

3.1 Organization of clusters along a pseudo-gradient

Interpretative procedures led to the emergence of a thematic gradient that can be best construed as an axis based on the degree by which the participants identified or cognitively fused with pain. When participants totally fuse with pain sensations, pain is experienced as a physical factor, while at the opposite end of this dimension, pain is mainly interpreted as a mental factor. To do justice to subjective semantic complexity, each participant was connected to multiple MCs, and therefore possibly to multiple PhCs. A participant's dominant PhC was treated as her primary assignment, while any other PhC she might be connected to was considered a secondary assignment. Subsequent analyses pertain to primary assignments, unless specified otherwise. The distribution of PhCs along this axis is described in Figure 2A. The distribution of primary and secondary assignments among the participants exhibited an internal structure sensitive to meditation expertise.

The anisotropic joint distribution of primary and secondary assignments further supports the existence of a pseudo-gradient (figure 2B). Interestingly, laying out the structure of assignments as a weighted graph unveils irregularities in the gradient, notably the comparable positions of PhC1 and 2, and the high proximity of PhC3 and 4 (figure 2C). This suggests possible overlapping themes in these clusters. Finally, the distribution of group dominance within PhCs shifted from novices to experts along the axis (see table 2 and pies in figure 2C).

FIGURE 2. Pseudo-gradient structure of phenomenological clusters. (A) The interdependent meaning of themes suggested a bipolar organization, from the construal of pain as a physical factor to experiencing it as a mental factor. (B) Distribution of secondary PhC assignments as a function of primary PhC assignment. Each row corresponds to one PhC and indicates the percentages of participants primarily assigned to the PhC on the y-axis that are secondarily assigned to PhCs on the x-axis. Diagonal values correspond to participants with no secondary assignments. (C) The same data represented in the form of a weighted and directed graph, where nodes are laid out using a force-directed, stress majorization algorithm so that two PhCs sharing a larger fraction of participants are closer together. Arrows point from primary PhC to secondary PhC. Arrows thickness is proportional to the percentages displayed in A. Pie charts: sizes are proportional to the number of participants primarily assigned to the PhC, slices indicate the expertise distribution of primary assignments (corresponding numerical values are provided in table 2).

3.2 Description of PhCs

Below we detail each PhC by providing representative quotations refining the description of the different internal models of pain. These narrative extractions are meant to clarify the meaning of each PhC. Secondary assignments are shown after quotations with a “+” and the number of the PhC.

PhC1. Internal model of pain based on aversive avoidance and rejection-suppression. This cluster gathers metacodes characterised by a combination of avoidant strategies such as self-diverting and/or taking drugs: *“When pain arrives it hurts, it’s painful, I try to think of something else, I try to distract myself. (...) If I have a migraine, I quickly take drugs”* (MC1–Nov). High sensitivity to pain leads to overexpression of even mild pain, while intense pain is eliminated or avoided through distractive activities such as going for a walk or writing, thus shifting the focus of attention and lessening the aversive attitude. Anticipatory worry hinders the contact with the incoming sensation framing it as negative. Pain is immediately perceived as threatening, a proof of one’s lack of control in preventing and avoiding it : *“the relationship with pain is immediately conflictual, very apprehensive, as I feel it I overthink and I don’t live it well.”* (MC16–Nov). Factual pain demonstrates the failure of the avoidant strategy based on apprehensive worry, conversely finding the confirmation of its content, the anticipated threat. A sense of powerlessness leads to negative beliefs about one’s ability to deal with pain: *“I’ve always been a wimp, I’m very sensitive to any positive or negative physical stimulation”* (MC48–Nov) or *“I’m not resistant to pain, when it’s there I just don’t like it”* (MC1–Nov). Pain circularly confirms the expected threat built to avoid it, with the belief that if it will be too intense it will be unbearable and reveal one’s weakness.

Interaction with meditation training. Novices attempt to focus attention on mild threatening objects trying to mentally anticipate and familiarise with them: *“I realized that I could lessen the painful impression of the cold shower in the morning by starting to do short meditations with a visual support like a drop of water”* (MC47–Nov). Therefore the meditation training provided some support counterbalancing and calming down personal susceptibility to pain.

PhC2. The internal model of pain based on emotional distancing and sensory control. PhC2 shows a pronounced sense of agency and efficacy towards pain based on the suppression

of unpleasantness and the reappraisal of the sensory experience of it. While controlling the physical sensation of pain, participants distanciate themselves from its affective unpleasantness, leading to a mixture of peripherality and proximity, i.e. a distance. First, distancing is achieved through observation of the sensation: *“there’s no painful sensation you cannot mitigate. I focus on it, as we saw with the meditation training, and detach while watching it from outside. I can detach and diminish it”* (MC32–Nov). Meanwhile, different types of distancing of unpleasantness occur: *“I could distance extremely intense, unpleasant pain, it was as if my brain put a veil”* (MC52–Nov). This perceptual distanciation enables one to control mild and intense pain more than chronic one. During sports, focusing on the sensory level of pain allows one to step back and put a distance between the sensation and its unpleasantness, keeping the focus on the target of the performance. Mental representations may support this process: *“I can easily distance sharp pain representing reflex arcs. I cut the arc in its path between the painful point and the brain. I make pain go back down to the point it starts. This way it’s not processed by the brain and it doesn’t bother me”* (MC34–Nov).

Participants in this cluster stem from a cultural perspective on pain as proof of personal resistance and value: *“I underwent a mortifying military training. Until we didn’t harm ourselves, we didn’t do things properly. It is a religious saving-scheme. In my family it was recurrent to say ‘the day you don’t have pain, it means you’re dead’. Bearing pain and suffering legitimates to exist, it valorises the one who’s able to bear, to resist”* (MC76–Nov+PhC2). Or again: *“You have to be strong and resistant without complaining for nothing and be weak. You have to be tough and resist without being a wimp. It’s cultural: to be good and correct you have to undertake pain, face it (...) You cannot cry for nothing”* (MC78–Nov+PhC2).

Interaction with meditation training. The meditation training supported the inclination to bracket unpleasantness, typically diverting attention to the abdominal breath: *“I enter a state where pain is elsewhere. I’m in my body and pain is outside, I don’t feel it. As in autohypnosis. (...) If it’s too much, I activate breathing systems and then it goes.”* (MC54–Nov). Unpleasantness is dissociated by observing pain as a depersonalised sensory event while breathing: *“there was the suffering side and the breath, I tried to detach, to be two different persons (...) To go out and watch it from outside, I didn’t need meditation for that”* (P53–Nov).

PhC3. The internal model of pain based on positive reappraisal and cognitive flexibility.

These participants adjust their attitude to pain by cultivating a flexible awareness of its psychosomatic components. Getting familiar with one's reactivity enables to adjust and welcome pain at the sensory, cognitive and emotional level, either reappraising or relativising it.

Allowance of mild pain supported by breath awareness allows participants to recenter in the body: *"when I have to face pain I rely on the breath to recenter on myself. A reconnection with myself which makes it lighter, it lessens it. I focus, I welcome, don't know exactly how, it is there and I stand with it. I don't reject, I allow, I take it and welcome it and compose with it"* (MC59-Nov). This connection with the body also lessens mental and physical negative feelings: *"I feel the way to deal with it is to welcome it without pushing it away, allowing it to be there. Approach it, bring awareness to it, feel it and try to be able to be with it. I come back to my body, to breathing, and the sensation of pain. Without being completely caught up in emotions, I bring presence in the moment and try to accept it as it is, a kind of lightness. (...) Yeah, to welcome it"* (MC42-Exp). The integration of cognitive and emotional welcoming of pain is based on the listening of the whole body while flexibly attuning to the painful sensation and "softening" it. For example, a painful sensation can be reduced to scattered particles which soften until disappearing: *"Pain now becomes something really subjective, its valence has changed, it's crumbled: small crumbs instead of something compact. Instead of clinging on to the emotion, I receive it just as something physical, and it dissolves. I accept and absorb. It is like a comet passing by, it erodes into small particles"* (MC38-Exp+PhC5). Pain is seen as a part of a whole, for example as an opportunity to be grateful for one's health: *"I relativise and think suffering could be much worse, without getting impatient. Life is not a given-for-granted right, we don't have the right of being without pain, and pain is not a scandal."* (MC43-Nov).

More time is available after retirement to listen to pain: *"My way to apprehend pain changed. Today I look for the cause, whether it is physical or mental. I integrate the perception of my body, I like it, even if I don't handle it, I try to accompany it and take care*

of it. Today I take more into account my bodily signals trying to integrate them. Before I had to work” (MC74–Nov).

Interaction with meditation training. Many of these processes were inspired or fostered by meditation training. In one case, intense pain is associated with the opportunity to get in touch with something beyond the self: *“As pain is there you cannot escape it, it is like a rebirth, you have to go through it and accept it is a form of transcendence of yourself. At some point you go beyond what you thought was possible, attaining something you thought didn’t exist. It is similar to death I guess” (MC60–Nov+PhC5).*

PhC4. Analytical deconstruction of mental afflictive patterns. Non-preferential awareness of pain offers the opportunity to discriminate its components, observing mental and emotional reactivity while inquiring one’s attachment to the self. Participants behold pleasant and unpleasant sensations regardless of their preference, balancing coercive pushes and pulls of desire and aversion and putting them on the same level: *“there is no intent to accept pain. Welcoming and rejecting are two opposite things, not rejecting doesn’t mean seeking or accepting. A neutral position doesn’t reject, nor welcome” (MC64–Exp+PhC5).* Despite spontaneous aversion, avoidance and rejection, pain and one’s reactivity to it become mental perceptions if neutrally observed: *“what hurts more and adds suffering is the concept which follows the sensation. Pain becomes unbearable when the mind takes over saying “it is unbearable, it shouldn’t happen to me, it’s horrible”. Meditation showed me that the agent that distinguishes pleasant and unpleasant physical sensations, painful or not, is a mental agent, not a physical one” (MC51–Exp+PhC4).* Pain as a mental phenomenon thus becomes a tool of concentration: *“pain is an occasion to practice. Sometimes it makes me more concentrated and focused. A tool of concentration? Yes” (MC37–Exp+PhC3).* This can lessen pain to the extent of forgetting it: *“Pain is always interesting as it connects, it allows to put things into perspective. With meditation I don’t necessarily perceive it, it’s almost astonishing. With sustained focused attention, pain is meaningless” (MC62–Exp).* Hence, pain represents an opportunity to overcome identification and attachment to the body: *“It is important for me to see the body as a vehicle of the mind, between birth and death. I try to see it like this without identifying with it. My relationship with pain changed. As, what pain finally is? It is just a*

mental perception” (MC50-Exp). To observe pain coming and going enables one to step back from mental apprehension and work with afflictive patterns: “It’s an opportunity to be aware of impermanence, to see clearly how the mind reacts to pain. Habits become very clear. Through meditation you can see what your mind does, self-pity coming out, all worries and fears, everything comes up, and you can work with it. You can see mental barriers and how good your meditation is” (MC49-Exp+PhC4). Without clinging on mental affliction, focusing on pain enables participants to go beyond it while getting vast: “the more you look at it, the more it refines the mind. The more you focus directly, the less important pain is as you’re not attached to the feeling. As you focus unceasingly, after a stage it’s just not there anymore. Facing it, looking at it, at the same time getting vast” (MC50-Exp), and “when pain is intense it seems to be everything: you have to create space” (MC64-Exp+PhC5).

By overcoming afflictive mental patterns, equanimity provides support for self-inquiry, becoming a source of self-knowledge and wisdom: *“pain was a promoter of greater awareness. In meditation unpleasant feelings are elements of knowledge as much as pleasant ones. To place them on the same level brings enormous knowledge. As you clear pain from being something and neutrally place it as a cognitive element, it becomes a source of knowledge and wisdom” (MC64-Exp+PhC5).*

PhC5. Integrating deconstructive insights with altruistic aspirations. Pain as a mental factor devoid of intrinsic essence goes beyond unpleasantness and brings bliss: *“Pain is how the body frames problems, but your suffering depends on how your mind relates to it. Suffering is not a physical phenomenon, it’s mental. Physical pain is physical, but its effect on your mind, if you suffer or not, is mental. Training your mind, you can undergo torture and think that’s bliss” (MC35-EXP). Devotion provides confidence in facing its essenceless nature: “Just like anything else, pain is... the mind, it has no essence in the end. Although you feel it as physical, you can accept it and have the confidence you can transform it. Devotion takes you through it. I know I can do something out of it and transform it” (MC66-EXP). Participants decenter from pain going beyond their subjective experience and including universal suffering: “As I calm my mind pain lessens its intensity. Then I use the support of the suffering of all sentient beings to offer them my suffering or put myself*

in their situation. By doing so I detach from my own suffering” (MC71-EXP). By actively embracing pain with the altruistic wish to relieve universal suffering, participants can lessen their self-centeredness: “I welcome pain and sincerely wish that through it universal suffering may exhaust. This gives space and truly relieves. I take vow and beg that «all beings’ suffering could be exhausted in this suffering», feeling how my suffering is meaningful, and that there’s something transcending pain. To be affected by suffering frees me from egocentrism” (MC24-EXP+PhC5). Such a compassionate attitude simultaneously turns pain into a means for altruism and concentrating support for practice: “As I breathe in I take the suffering of beings, as I breathe out I spread relief, wishing the end of all illnesses. It is a long training based on the nature of vacuity. When I suffer, opening to others’ suffering is a miracle. When I take pain as a support I feel it’s worthy. Suffering is always there, living. This practice is miraculous, I can really take pain as support and use it to concentrate by taking it from others” (MC71-EXP). With the support of this altruistic practice, participants account for a direct experience of absolute reality of existence through pain: “As I pay attention to pain, by simply this, I just maintain awareness always on the same thing, the direct experience of reality” (MC63-EXP+PhC5). Committing to practice meditation while experiencing sharp pain enables to experience this reality of existence as pure consciousness: “Intense pain is so sharp that it enables the perception of the reality of existence if you keep a strong connection with it. This body doesn’t last. No matter how intense pain or death can be, we can only strive to approach this reality. When I realised I was maybe about to die, right before fainting, I approached pain and felt in phase with the reality of life as absolute consciousness beyond life” (MC20-EXP).

This connection with a deeper nature of things enables participants to accept and diminish intense pain: *“Before, focusing my attention on pain increased it. Once gone beyond, penetrated and understood existence, I could accept even intense pain and overcome it by emotionally facing it. This is simply due to the trust in a certain reality of existence” (MC20-EXP).*

3.3 Relationship to trait questionnaires

To further explore the conceptual meaning of the PhCs, we looked at the statistical association between participants' ranking along the pseudo-gradient from the PhCs and participants' scores to a range of trait questionnaires (Table 3). We found that cluster assignment could predict a moderate amount of variance of all but the negative psychological constructs (STAI, PSWQ, BDI) nor of the psychological well-being scale (PWBS). After controlling for the variance due to expertise, PhCs could predict additional variance for PCS scores only, and not for any other trait score with known relevance to the experience of pain. This highly specific pattern of results supports the notion that the interview and analytic procedure primarily overlap with pain-specific and mindfulness-related constructs.

scale	Adjusted R^2 (%)		
	~ expertise	~ PhC	~ PhC + expertise
PCS	27.5	26.3	34.0
DDS	33.4	18.7	29.5
CFQ	25.3	13.3	20.3
STAI	8.1	0.5	2.4
PSWQ	22.6	10.1	19.1
BDI	1.4	8.2	7.1
PWBS	2.8	-3.8	-2.4
MAIA	35.7	25.9	36.2
FFMQ	30.0	23.6	28.0

TABLE 3. Statistical associations between PhCs and trait questionnaires.

Phenomenological cluster assignment is a good predictor of pain-related (PCS) and mindfulness-relevant constructs (DDS, CFQ, FFMQ and MAIA) but not of general negative psychological constructs (STAI, PSWQ, BDI).

3.4 Triangulation with self-report during an experimental pain paradigm

PhCs emerged from descriptions of participants of their general experience of pain. Although interviewees were invited to illustrate their responses with memories of actual experiences of pain, the interview was not related to any specific occurrence of pain. Therefore, whether the theoretical content of PhCs matches the phenomenology of a real experience of pain is an open matter.

We addressed this empirical question by examining the relationship between PhCs and phenomenological self-reports during a pain task in two ways. First, the logistic regression

model showed that participants' self-reports during the task could predict their primary PhC assignment with high accuracy (72.3%, well above the 20% chance level).

FIGURE 3. Experiential signature of phenomenological clusters. Dots indicate features that are significantly different between a given cluster and all others (false discovery rate controlled at .25). *temp*: moderate (7/10) pain threshold temperature in °C, *int*: pain intensity, *unpl*: pain unpleasantness, *avd*: experiential avoidance, *open*: openness to experience, *vvd*: vividness.

Second, we qualitatively and quantitatively examined the average phenomenological signature of each PhC (figure 3). In general, findings were congruent with the semantic content of PhCs:

- PhC1 is characterised by high avoidance and unpleasantness, especially in OM, consistent with the avoidant attitude and the pain amplification induced by

anticipatory worry typical of this cluster. Participants of this cluster also reported poor phenomenological qualities (openness, vividness and bliss) during OM.

- A distinctive feature of PhC2 is a higher pain threshold temperature compared to all other clusters, an expected outcome of the distancing and suppressive strategies towards pain deployed by members of this cluster.
- Participants in PhC4 reported lower avoidance and higher openness, vividness and bliss during OM only. This state specificity is consistent with the inclination of the members of this cluster to approach pain with an attitude of equanimity and self-inquiry cultivated through the practice of meditation.
- In contrast to PhC4, PhC5 have a more balanced phenomenological profile across states, suggesting that their insights into the nature of pain have permeated their ordinary state of mind. This cluster also reports the lowest pain unpleasantness.

In addition, there were two unexpected findings (discussed later): participants in PhC3 reported low experiential openness across both experimental conditions, and participants in PhC5 had a lower pain threshold temperature than other clusters.

4 Discussion

The present study aimed to explore and compare the subjective experience and meaning of pain in connection with mindfulness meditation (MM) of expert and novices meditators. It combined results from an interpretative-phenomenological qualitative approach with the ones from an experimental thermal pain paradigm. There were three main findings. Firstly, we identified from the qualitative interviews five specific phenomenological clusters (PhCs) describing relevant features implied in pain-regulative strategies and MM. Secondly, we found that these clusters were organized along a well-defined pseudo-gradient, which also captured meditation expertise. Finally, we found that these PhCs predicted self-reports relative to the experimental pain paradigm and were related to specific psychometric scales associated with pain and its regulation. In the present

discussion, we will start by discussing each specific cluster through the lenses of the psychological and phenomenological research on meditation before proposing a synthetic interpretation of this pseudo-gradient illustrated in table 4.

Theoretical constructs		PhC1	PhC2	PhC3	PhC4	PhC5
<i>Cognitive fusion</i> <i>Pain sensation as a physical factor</i>	<i>Pain catastrophizing</i>	X				
	<i>Experiential avoidance</i>	X				
	<i>Metacognitive monitoring & control</i>	X	X			
	<i>Perceived agency</i>		X			
	<i>Focused Attention & attentional control</i>		X	X		
	<i>Metacognitive knowledge</i>			X		
	<i>Cognitive flexibility & reappraisal</i>			X		
	<i>Self-compassion & self-acceptance</i>			X		
	<i>Open awareness</i>				X	X
<i>Pain sensation as a mental factor</i> <i>Cognitive defusion</i>	<i>Metacognitive awareness</i>				X	X
	<i>Metacognitive-insight</i>				X	X
	<i>Non-dual compassion</i>					X

TABLE 4. Interpretative synthesis. Distribution of cognitive and metacognitive processes for each PhC.

4.1 PhC1: Catastrophizing pain through experiential avoidance and metacognitive monitoring: ‘the tongue always turns to the aching tooth’

Participants in PhC1 frame pain as a negative physical sensation, which triggers catastrophizing thoughts such as “it’s terrible and it’s never going to get any better” generating anticipatory worry and experiential avoidance. Such automatic regulatory strategy is characterised by cognitive inflexibility and the belief that avoidance is a good strategy to obtain relief. This narrative is consistent with the fear-avoidance model of pain, where negative expectations and negative affect motivate and reinforce each other (Vlaeyen, Linton 2000&2012). Consistently with this model, anticipatory worry amplifies

pain unpleasantness by triggering negative affectivity, circularly supporting aversive attitudes and behaviors (Edwards et al., 2016) such as avoidance (Jong & Vroling 2014). This affective coupling falls in line with believing the literal meaning of thoughts instead of viewing them as transient internal states, i.e. cognitive fusion (Masuda et al. 2004) and causes one to identify with them. For instance, the thought “I am powerless” coincides with the psychological experience of powerlessness, affectively coupling pain and unpleasantness (Zorn et al. 2020a).

In accordance with a “better safe than sorry” reasoning (Jong, Vroling 2014), apprehensive worry anticipates and increases the perceived level of threat while enhancing unwillingness to remain in contact with pain. This process is consistent with experiential avoidance of emotions (Moses & Barlow, 2006) and supports an internal model of pain based on its catastrophizing alarmism: “*I often think there is something severe behind a symptom*” (MC27–Nov), and avoidance–distraction “*if it’s intense, I try to eliminate it, or to distract from it*” (MC70–Exp). On this basis, participants worry about their coping skills: “*I think to which extent I’ll be able to bear it, it resonates with something (emotionally) deep*” (MC28–Nov). As a result, the lack of pain self-efficacy (Chen, Jackson 2019), elicitates self-disparaging judgments like “*I’ve always been a wimp,*,” “*I’m very sensitive,*,” “*I’m not resistant*”, that trigger fight-or-flight patterns.

Phenomenological inter-reliability with self-reports: these participants showed higher unpleasantness and avoidance in both OM and DIS during the pain task, which was associated with high pain catastrophizing scores (Zorn et al. 2020). Together with a lack of openness, bliss and vividness (Figure 3) this outcome falls in line with the overall pessimistic beliefs about the ability to cope with pain (Sullivan et al. 1995) converging in fear-avoidance strategies (Turk & Wilson 2010).

This PhC shows how a regulative metacognitive style based on control can be unfavourable when driven by negative beliefs of powerlessness. Cognitive fusion supports and foster metacognitive styles driven by negative beliefs, which are known to be positively associated with psychological and emotional distress (Bardeen, Fergus 2016), to exacerbate pain unpleasantness (Zorn et al. 2021), and to correlate with depression and anxiety in general (Quartana et al., 2009). As “the tongue always turns to the aching tooth”,

negative beliefs consistently trigger negative affect and self-fragility with respect to pain, as a consequence of perceived coping inadequacy.

4.2 PhC2: Cognitive suppression and metacognitive volitional control based on distancing: 'no pain no gain'.

Stemming from a warrior-like narrative, these participants explicitly rely on the belief that “without pain, there is no gain”. Participants manage pain as an opportunity to probe their ability to reach mental mastery over the body: *“physical pain doesn't frighten me, as moral pain does. I prefer a tangible pain I can feel and manage to endless bruises of the soul. I can detach from physical one, as being two separate persons”* (MC53-Nov). Cognitive and emotional apprehension thus becomes manageable as far as pain can be localised, confined to its sensory-discriminative level, and dissociated from its unpleasantness: *“I could put a veil, a kind of a distance with very intense pain”* (MC52-Nov) or *“to meditate enables you to put a distance between pain and yourself”* (MC61-Exp).

The dissociation of affective and sensory dimensions of pain using autohypnotic-like modulations is known in the literature as hypnoanalgesia (Rainville et al. 1999; Patterson, Jensen 2003): *“I enter a state where pain is outside, as in autohypnosis”* (MC54-Nov). Through this interoceptive and metacognitive control participants regulate ongoing cognitive activities by intentionally suppressing emotional unpleasantness triggered by pain while anchoring attention in the body, in a visualisation, or on the breath, to maintain a sport effort for example. This volitional attitude integrates MM in a way that partially fits its known association with hero-narratives (Jones 2019). This way MM is meant to augment mental and physical capabilities through positive reappraisal compatible with sport and positive psychology to the extent they underscore the virtuous strength of bravery and persistence through conscious control of experience: *“pain during sport comes from positive action and can be mastered, I use it to keep the focus on the performance”* (MC26-Nov). . For these participants, self-relevant challenges enable the control of pain unpleasantness via preservation of self-efficacy and mental mastery (Brown et al., 2007).

Phenomenological inter-reliability with self-reports: before the pain task these participants had a higher calibration temperature than others proving more pain tolerance

with respect to the rest of the sample. Similarly, during the pain task, a participant described the sensation as pleasant and not intense enough for him. These self-reports during the pain paradigm are congruent with the self-challenging attitude towards pain described later during the interview.

4.3 PhC3: Cognitive flexibility through psychosomatic metacognitive knowledge: ‘better welcoming than to add fuel to the fire’.

Participants in PhC3 engage in open explorative attention and awareness of pain to gather information, develop insights, and facilitate well-being and adaptation. PhC3 shows a first step towards integrative awareness as characterized by an assimilatory, non-discriminatory interest in what is occurring in the body in accordance with the attentional family of MM practices (Dahl et al. 2015). This “relaxed” attention permits the awareness of the worsening effect of negative evaluation on pain, bringing these participants to seek relief by enhancing cognitive flexibility and allowance of pain. Beliefs connected with holistic medicine drive these participants in relativising pain by emphasizing the principle of acceptance based on one’s mind-body attunement in order to come out of conflictual modes: *“I feel my body to discern what really causes pain, distinguishing fatigue from nervous or muscular pain, and acting consistently not to increase it. Today I can integrate my bodily messages better”* (MC74–Nov). This strategy is characterized by the integration of meta-cognitive knowledge about pain regulation (Jordano, Touron 2018) centered on interoception. The belief that a flexible way to handle pain works better than a rigid one stems from the evidence that *“the more you let it go, the less you resist, the less pain affects you”* (MC42–Exp) and *“If there’s no solution, I accept it, let it be there”* (MC44–Exp). This result is opposite to PhC1 perceived powerlessness and conforms with the evidence that subjective adaptive coping strategies should be recognised and enhanced to improve clinical outcomes (Miller-Matero et al. 2016). According to a process model of emotion regulation (Gross 1998), PhC3 is compatible with a self-regulative strategy where positive reappraisal seemingly decreases negative affect and well-being as opposed to suppression (Gross and John 2003). This welcoming attitude also falls in line with mindful emotion-regulation processes (Chambers 2009; Carver & Scheier 2011) as specifically associated to a reappraisal of pain-related emotional distress based on self-awareness: *“/*

approach and welcome it instead of pushing it away and being caught in emotions, thoughts and resistance. I allow it to be there, bringing awareness to it, feeling it and trying to be with it. I come back to my body, to breathing, bringing presence and lightness” (MC42-Exp). Taking into account psychosomatic emotional discomfort allows more cognitive flexibility in PhC3 (Hayes and Shenk, 2004).

Phenomenological inter-reliability with self-reports: participants in PhC3 reported a level of pain unpleasantness lower than PhC1, comparable to PhC2, but higher than PhC4 and PhC5. The most salient feature was a lower openness, compared to other participants, during the pain experiment. This finding points to a possible negative relationship between the focus on bodily response to pain sensation applied during this strategy (Mehling 2016) and the sense of experiential openness.

4.4 PhC4. Metacognitive, non-preferential awareness: deconstructing pain into phenomenological components: ‘just as it is: neither rejecting nor looking for’.

Participants in PhC4 perceive pain components as mental factors which can be explored by allowing one’s mind to stay with unpleasantness as it is, letting go of the urge to avoid or change it. Participants’ commitment to stay open to current experience is said to inherently undermine preferential-volitional reactions by recognising reappraisals as natural consequences of one’s mind, in accordance with MM specific effectiveness (Teasdale et al. 2003). This non-reactive posture conforms to the deconstructive family of MM practices based on self-inquiry (Dahl et al. 2015) and enables the observation of experience, allowing unpleasant emotional and physiological responses to diffuse in line with mindful emotion regulation (Chambers 2009). The allowance of pain as part of experience contrasts with the habitual “fight or flight” drive and deflates defensive anxiety (Baer 2003; Borkovec et al. 2002; Sharma et al. 2014) and experiential avoidance in accordance with the third wave of cognitive behavior therapies (Kumar et al., 2008).

As synthesized by a participant the non-preferential attitude of “not rejecting not looking for” stems from open, relaxed presence rather than a fixed or focused one (this description is in line with a so-called non-dual style of OM named Open Presence meditation; Lutz et al. 2013 figure 19.1). This feature contrasts this PhC from the two previous ones (PhC 2-3). Consistently, participants favor OM practices in dealing with intense pain: “*Focused*

attention works only for mild pain whereas a state of open presence to mind itself, lessens pain. The sensation may stay, but the notion of pain as such disappears. Intense pain constantly interferes with the conscious effort of focusing on a point: it takes over and we constantly fight with it. While in open consciousness pain really diminish” (MC69-Exp+PhC4). By enlarging the mental focus, pain can be integrated as a part of an entire experience, bringing awareness itself to the forefront: *“Once awareness decentralises from pain it is possible to see the chain of processes that leads to aversion about unpleasantness”* (MC64-Exp+PhC5). In concordance with MM foundational principles, once the field of awareness comes to the forefront, pain is neutrally observed giving room for emotional processing and diverting from automatic evaluative patterns (Kabat-Zinn et al., 1992). Whatever pain triggers, it becomes an opportunity for keeping awareness oriented to itself while lessening the stimulus–response automatic loop which characterises mood disturbance and stress (Brown et al., 2007). This metacognitive exploration and deconstruction of the self-related evaluative schemas largely falls in line with cognitive defusion (Hayes & Wilson, 1994) and dereification (Lutz et al. 2015, Dahl et al. 2015), conforming to MM-related downregulation of anxious worry and ruminative thinking (Brown & Ryan, 2004; Hayes 1994; Roemer & Orsillo, 2002; Teasdale et al., 1995).

Phenomenological inter-reliability with self-reports: consistently, these participants report lower avoidance and higher vividness and openness in OM state during the pain task , suggesting a better discrimination of this state while having a clear perception of cognitive–emotional patterns. Interestingly, PhC4 non-preferential awareness is marked by a non-affirmative reappraisal, as any cognitive evaluation falls in an open metacognitive field of recognition and deconstruction. In this sense, PhC4 could be framed as being beyond common reappraisal strategies.

4.5 PhC5. Metacognitive insight and compassion. Decentering from subjective pain to relief universal suffering

Through specific techniques PhC5 entangles pain with the affective system evoking a prosocial, compassionate attitude towards others’ suffering. This enriches the previous cluster’s strategy, integrating non-preferential metawareness with the altruistic motivation to relieve others. This posture decenters one’s perspective relativising personal pain as a

part of a shared whole which is beyond one's experience. This purposeful attitude towards pain is consistent with the constructive family of MM practices (Dahl et al. 2015), as being characterised by an ethical reorienting of the mind toward existential meaningfulness and kindness. This aspect is also in line with the Mindfulness-to-Meaning Theory (Garland et al. 2015) as emotion is regulated by positive affect (through compassion) expanding cognition to promote reappraisal of pain in a meaningful engagement with it. This radical connection with suffering reappraises experience generating a sense of wholesome purposefulness connected with spiritual practice: *"For a Buddhist practitioner to fall sick means to purify his karma."* (MC71-Exp) (Note: here "purify his karma" refers to the process of undoing a mental habit). Taking pain and sending relief reverses the automatic avoidance of suffering. Instead pain is used as a meaningful medicine which takes its sense only in connection with a spiritual aspiration that transcends the worldly pursuit of pleasure.

In contrast with PhC3 and in line with PhC4, this cluster emphasizes open awareness of pain with respect to states where attention is focused on or absorbed into an object. As for the previous PhC, meta-awareness results in metacognitive insight, bringing awareness of thoughts instead of being fused or absorbed with their contents (Safran & Segal, 1990; Masuda et al. 2004). On top of this, the prosocial-altruistic aspiration makes affective states such as empathy and referential compassion available for explicit processing, enhancing cognitive reappraisal, decentering and perspective-taking processes (Dahl et al. 2015): *"using the support of all sentient beings and offering my own suffering to relief them detaches me from my own suffering"* (MC71-Exp). While referential compassion towards self and others is known to be a rather explicit object of focus for meditation practice (Kirby 2017; Lutz et al. 2008), to proactively devote one's self to universal suffering participants open and awaken non-referential or non-dual compassion: *"I don't try to get rid of pain, I really use it as a support to focus on compassion"* (MC71-Exp).

Being touched by suffering while bringing kindness and care here involves well-known processes in self-compassion approaches, such as self-kindness, common humanity, and mindful acceptance (Wilson et al. 2019; Montero-Marin et al. 2020; Germer and Neff 2013). These aspects prove to be critical if we consider that mindfulness itself has been conceived as that facet of compassion allowing one to hold painful thoughts and feelings in balanced awareness rather than identifying with them (Neff 2003).

Phenomenological inter-reliability with self-reports: PhC5 demonstrates the lowest levels of unpleasantness during both OM and DIS states, while consistently showing higher openness. This lessening of unpleasantness associated with a greater openness may follow a decentering from subjective pain based on the altruistic wish to relieve universal suffering. This outcome is in line with the evidence that mindfully disengaging from negative-automatic thought patterns facilitates adaptive coping abilities (Hussain 2015). As stated by a participant: *“Just like anything else, pain is... the mind, it has no essence in the end. Although you feel it physically to a certain degree, you can transform it”* (MC66-Exp). Finally, lower scores in temperature during pain calibration could be interpreted as a self-compassionate attitude towards suffering, as opposed to the self-challenging one shown in PhC2.

4.6 Interpreting the organization of the PhCs along a pseudo-gradient

Table 4 synthesizes our effort to interpret the internal structure across PhCs visually displayed in Figure 2 by mapping the clusters onto common theoretical constructs found in the literature. Overall we first noticed a progression in the PhCs from PhC1 to PhC5 from interpreting pain as mostly a physical factor to interpreting it preferably as a mental one. In the framework of cognitive therapy, this representation is compatible with the progression proposed by Teasdale (1999) who specifies three distinct modes of emotional processing:

1. an immersive mode: involvement or active engagement in emotions or experience;
2. a conceptualizing/doing mode: thought about, and evaluation of, self and emotions;
3. a mindful experiencing mode: direct experiential awareness of what is occurring, or non-evaluative intuitive knowing.

Accordingly, our pseudo-gradient seems to capture a dimension related to cognitive fusion with pain and its regulation (see above, and far-left column Table 4). In this framework, PhC1 is interpreted as a tendency to cognitively fuse with pain (i.e. ‘pain catastrophizing’, Sullivan et al., 1995) through automatic regulatory strategies (e.g. ‘experiential avoidance’, Hayes et al. 2004; Kumar et al., 2008). While participants in PhC2 describe already reappraisal strategies to distance oneself from the content of pain, it

exhibits also a strong sense of agency, which is reduced in subsequent clusters. This progression further suggests that this pseudo-gradient captured not only the degree of fusion or reification related to the content of the painful experience (e.g. emotions, or thoughts), but also to the one from the agent's self. The second column of table 4 further specifies the various regulatory strategies associated with cognitive defusion or dereification. Similarly to cognitive defusion, the notion of 'dereification' refers to the degree to which thoughts, feelings, and perceptions are phenomenally perceived as mental processes rather than as accurate depictions of reality (Lutz et al. 2015). We used specific cognitive and meta-cognitive processes previously described in psychology or meditation literature as synthetic descriptors. Starting at PhC2, we noted the use of implicit and explicit metacognitive strategies (Reder & Schunn, 2014). We described them using constructs from the literature on metacognition (Fleming et al., 2012; Nelson, 1996; Schooler & Smallwood, 2009; Schooler et al., 2011) distinguishing metacognitive knowledge (information about how the mind works), metacognitive monitoring (observation and following of mental processes), and metacognitive control (self-regulatory actions based on metacognitive monitoring). We also used constructs from psychotherapies and meditation such as metacognitive insight (Jankowski & Holas, 2014), metawareness (Dunne et al. 2019) and cognitive reappraisal (Opialla et al. 2014). Overall Table 4 suggests a progression in the degrees of implicit versus explicit meta-awareness from PhC1 to PhC5 and a progression from an active, meta-cognitive control in PhCs 2-3 to a relaxed, non-reactive meta-awareness in PhCs 4-5.

4.7 Limitations

This study could be influenced by different limitations. Self-reports may suffer from well-known distortions (Baer et al. 2003), notably social desirability. In a previous work with a subset of novice participants from the current article, we evaluated the reliability of self-reports and found that they exhibited patterns that were largely predicted by home practice but could not be easily explained by desirable responding (Abdoun et al. 2019).

It remains possible that expert practitioners' motivation to serve the experiment in the best possible way may have led them to distort their responses in order to try to confirm

presumed research hypotheses. The fact that exploratory interviews sought to gather new information out of hypotheses systems make this possibility less likely. Our work has combined an interview with self-reports using quantitative methods. Some of these methods are statistical and inferential in nature, implying random sampling from a larger population. However, the generalizability of our study is limited by the use of qualitative methods under similar characteristics (Kvale 2009); in particular, the phenomenological structure that emerged in our study is likely to be at least in part contingent on the participants who were interviewed.

Finally, parallels with processes implied in chronic and severe pain are meant to encourage the integration of experimental mixed-methods approaches into the development of pain treatments, not to extend or generalise our findings to clinical samples.

5 Future directions

Worldwide health institutes are supporting programs on the application of MM in treating a wide spectrum of pain conditions such as cancer pain, through self-regulation of mood state, self-compassion and spiritual relief. At the same time, the evidence that spirituality plays a role in MM in clinical samples is growing (Poletti et al. 2019).

This study on a healthy sample provides a more refined enquiry about dual and non-dual contemplative dimensions in relation with pain depending on long-term MM expertise, bringing into view novel ways to deal with pain. In a healthy sample, PhC1 shows psychological traits that could fall in line with literature on clinical samples. If this were the case, this cluster could describe an early developmental trajectory which should be met by appropriate educational and preventive approaches in clinical settings.

This study also shows how personal meaning of pain predicts specific facets of self-reports during an experimental paradigm, providing evidence for the ecological validity of laboratory-induced pain in healthy subjects. The integration of qualitative, multidimensional methods with brain imaging data thus offers a promising avenue to the refinement of neurocognitive models of pain.

Consistency between qualitative accounts and self-reports during a pain task supports the idea that pain experience stems from specific internal models, beliefs, and expectations.

Current cognitive models of pain overlook the relevance of patterns driven by metacognitive processes based on contemplative practices. Through a long-lasting training, these may priorly influence pain regulative strategies by tempering catastrophizing patterns with equanimity, openness, non-duality and compassion. To explore this possibility, future research should investigate how phenomenological features targeted by meditation practices differently impact perceived regulative capacities.

Some findings in this study also raise challenges for the learning of meditation. As practitioners may integrate MM in accordance with personal and cultural schemas, meditation training should take into account the influence of these aspects on learning trajectories.

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Conflict of interest

All authors of the present paper declare no conflicting interests.

Authors contributions

SP, JZ and AL designed the qualitative interview. SP executed the interviews and analysed the qualitative data. OA, JZ and AL assisted with the data interpretation. AL conceived the pain experiment. AL and JZ designed the study and OA helped implement the experimental design. JZ executed the pain experiment. JZ and OA collected the psychometric data. OA combined the phenomenological clusters with quantitative data from the psychometric scales and pain experiment.

SP wrote a first draft of the manuscript. All the authors collaborated in the writing and editing of the final manuscript.

References

1. Abdoun, O., Zorn, J., Fucci, E., Perraud, E., Aarts, K., & Lutz, A. (2018). Brain & Mindfulness Project Manual. OSF. <https://osf.io/dbwch/>
2. Abdoun, A., Zorn, J., Poletti, S., Fucci, E., Lutz, A. (2019). Training novice practitioners to reliably report their meditation experience using shared phenomenological dimensions. *Consciousness and Cognition* 68: 57-72.
3. Baer, R. A. (2003), Mindfulness Training as a Clinical Intervention: A Conceptual and Empirical Review. *Clinical Psychology: Science and Practice*, 10: 125-143. doi:10.1093/clipsy.bpg015
4. Baer, R. A., Rinaldo, J. C., & Berry, D. T. R. (2003). Self-report distortions (including faking, lying, malingering, social desirability). *Encyclopedia of Psychological Assessment: Vol. 1-2*, (pp. 862-866). London: SAGE Publications Ltd. <https://doi.org/10.4135/9780857025753>.
5. Baer, R. A., Smith, G. T., Hopkins, J., Krietemeyer, J., & Toney, L. (2006). Using Self-Report Assessment Methods to Explore Facets of Mindfulness. *Assessment*, 13(1), 27-45. <https://doi.org/10.1177/1073191105283504>
6. Bardeen, J. R., & Fergus, T. A. (2016). The interactive effect of cognitive fusion and experiential avoidance on anxiety, depression, stress and posttraumatic stress symptoms. *Journal of Contextual Behavioral Science*, 5, 1-6. <http://doi.org/10.1016/j.jcbs.2016.02.002>
7. Beck, A., Ward, C., Mendelson, M., Mock, J., & Erbaugh, J. (1961). An inventory for measuring depression. *Archives of General Psychiatry*, 4(6), 561-571. <https://doi.org/10.1001/archpsyc.1961.01710120031004>
8. Benjamini, Y., & Hochberg, Y. (1995). Controlling the False Discovery Rate: A Practical and Powerful Approach to Multiple Testing. *Journal of the Royal Statistical Society: Series B (Methodological)*, 57(1), 289-300. <https://doi.org/10.1111/j.2517-6161.1995.tb02031.x>
9. Borkovec, T. D., Newman, M. G., Pincus, A. L., & Lytle, R. (2002). A component analysis of cognitive-behavioral therapy for generalized anxiety disorder and the role of interpersonal problems. *Journal of Consulting and Clinical Psychology*, 70(2), 288-298. <https://doi.org/10.1037/0022-006X.70.2.288>
10. Bitbol, M., Petitmengin, C. (2017). *Neurophenomenology and the Micro-phenomenological Interview*. John Wiley & Sons <https://doi.org/10.1002/9781119132363.ch51>
11. Brown, K. W., Ryan, R. M. & Creswell, J. D. (2007) Mindfulness: Theoretical Foundations and Evidence for its Salutary Effects. *Psychological Inquiry*, 18:4, 211-237, DOI: 10.1080/10478400701598298
12. Brown, K. W., Ryan, R. M. (2003). The benefits of being present: mindfulness and its role in psychological well-being. *J Pers Soc Psychol*. 84(4):822-848. doi:10.1037/0022-3514.84.4.822

13. Carver, C. S., & Scheier, M. F. (2011). *Self-regulation of action and affect*. In K. D. Vohs & R. F. Baumeister (Eds.), *Handbook of self-regulation: Research, theory, and applications* (p. 3–21). Guilford Press.
14. Chambers, R., Gullone, E., Allen, N. B. (2009). Mindful emotion regulation: An integrative review. *Clin Psychol Rev*. 2009; 29(6):560–572. doi:10.1016/j.cpr.2009.06.005
15. Chen, S., & Jackson, T. (2019). Causal effects of challenge and threat appraisals on pain self-efficacy, pain coping, and tolerance for laboratory pain: An experimental path analysis study. *PloS one*, 14(4), e0215087. <https://doi.org/10.1371/journal.pone.0215087>
16. Dahl, C. J., Lutz, A., & Davidson, R. J. (2015). Reconstructing and deconstructing the self: cognitive mechanisms in meditation practice. *Trends in cognitive sciences*, 19(9), 515–523. <https://doi.org/10.1016/j.tics.2015.07.001>
17. Dunne, J. D., [Thompson, E.](#), [Schooler, J.](#) (2019). Mindful meta-awareness: sustained and non-propositional. *Current Opinion in Psychology*, Volume 28, August 2019, Pages 307–311
18. Edwards, R. R., Dworkin, R. H., Sullivan, M. D., Turk, D.C., Wasan, A.D. (2016). The Role of Psychosocial Processes in the Development and Maintenance of Chronic Pain. *J Pain* 17(9 Suppl): T70–T92. doi:10.1016/j.jpain.2016.01.001
19. Fleming, S. M., Huijgen, J., Dolan, R. J. (2012). Prefrontal Contributions to Metacognition in Perceptual Decision Making. *Journal of Neuroscience*, 32(18) 6117–6125; DOI: 10.1523/JNEUROSCI.6489–11.2012
20. Gallagher, S., Zahavi D. (2008). *The Phenomenological Mind*. Routledge.
21. Garland, E.L., Farb, N.A., Goldin, P.R. & Fredrickson, B.L. (2015). Mindfulness Broadens Awareness and Builds Eudaimonic Meaning: A Process Model of Mindful Positive Emotion Regulation, *Psychological Inquiry*, 26:4, 293–314, DOI: 10.1080/1047840X.2015.1064294
22. Gatchel, R. J., Peng, Y. B., Peters, M. L., Fuchs, P. N., Turk, D. C. (2007). The biopsychosocial approach to chronic pain: scientific advances and future directions. *Psychol Bull* 133(4):581–624. doi:10.1037/0033-2909.133.4.581
23. Germer, C. K. and Neff, K. D. (2013). Self-Compassion in Clinical Practice. *J. Clin. Psychol.*, 69: 856–867. doi:10.1002/jclp.22021
24. Gillanders, D. T., Bolderston, H., Bond, F. W., Dempster, M., Flaxman, P. E., Campbell, L., Kerr, S., Tansey, L., Noel, P., Ferenbach, C., Masley, S., Roach, L., Lloyd, J., May, L., Clarke, S., & Remington, B. (2014). The Development and Initial Validation of the Cognitive Fusion Questionnaire. *Behavior Therapy*, 45(1), 83–101. <https://doi.org/10.1016/j.beth.2013.09.001>
25. Gross, J. J., & John, O. P. (2003). Individual differences in two emotion regulation processes: Implications for affect, relationships, and well-being. *Journal of Personality and Social Psychology*, 85(2), 348–362. <https://doi.org/10.1037/0022-3514.85.2.348>

26. Gross, J. J. (1998). The Emerging Field of Emotion Regulation: An Integrative Review. *Review of General Psychology*, 2(3), 271–299. <https://doi.org/10.1037/1089-2680.2.3.271>
27. Hayes, S. C., & Shenk, C. (2004). Operationalizing mindfulness without unnecessary attachments. *Clinical Psychology: Science and Practice*, 11(3), 249–254. <https://doi.org/10.1093/clipsy.bph079>
28. Hayes, S. C., Strosahl, K., Wilson, K. G. et al. (2004). Measuring experiential avoidance: A preliminary test of a working model. *Psychol Rec* 54, 553–578. <https://doi.org/10.1007/BF03395492>
29. Hayes, S. C. (1994). *Content, context, and the types of psychological acceptance*. In S. C. Hayes, N. S. Jacobson, V. M. Follette, & M. J. Dougher (Eds.), *Acceptance and change: Content and context in psychotherapy* (pp. 13–32). Reno, NV: Context Press.
30. Hayes, S. C, Wilson, K. G. (1994). Acceptance and commitment therapy: Altering the verbal support for experiential avoidance. *Behav Anal*; 17(2):289–303. doi:10.1007/BF03392677
31. Hilton, L., Maher, A. R., Colaiaico, B., et al. (2017). Meditation for posttraumatic stress: Systematic review and meta-analysis. *Psychol Trauma*. 9(4):453–460. doi:10.1037/tra0000180
32. Høffding, S., & Martiny, K. (2016). Framing a phenomenological interview: What, why and how. *Phenomenology and the Cognitive Sciences*, 15(4), 539–564. <https://doi.org/10.1007/s11097-015-9433-z>
33. Hussain, D. (2015). Meta-Cognition in Mindfulness: A Conceptual Analysis. *Psychological Thought*, Vol. 8(2), 132–141, doi:10.5964/psyct.v8i2.139
34. IASP (1994). Part III: *Pain Terms, A Current List with Definitions and Notes on Usage* (pp 209–214) Classification of Chronic Pain, Second Edition, IASP Task Force on Taxonomy, edited by H. Merskey and N. Bogduk, IASP Press, Seattle.
35. Jankowski, T., Holas, P. (2014). Metacognitive model of mindfulness. *Conscious Cogn*. 2014;28:64–80. doi:10.1016/j.concog.2014.06.005
36. Jones, P. (2019) Mindfulness Training: Can It Create Superheroes? *Front. Psychol*. 10:613. doi: 10.3389/fpsyg.2019.00613
37. Jong, P. J., & Vroling, M. (2014). Better safe than sorry: Threat-confirming reasoning bias in anxiety disorders. In I. Blanchette (Ed.), *Current issues in thinking and reasoning. Emotion and reasoning* (p. 22–43). Psychology Press.
38. Jordano, M. L., & Touron, D. R. (2018). How often are thoughts metacognitive? Findings from research on self-regulated learning, think-aloud protocols, and mind-wandering. *Psychonomic Bulletin & Review*, 25(4), 1269–1286. <https://doi.org/10.3758/s13423-018-1490-1>
39. Kabat-Zinn, J., Massion, A. O., Kristeller, J., Peterson, L. G., Fletcher, K. E., Pbert, L., Lenderking, W. R., & Santorelli, S. F. (1992). Effectiveness of a meditation-based stress reduction program in the

- treatment of anxiety disorders. *The American Journal of Psychiatry*, 149(7), 936–943. <https://doi.org/10.1176/ajp.149.7.936>
40. Kabat-Zinn, J. (2013). *Full Catastrophe Living (Revised Edition): Using the Wisdom of Your Body and Mind to Face Stress, Pain, and Illness*. Bantam Books Trade Paperbacks.
 41. Kirby, J. N., Tellegen, C. L., & Steindl, S. R. (2017). A meta-analysis of compassion-based interventions: current state of knowledge and future directions. *Behavior Therapy*, 48, 778–792. <https://doi.org/10.1016/j.beth.2017.06.003>.
 42. Kirkham, J., Smith, J. A., Havsteen-Franklin, D. (2015). Painting pain: an interpretative phenomenological analysis of representations of living with chronic pain. *Health Psychology* 34 (4) 398–406. ISSN 0278-6133.
 43. Kumar, S., Feldman, G., [Hayes](#), A. (2008). Changes in Mindfulness and Emotion Regulation in an Exposure-Based Cognitive Therapy for Depression. *Cognitive Therapy and Research* 32(6):734–744 10.1007/s10608-008-9190-1
 44. Kvale, S., & Brinkmann, S. (2009). *InterViews: Learning the craft of qualitative research interviewing* (2nd ed.). Sage Publications, Inc.
 45. Lutz, A., Jha, A. P., [Dunne, J. D.](#), [Saron, C. D.](#) (2015). Investigating the phenomenological matrix of mindfulness-related practices from a neurocognitive perspective. *Am Psychol.* 70(7):632–58. doi: 10.1037/a0039585.
 46. Lutz, A., McFarlin, D. R., Perlman, D. M., Salomons, T. V., & Davidson, R. J. (2013). Altered anterior insula activation during anticipation and experience of painful stimuli in expert meditators. *NeuroImage*, 64, 538–546. <https://doi.org/10.1016/j.neuroimage.2012.09.030>
 47. Lutz, A., Slagter, H. A., Dunne, J. D., & Davidson, R. J. (2008). Attention regulation and monitoring in meditation. *Trends in cognitive sciences*, 12(4), 163–169. <https://doi.org/10.1016/j.tics.2008.01.005>
 48. Lutz, A., Dunne, J., Davidson, R. (2006). Meditation and the neuroscience of consciousness: an introduction. *The Cambridge Handbook of Consciousness*, 19.
 49. Masuda, A., Hayes, S. C., Sackett, C. F., Twohig, M. P. (2004). Cognitive defusion and self-relevant negative thoughts: examining the impact of a ninety year old technique. *Behaviour Research and Therapy*. Vol 42, Issue 4, April 2004, Pages 477–485
 50. Mehling W. (2016). Differentiating attention styles and regulatory aspects of self-reported interoceptive sensibility. *Philosophical transactions of the Royal Society of London. Series B, Biological sciences*, 371(1708), 20160013. <https://doi.org/10.1098/rstb.2016.0013>
 51. Mehling, W. E., Price, C., Daubenmier, J. J., Acree, M., Bartmess, E., & Stewart, A. (2012). The Multidimensional Assessment of Interoceptive Awareness (MAIA). *PLOS ONE*, 7(11), e48230. <https://doi.org/10.1371/journal.pone.0048230>

52. Meyer, T. J., Miller, M. L., Metzger, R. L., & Borkovec, T. D. (1990). Development and validation of the Penn State Worry Questionnaire. *Behaviour Research and Therapy*, 28(6), 487–495. [https://doi.org/10.1016/0005-7967\(90\)90135-6](https://doi.org/10.1016/0005-7967(90)90135-6)
53. Miller-Matero, L. R., Chipungu, K., Martinez, S., Eshelman, A. & Eisenstein, D. (2016). How do I cope with pain? Let me count the ways: awareness of pain coping behaviors and relationships with depression and anxiety. *Psychology, Health & Medicine*, DOI: 10.1080/13548506.2016.1191659
54. Montero-Marin, J., Zubiaga, F., Cereceda, M., Marcos Piva Demarzo, M., Trenc, P., et al. (2020). Correction: Burnout Subtypes and Absence of Self-Compassion in Primary Healthcare Professionals: A Cross-Sectional Study. *Plos One* 15(4): e0231370. <https://doi.org/10.1371/journal.pone.0231370>
55. Moseley, L. (2002). Combined physiotherapy and education is efficacious for chronic low back pain. *Aust J Physiother.* 48:297–3022
56. Moseley, G.L., Nicholas, M. K., Hodges, P. W. (2004). A randomized controlled trial of intensive neurophysiology education in chronic low back pain. *Clin J Pain* 20:324–330
57. Moses, E. B., & Barlow, D. H. (2006). A New Unified Treatment Approach for Emotional Disorders Based on Emotion Science. *Current Directions in Psychological Science*, 15(3), 146–150. <https://doi.org/10.1111/j.0963-7214.2006.00425.x>
58. Namgyal, D.T., Kunsang, E.P., Rinpoche, K.T. (2004). Clarifying the Natural State: A Principal Guidance Manual for Mahamudra. North Atlantic Books.
59. Neff, K. (2003). Self-Compassion: An Alternative Conceptualization of a Healthy Attitude Toward Oneself. *Self and Identity* 2(2):85–101 DOI:10.1080/15298860309032
60. Nelson, T. O. (1996). Consciousness and metacognition. *American Psychologist*, 51(2), 102–116. <https://doi.org/10.1037/0003-066X.51.2.102>
61. Opialla, S., Lutz, J., Scherpiet, S., et al. (2015). Neural circuits of emotion regulation: a comparison of mindfulness-based and cognitive reappraisal strategies. *Eur Arch Psychiatry Clin Neurosci*; 265(1):45–55. doi:10.1007/s00406-014-0510-z
62. Osborn, M., Smith, J. A. (2015). The personal experience of chronic benign lower back pain: an interpretative phenomenological analysis. *British Journal of Pain* 9 (1), pp. 65–83. ISSN 2049–4637.
63. Osborn, M., Rodham, K. (2010). Insights into Pain: A Review of Qualitative Research. *Rev Pain* 4(1): 2–7. doi: 10.1177/204946371000400102
64. Patterson, D. R., & Jensen, M. P. (2003). Hypnosis and clinical pain. *Psychological Bulletin*, Vol. 129, pp. 495–521.
65. Perlman, D. M., Salomons, T. V., Davidson, R. J., & Lutz, A. (2010). Differential effects on pain intensity and unpleasantness of two meditation practices. *Emotion*, 10(1), 65–71

66. Pietkiewicz, I., and Smith, J.A. (2014). A Practical Guide to Using Interpretative Phenomenological Analysis in Qualitative Research Psychology, *Psychological Journal*, 20, 1, 7-14.
67. Poletti S, Razzini G, Ferrari R, et al. Mindfulness-Based stress reduction in early palliative care for people with metastatic cancer: A mixed-method study. *Complement Ther Med*. 2019;47:102218. doi:10.1016/j.ctim.2019.102218
68. Price D., Aydede M. (2005). *The Experimental Use of Introspection in the Scientific Study of Pain and its Integration with Third-Person Methodologies: The Experiential-Phenomenological Approach*. In *Pain: New Essays on Its Nature and the Methodology of Its Study*, Murat Aydede (Ed.), Cambridge, Massachusetts: MIT Press, 2006.
69. Price, D. D., Barrell, J. J., & Rainville, P. (2002). Integrating experiential-phenomenological methods and neuroscience to study neural mechanisms of pain and consciousness. *Consciousness and Cognition* 11(4): 593-608
70. Quartana, P. J., Campbell, C. M., & Edwards, R. R. (2009). Pain catastrophizing: a critical review. *Expert review of neurotherapeutics*, 9(5), 745-758. <https://doi.org/10.1586/ern.09.34>
71. Rainville, P., Carrier, B., Hofbauer, R. K., Bushnell, M. C., & Duncan, G. H. (1999). Dissociation of sensory and affective dimensions of pain using hypnotic modulation. *Pain*, Vol. 82, pp. 159-71.
72. Reder, L. M., & Schunn, C. D. (2014). *Metacognition does not imply awareness: Strategy choice is governed by implicit learning and memory*. In *Implicit memory and metacognition* (pp. 57-90). Psychology Press
73. Roemer, L. and Orsillo, S. M. (2002), Expanding Our Conceptualization of and Treatment for Generalized Anxiety Disorder: Integrating Mindfulness/Acceptance-Based Approaches With Existing Cognitive-Behavioral Models. *Clinical Psychology: Science and Practice*, 9: 54-68. doi:10.1093/clipsy.9.1.54
74. Ryff, C. D. (1989). Happiness is everything, or is it? Explorations on the meaning of psychological well-being. *Journal of Personality and Social Psychology*, 57(6), 1069-1081. <https://doi.org/10.1037/0022-3514.57.6.1069>
75. Rysewyk van, S. (2017). *A Call for Study on the Meanings of Pain*. Springer
76. Rysewyk van, S. (2016). *Meanings of pain*. Springer
77. Rysewyk van, S. (2014). Objective knowledge of subjective pain? towards a subjective-neuroscience of pain. *Ngau Mamae* 10-20
78. Safran, J. D. and Segal, Z. V. (1990). *Therapy Adherence Rating Scale. Interpersonal process in Cognitive Therapy*. Basic Books, New York.

79. Schooler, J. W., Smallwood, J., Christoff, K., Handy, T. C., Reichle, E. D., Sayette, M. A. (2011). Meta-awareness, perceptual decoupling and the wandering mind. *Trends Cogn Sci*. 15(7):319–326. doi:10.1016/j.tics.2011.05.006
80. Schooler, J. W., & Smallwood, J. (2009). *Metacognition*. In *Oxford Companion to Consciousness* (pp. 438–442). Oxford University Press.
81. Schutze, R., Rees, C., Slater, H., Smith, A., O'Sullivan, P. (2017). 'I call it stinkin' thinkin': A qualitative analysis of metacognition in people with chronic low back pain and elevated catastrophizing. *British Journal of Health Psychology*, The British Psychological Society
82. Sharma, M., Rush, S. E. (2014). Mindfulness-based stress reduction as a stress management intervention for healthy individuals: a systematic review. *J Evid Based Complementary Altern Med*; 19(4):271–286. doi:10.1177/2156587214543143
83. Smith J. A. (2019) Participants and researchers searching for meaning: Conceptual developments for interpretative phenomenological analysis. *Qualitative Research in Psychology*, 16:2, 166–181, DOI: 10.1080/14780887.2018.1540648
84. Smith, J. A., and Osborn, M. (2014) Interpretative phenomenological analysis as a useful methodology for research on the lived experience of pain. *British Journal of Pain* 9 (4), pp. 41–42. ISSN 2049–4637.
85. Smith, J. A., Flower, P. and Larkin, M. (2009), *Interpretative Phenomenological Analysis: Theory, Method and Research*., *Qualitative Research in Psychology*, 6:4, 346–347, DOI: 10.1080/14780880903340091
86. Smith, J. A., Osborn M. (2008). *Interpretative phenomenological analysis*, in: J. Smith (Ed.), *Qualitative psychology: a practical guide to research methods*. Sage, London, pp. 53–80.
87. Spielberger, C. D., Gorsuch, R. L., & Lushene, R. E. (1970). State-trait anxiety inventory manual. *Mind Garden, Inc*.
88. Sullivan, M. J. L., Thorn, B. E., [Haythornthwaite](#) J. A., et al. (2001). Theoretical Perspectives on the Relation Between Catastrophizing and Pain. *Clinical Journal of Pain* 17(1):52–64. 10.1097/00002508-200103000-00008
89. Sullivan, M. J. L., Bishop, S. R., & Pivik, J. (1995). The pain catastrophizing scale: Development and validation. *Psychological Assessment*, 7(4), 524–532. <https://doi.org/10.1037//1040-3590.7.4.524>
90. Teasdale, J. D. (1999). Emotional processing, three modes of mind and the prevention of relapse in depression. *Behav Res Ther*. 1999;37 Suppl 1:S53–S77. doi:10.1016/s0005-7967(99)00050-9
91. Teasdale, J. D., Segal, Z., & Williams, J. M. (2003). Mindfulness training and problem formulation. *Clinical Psychology: Science and Practice*, 10, 157–160
92. Teasdale, J. D., Dritschel, B. H., Taylor, M. J. et al. (1995). Stimulus-independent thought depends on central executive resources. *Memory & Cognition* 23, 551–559. <https://doi.org/10.3758/BF03197257>

93. Tracey, I. (2010). Getting the pain you expect: mechanisms of placebo, nocebo and reappraisal effects in humans. *Nat Med*.16(11):1277–83. doi: 10.1038/nm.2229.
94. Turk, D. C., & Wilson, H. D. (2010). Fear of pain as a prognostic factor in chronic pain: conceptual models, assessment, and treatment implications. *Current pain and headache reports*, 14(2), 88–95. <https://doi.org/10.1007/s11916-010-0094-x>
95. Villemure, C., Čeko, M., Cotton, V. A., & Bushnell, M. C. (2015). Neuroprotective effects of yoga practice: age-, experience-, and frequency-dependent plasticity. *Frontiers in human neuroscience*, 9, 281. <https://doi.org/10.3389/fnhum.2015.00281>
96. Vlaeyen, J. W., Linton, S. J. (2012). Fear-avoidance model of chronic musculoskeletal pain: 12 years on. *Pain*. 2012;153(6):1144–1147. doi:10.1016/j.pain.2011.12.009
97. Vlaeyen, J. W. S., & Linton, S. J. (2000). Fear-avoidance and its consequences in chronic musculoskeletal pain: A state of the art. *Pain*, 85(3), 317–332. [https://doi.org/10.1016/S0304-3959\(99\)00242-0](https://doi.org/10.1016/S0304-3959(99)00242-0)
98. Wielgosz, J., Goldberg S. B., Kral T. R. A., Dunne J. D., Davidson R. J. (2019). Mindfulness Meditation and Psychopathology. *Annual Review of Clinical Psychology* 15:1, 285–316
99. Wilson, A. C., Mackintosh, K., Power, K. *et al.* (2019). Effectiveness of Self-Compassion Related Therapies: a Systematic Review and Meta-analysis. *Mindfulness* 10, 979–995. <https://doi.org/10.1007/s12671-018-1037-6>
100. Zeidan, F., Baumgartner, J. N., & Coghill, R. C. (2019). The neural mechanisms of mindfulness-based pain relief: a functional magnetic resonance imaging-based review and primer. *Pain reports*, 4(4), e759. <https://doi.org/10.1097/PR9.0000000000000759>
101. Zeidan, F., Adler-Neal, A. L., Wells, R. E., Stagnaro, E., May, L. M., Eisenach, J. C., McHaffie, J. G., Coghill, R. C. (2016). Mindfulness-meditation-based pain relief is not mediated by endogenous opioids. *J Neurosci Off J Soc Neurosci* 2016, 36:3391–3397.
102. Ziadni, M. S., Sturgeon, J. A., Darnall, B. D. (2018). The relationship between negative metacognitive thoughts, pain catastrophizing and adjustment to chronic pain. *Eur J Pain* 22(4):756–762. doi:10.1002/ejp.1160
103. Zorn, J., Abdoun, O., Bouet, R., Lutz, A. (2020a). Mindfulness meditation is related to sensory-affective uncoupling of pain in trained novice and expert practitioners. *Eur J Pain* 00:1–13. <https://doi.org/10.1002/ejp.1576>
104. Zorn, J., Abdoun, O., Sonié, S., Lutz, A. (2020b). Cognitive defusion is a core cognitive mechanism for the sensory-affective uncoupling of pain during mindfulness meditation. *Psychosomatic Medecine*. In print.