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1 Running Head: Meditation and Self-Location

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Changes in Self-Location During the Practice of Mindfulness Meditation in Novices

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Abstract

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Objectives: We investigated the effect of mindfulness meditation on self-location in novices. We mainly hypothesized that meditation exercises tend to redirect where individuals locate themselves toward the body area of attention during practice.

Methods: Participants were randomly assigned to either a body scan meditation, a breathing meditation, or an active control condition and completed a brief practice (Study 1: $n = 87$; Study 2: $n = 92$; Study 3: $n = 127$). Participants in Study 1 also received a 1-week training before the practice. All measures were assessed by means of self-report measures using visual analog scales.

Results: Brief meditation practice significantly changed self-location. Body scan practice was associated with an increase in self-location to the upper-torso, the abdomen and body limbs. The practice of breathing meditation increased self-location to the upper-torso and the abdomen. This change in self-location was associated with an increase in happiness only in the body scan meditation (Study 1). A decrease in ongoing thoughts during body scan meditation (i.e. narrative self) mediated the effect of practice on the reduction of self-location in the head (Study 2). Study 3 found that attention directed to targeted body areas during mindfulness meditation practice significantly mediated the effect of the practice on self-location in those same body areas.

Conclusions: These results support the hypothesis that a brief meditation practice modifies both narrative and minimal self in novices, and that self-location is related to the object of attention during the practice of meditation.

Trial Registration: This study is not preregistered.

Keywords: mindfulness meditation, self-consciousness, minimal self, narrative self, self-location, directed attention.

58 **Changes in Self-Location During the Practice of Mindfulness Meditation in Novices**

59 Research examining the effects of mindfulness meditation on self-consciousness is in its
60 infancy (Desbordes, 2019). Some studies suggest that meditation practice changes self-related
61 processes at both the bodily and conceptual levels (e.g. Britton et al., 2021; Dambrun et al.,
62 2019). Research on self-consciousness distinguishes the minimal self from the narrative self.
63 The latter refers to explicit autobiographical memory, implying the construction of an identity
64 which extends over time and offers a coherent image of the self with a past, present and future
65 (Gallagher, 2000). It involves self-related future and past cognitions (i.e. extended
66 consciousness; Berkovich-Ohana & Glicksohn, 2014). It is a self that involves a conceptual
67 mental activity. On the other hand, the minimal self refers to the self as "I", the subjective
68 knower, the pre-reflective experience of the self (i.e. core consciousness). It is a self as an
69 immediate experience without extension in time. It involves self-referential sensorimotor
70 experiences, such as a specific spatial perspective rooted in the body, a sense of agency, and a
71 sense of ownership (Blanke, 2012). The minimal self is phenomenologically linked to the
72 body; it is embodied.

73 Mindfulness meditation is an attentional training where focus is directed toward what is
74 manifested in the present-moment. Mindfulness is “the awareness that emerges through
75 paying attention on purpose, in the present moment, and non-judgmentally to the unfolding of
76 experience moment by moment.” (Kabat-Zinn, 2003, p. 145). Research indicates that
77 meditation practice tends to attenuate components of the narrative self, such as repetitive
78 thoughts. For example, a brief meditation training significantly decreases mind wandering
79 (Mrazek et al., 2012), particularly the frequency of mental activities referring to the past and
80 the future (Dambrun et al., 2019). A meta-analysis on 8-week Mindfulness Based
81 Interventions (MBI) shows a significant decrease in negative repetitive thoughts (Gu et al.,
82 2015; see also Perestelo-Perez et al., 2017). More than just an attenuation of the narrative self

83 and self-related mental activities, the Consciousness State Space model (Berkovich-Ohana &
84 Glicksohn, 2014) proposes that mindfulness practice would lead to a transition from the
85 narrative self to the minimal self, the latter being more available to access awareness.

86 A qualitative study conducted by Droit-Volet and Dambrun (2018) with expert meditators
87 reveals a change in both the narrative and minimal self. During a deep meditative state, expert
88 meditators report changes in self-concept, mind-wandering, sense of body ownership, sense of
89 agency, but also self-location. More specifically, they report (i) a reduction or extinction of
90 their personal identity, (ii) a reduction or extinction of thoughts, (iii) they perceive their body
91 as autonomous and functioning independently of their will, (iv) a decrease in identification
92 with their body, and (v) difficulty to locate themselves. While self-location usually regroups
93 head and upper torso (Alsmith & Longo, 2014), in deep meditative state no specific body part
94 is mentioned. This relates to the loss of a sense of authorship and an absence of self-location
95 as reported in previous literature (Ataria et al., 2015). In expert meditators, such alterations
96 are associated with neurophysiological changes. Deep meditative states tend to decrease
97 activity in brain regions related to the narrative self (i.e. DMN; e.g. MPFC), or the minimal
98 self (e.g. Inferior parietal lobule; Dor-Ziderman et al., 2013; Farb et al., 2007).

99 In novices, some evidence also suggests that self-related phenomena are modified during
100 meditation practice. For example, they report less salient body boundaries (Dambrun, 2016),
101 which favors a perception of self-extension (Hanley et al., 2020). Other research with novices
102 also suggests significant changes in body sensations, sometimes with sensations of
103 disappearance of certain body parts during body scan meditation (Dambrun et al., 2019).
104 However, to our knowledge, few studies directly addressed quantitatively the effect of
105 meditation practice on this type of phenomenon in novices.

106 Self-location, the experience of being a body with a given location in the environment
107 (Serino et al., 2013), is a key aspect of the minimal self, along with self-identification and

108 first-person perspective (Blanke, 2012; Blanke & Metzinger, 2009). The location of the self is
109 typically experienced within the physical confines of the body (Alsmith & Longo, 2014), but
110 it can be modified under a variety of conditions. Out-of-body experiences refer to the
111 sensations of being located outside the physical body (i.e. disembodied self-location; e.g.
112 Blake et al., 2004). Using virtual reality or robotic technology, a shift in the perceived self-
113 location toward the location of the virtual body has been documented (e.g. Ionta et al, 2011;
114 Nakul et al., 2022). Thus, self-location appears to be relatively flexible and we propose that it
115 can change substantially during meditation practice.

116 It has been found that self-location judgements are mainly distributed on two body regions:
117 the upper face and the upper torso (Alsmith & Longo, 2014). One can expect mind-wandering
118 like experiences to be associated to self-location in the head. Such experiences are
119 antagonistic with the “extrinsic” system involving sensory-motor networks (e.g. Fox et al.,
120 2005; Tian et al., 2007). Thus, the bodily self is less available to access awareness when
121 inward-oriented networks (i.e. “intrinsic” or DMN) are activated. On the other hand, during
122 the practice of meditations such as body scan or breathing meditation, attention is deliberately
123 directed to parts of the body. For example, breath meditation involves directing attention to
124 the upper torso, the abdomen, the nose, the mouth, where the breath is felt. In body scan
125 meditation, attention is guided toward different parts of the body (e.g. legs, feet, etc.) and then
126 the whole body. This type of meditation has already been shown to increase body awareness
127 (Farb et al., 2015; Hölzel et al., 2011).

128 In this research, we propose three studies that experimentally test the effect of different
129 meditation practices on self-location. We suggested that during the practice of body scan or
130 breathing meditation, the part most available to access awareness would be the one where
131 attention is directed. Thus, we predicted that the location of the self would follow the object
132 of attention. We tested this main prediction in three studies. In a first study we tested the

133 prediction that meditation should lead to a location of the self not only to the head, but also to
134 other parts of the body that are mobilized during practice; the main breath zones (i.e. upper
135 torso, abdomen) in breathing meditation and any part of the body in body scan meditation.
136 Study 1 also considered the relationships between change in self-location during meditation
137 and change in happiness, as alteration of the self during meditation has been found associated
138 with increased happiness (Dambrun, 2016; Dambrun & al., 2019). In a second study, we
139 considered a potential underlying process of change in self-location. If self-location reflects,
140 at least partly, what is available to access awareness, then a reduction in thoughts (i.e.
141 narrative self) during meditation should be associated with a reduction in self-location to the
142 head (and an increase in self-location toward the object of attention during practice). Finally,
143 Study 3 investigated more directly the role of directed attention to the body during
144 mindfulness practice and tested its mediating role in the effect of mindfulness practice on self-
145 location.

146 **Study 1**

147 **Method**

148 *Participants*

149 Eighty-seven participants composed the sample (81 women and 6 men; $M_{\text{age}} = 19.4$, $SD =$
150 1.04). All participants were undergraduate psychology students at the University of Clermont
151 Auvergne (UCA, France) and received course credit for their participation. Among
152 participants, 10 had already practiced meditation at least once. Since this variable did not
153 influence the results, it was not included in the statistical analyses. Participants signed a
154 formal agreement before taking part in this experiment approved by a French ethical
155 committee (RCB: 2019-A03312-55).

156 *Procedure*

157 Participants started with a week of training and then came to the lab for a 30-minute
158 practice session. Participants were randomly assigned to one of three experimental conditions:
159 body scan meditation, breathing meditation, and active control (i.e. listening to poems). Those
160 in the body scan condition trained for one week to do this practice and then came to the lab to
161 perform a 30-minute body scan session. In the breathing meditation condition, the procedure
162 was identical, the only variation being that the practice was focused on breathing meditation.
163 In the active control condition, participants practiced listening to poems for a week and then
164 came to the lab to listen poems for a session of 30 minutes. Thus, all participants performed a
165 1-week training (i.e. meditation or listening to poems). Once this training was completed, they
166 were invited to come and do a 30-minute practice session in the laboratory (i.e. meditation or
167 listening to poems).

168 Before starting the training week, the participants were received by an experimenter at the
169 lab to complete the first questionnaire (T1) after a 5-min rest period, lying on a mat with their
170 eyes closed. Then they received the instructions and the material. Specifically, participants
171 received on a USB stick a recorded 11-min guided exercise (i.e. body scan exercise, breathing
172 exercise, or listening to poems) to perform each day at home. In both meditation conditions,
173 participants were asked to focus their attention on the different parts of the body (i.e., body
174 scan) or on the breath (breathing meditation). Those in the active control condition were
175 asked to listen to poems by Jacques Prévert (Droit-Volet et al., 2018, 2019; S1 in
176 Supplementary Materials). Participants had to perform the training at home, lying on their
177 backs with their eyes closed, once a day, every day, for a full week. After each daily training,
178 participants fill-in a short follow-up notebook. Out of seven, participants completed an
179 average of 5.89 ($SD = 0.99$) training exercises in the active control condition, 6.28 ($SD =$
180 0.84) in the body scan condition, and 6.23 ($SD = 0.82$) in the breathing condition. There was
181 no significant difference between conditions ($F = 1.60, p < .21$).

182 One week later, at the end of the training week, the participants returned to the laboratory
183 for a 30-min practice session. Again, this session began with a 5-min rest period, lying on a
184 mat with their eyes closed. Participants then completed the second questionnaire (T2) before
185 returning to the mat for a 30-min practice (i.e., body scan, breathing, or poems). At the end of
186 this practice, participants completed the questionnaire a third time (T3). Finally, participants
187 were invited to take part in another and distinct study using a cognitive task on a computer.
188 All participants completed self-report scales (questionnaire) at three different times, and each
189 after a period of quiet lying on a floor mat, i.e. under comparable situations (Dambrun et al.,
190 2019).

191 *Measures*

192 Participants were asked to complete self-report scales at three different times: before the
193 training session (T1), after the 1-week training session (i.e., just before the laboratory session;
194 T2), and after the 30-min practice session (T3). These self-report scales targeted both (i) self-
195 location while lying on the mat and (ii) current level of happiness. The order of presentation
196 was counterbalanced. Participants also completed additional scales that are reported
197 elsewhere (Juneau et al., 2021).

198 **(i) Self-Location.** Participants were asked to indicate where they were located during the
199 time they were lying down at rest. They were asked to evaluate several proposals using a
200 visual analog scale from 0 (no, not at all) to 14 (yes, totally) centimeters. The proposals were
201 as follows: head, upper-torso/chest, abdomen, arms/hands, and legs/feet. Higher scores
202 indicated greater self-location in the concerned body area.

203 **(ii) Happiness.** Happiness was assessed using the Subjective Authentic-Durable Happiness
204 Scale (SA-HDS; Dambrun et al., 2012). Participants had to indicate their current feeling of
205 happiness by responding to 13 items (e.g. happiness, inner-peace) using a visual analog scale.
206 A single composite score was computed by averaging responses to the 13 items. Composite

207 scores can range from 0 (very low) to 14 (very high) centimeters. Higher scores indicated
208 higher levels of subjective state happiness. The reliability of the scale was satisfactory (T1: α
209 = 0.96 and $\omega = 0.97$; T2: $\alpha = 0.97$ and $\omega = 0.98$; T3: $\alpha = 0.98$ and $\omega = 0.98$).

210 *Data Analyses*

211 First, a power analysis was conducted using G*Power 3.1 (i.e. “F-tests”; “Repeated
212 measures, within-between interaction”, “corr. Among rep measure = 0.50). We specified three
213 groups, three measurements, and an alpha of 0.05. Second, a series of mixed-design ANOVA
214 (with Greenhouse-Geisser correction) and correlation analysis was performed using Jamovi
215 software (2.3.3). Specifically, an initial 3 (experimental conditions: body scan meditation vs.
216 breathing meditation vs. active control) x 5 (body areas: head, upper-torso, abdomen,
217 arms/hands, legs/feet) mixed-design was performed on the self-location scores for the
218 participants’ baseline, i.e., at T1. In a second step, we performed a 3 (experimental
219 conditions) x 5 (body areas) x 3 (time: T1, T2, T3) mixed-design ANOVA. In a third, step, we
220 conducted a 3 (experimental condition: body scan meditation vs. breathing meditation vs.
221 active control) x 3 (time: T1, T2, vs. T3) mixed-design ANOVA on the mean scores of
222 happiness was performed. Each time, we decomposed significant interaction effects. In each
223 case, we decomposed the significant effects by applying a Holm correction (Holm, 1979).
224 Finally, mediation analyses were performed using PROCESS 4.0 for SPSS (Hayes, 2017)
225 with the following specifications: model number 4, 5000 bootstrap samples and 95%
226 confidence intervals. We provided the standardized beta (β) of the relationships between the
227 variables and the unstandardized beta (b) for the direct and indirect effects.

228 **Results**

229 *Power analysis*

230 Based on the meta-analysis of the psychological effects of meditation (Sedlmeier et al.,
231 2012), which found a medium average effect on various dimensions, including self-concept, a

232 power analysis was conducted using a medium effect size ($\eta^2_p = 0.06; f = 0.25$). The results
233 showed a total sample of 51 participants was required to achieve a power of 0.95.

234 ***Base-line Self-Location***

235 This analysis only revealed a significant effect of body area ($F(3.24, 271.96) = 76.86, p <$
236 $0.001, \eta^2_p = 0.48$). Decomposition with a Holm correction (Holm, 1979) revealed that
237 participants located themselves significantly more to their head ($M = 11.31$) than to the upper-
238 torso ($M = 4.57; p_{\text{holm}} < 0.001$), abdomen ($M = 5.17; p_{\text{holm}} < 0.001$), arms/hands ($M = 4.62;$
239 $p_{\text{holm}} < 0.001$), and legs/feet ($M = 3.82; p_{\text{holm}} < 0.001$). They also located themselves
240 significantly more in their abdomen than in their legs/feet ($p_{\text{holm}} < 0.037$). See Figure 1a and
241 1b (Table S1 in Supplementary Materials).

242 ***Effect of meditation on self-location***

243 Figure 1a and 1b showed changes in self-location (see also Table S1 in Supplementary
244 Materials). As expected, the mixed-design ANOVA found a significant interaction between
245 experimental condition, time and body area ($F(12.29, 491.58) = 2.85, p < 0.001, \eta^2_p = 0.07$).
246 To decompose this significant interaction, we conducted an ANOVA on the mean self-
247 location score for each body part with the experimental conditions and the questionnaire times
248 as factors.

249 **Head.** The ANOVA on the self-location scores in the head showed neither effect of time
250 ($F(1.93, 158.07) = 1.48, p = 0.23, \eta^2_p = 0.02$), nor interaction between time and condition (F
251 $(3.86, 158.07) = 1.10, p = 0.35, \eta^2 = 0.03$).

252 **Upper-torso.** The same analysis for locating the self in the upper-torso revealed a
253 significant effect of time ($F(1.82, 149.29) = 12.23, p < 0.001, \eta^2_p = .13$), and a significant
254 time x condition interaction ($F(3.64, 149.29) = 5.35, p < 0.001, \eta^2_p = 0.12$). Therefore, we
255 tested the effect of the initial 1-week training (T1 to T2) and the direct effect of the 30-min
256 practice exercise (T2 to T3), by using a difference score between T2 and T1, and T3 and T2,

257 respectively. The effect of experimental condition was not statistically significant for the T2-
258 T1 score ($F(2, 84) = 2.57, p = 0.083, \eta^2_p = 0.06$). On the contrary, the effect of experimental
259 condition was significant for the T3-T2 score ($F(2, 82) = 6.08, p = 0.003, \eta^2_p = 0.129$). The
260 increase in upper-torso's self-location was significantly greater in the body scan condition (M
261 $= +3.15$) compared to the active control condition ($M = -0.10; t(82) = -3.48, p_{\text{holm}} = 0.002$,
262 Cohen's $d = 0.93$). Other comparisons were not significant.

263 **Abdomen.** For the self-location in the abdomen, there were both a significant effect of
264 time ($F(1.73, 141.68) = 8.96, p < 0.001, \eta^2_p = 0.10$), and a significant time x condition
265 interaction ($F(3.46, 141.68) = 3.06, p = 0.018, \eta^2_p = 0.07$). For the T2-T1 difference score,
266 there was no significant result ($F < 1$). However, for the T3-T2 score, there was a significant
267 effect of experimental condition ($F(2, 82) = 4.97, p = 0.009, \eta^2_p = 0.11$). The increase in
268 abdomen's self-location was greater in both body scan ($M = +2.76$) and breathing ($M = +2.22$)
269 conditions compared to the active control condition ($M = +0.05$; respectively, $t(82) = -2.99$,
270 $p_{\text{holm}} = 0.011$, Cohen's $d = 0.80$ and $t(82) = -2.40, p_{\text{holm}} = 0.037$, Cohen's $d = 0.64$). The body
271 scan and the breathing conditions did not differ significantly.

272 **Arms and hands.** There was also a significant effect of time ($F(1.81, 150.21) = 6.31, p =$
273 $0.002, \eta^2_p = 0.07$), and a significant time x condition interaction ($F(3.62, 150.21) = 3.33, p =$
274 $0.012, \eta^2_p = 0.07$) for the self-location in the arms and hands. As previously observed, no
275 effect was found for the T2-T1 ($F < 1$), and a significant effect emerged for the T3-T2
276 difference score ($F(2, 83) = 4.45, p = 0.015, \eta^2_p = 0.10$). The increase in self-location in both
277 arms and hands was greater in the body scan meditation condition ($M = +2.93$) compared to
278 the breathing meditation condition ($M = +0.13; t(83) = 2.90, p_{\text{holm}} = 0.014$, Cohen's $d = 0.76$)
279 and the active control condition ($M = +0.93; t(83) = -2.05, p_{\text{holm}} = 0.087$, Cohen's $d = 0.54$).

280 **Legs and feet.** For locating the self in the legs and feet, we found the same results with a
281 significant time effect ($F(1.94, 160.80) = 6.91, p < 0.001, \eta^2_p = 0.08$), and a significant time x

282 condition interaction ($F(3.87, 160.80) = 3.13, p = 0.016, \eta^2_p = 0.07$), and an effect that was
283 significant for the practice exercise (T3-T2) ($F(2, 83) = 4.30, p = 0.017, \eta^2_p = 0.094$) but not
284 the training (T2-T1) ($F < 1$). The increase in self-location in both legs and feet was greater in
285 the body scan meditation condition ($M = +2.75$) compared to the breathing meditation
286 condition ($M = -0.33; t(83) = 2.90, p_{\text{holm}} = 0.014, \text{Cohen's } d = 0.76$). There was no significant
287 difference in the active control condition ($M = +1.61$).

288 ***Happiness***

289 This analysis revealed a significant effect of time ($F(1.94, 160.62) = 8.67, p < 0.001, \eta^2_p =$
290 0.10), and a non-significant time x condition interaction ($F(3.87, 160.62) = 2.22, p = 0.071,$
291 $\eta^2_p = 0.05$). The results on the difference scores revealed no significant effect of both the 1-
292 week training ($F(2, 83) = 1.33, p < 0.27, \eta^2_p = 0.03$) and of the 30-min exercise ($F(2, 83) =$
293 $1.70, p < 0.189, \eta^2_p = 0.04$). Insofar as the effect of meditation practice on happiness has been
294 replicated several times in the literature, we checked that the lack of significant effect on this
295 variable was not due to the presence of extreme outliers, which can promote Type I and Type
296 II errors. It has been documented that their elimination can have a significant beneficial effect
297 (see Osborne & Overbay, 2004). To identify extreme outliers, an explore analysis by
298 experimental conditions was conducted. Extreme outliers were any score more than 3*IQR
299 (InterQuartile Range) from the rest of the scores. Specifically, regarding the change between
300 T1 and T2, participants number 1 (extremely high) and 24 (extremely low) were excluded
301 from the active control condition. Concerning the change between T2 and T3, participants
302 number 21 (extremely low) and 4 (extremely high) were excluded from the active control
303 condition, and participant number 30 (extremely low) was excluded from the body scan
304 condition. Once these four extreme outliers were excluded, the results on the difference scores
305 showed no effect of the 1-week training ($F(2, 81) = 1.56, p = 0.216, \eta^2_p = 0.04$), and a
306 significant effect of the 30-min exercise ($F(2, 80) = 5.35, p = 0.007, \eta^2_p = 0.12$). The increase

307 in happiness was greater in the body scan condition ($M = +1.43$) than in the active control
308 condition ($M = +0.10$; $t(80) = -3.27$, $p_{\text{holm}} = 0.005$, Cohen's $d = 0.90$). Other differences were
309 not significant.

310 *Relationships between Change in Self-Location and Change in Happiness during the 30-* 311 *min Practice*

312 We computed Pearson correlation between the change scores in self-location and the
313 change scores in happiness during the 30-min practice (Figure S1 in Supplementary
314 Materials). The increase in happiness was positively and significantly related to an increase in
315 upper-torso's self-location ($r = 0.238$, $p < 0.032$), self-location in the arms/hands ($r = 0.264$, p
316 < 0.017) and legs/feet ($r = 0.278$, $p < 0.012$). In addition, increase in abdomen's self-location
317 was positively and significantly related to increase in upper-torso's ($r = 0.576$, $p < 0.001$),
318 arms/hands' ($r = 0.442$, $p < 0.001$), and legs/feet' self-location ($r = 0.374$, $p < 0.001$). The
319 increase in upper-torso self-location also was significantly related to the increase in
320 arms/hands' self-location ($r = 0.388$, $p < 0.001$). Finally, the increase in arms/hands' self-
321 location was positively related to the increase in legs/feet' self-location ($r = 0.655$, $p < 0.001$).

322 *Mediation analyses*

323 We tested the mediation model (i.e. body scan meditation \rightarrow increase in self-location in the
324 part of the body below the head \rightarrow increase in happiness) by following the procedure
325 advocated by Preacher and Hayes (2004).

326 We computed a composite score of change in self-location by averaging the scores of self-
327 location in torso, abdomen, arms/hands, and legs/feet. The head was not considered because
328 (i) the location in this area did not vary with condition, (ii) location in the head was not
329 significantly related to happiness, and (iii) it loaded on a distinct factor. A principal
330 component factor analysis with direct oblimin rotation on the difference scores between T2
331 and T3 with the five body areas was performed. This analysis disclosed two factors with

332 Eigenvalues greater than 1. The first factor accounted for 45.25% of the explained variance
333 and regrouped the following four body areas: upper-torso, abdomen, arms-hands, and legs-
334 feet (Eigenvalue = 2.29). The second factor accounted for 21.67% of the explained variance
335 and was composed of the head (Eigenvalue = 1.08). Because the increase in happiness during
336 the breathing meditation did not differ from the control condition, we based our mediation
337 model on a contrast comparing the body scan condition with the other two conditions (i.e.
338 body scan condition = +2; breathing meditation condition = -1; active control condition = -1).
339 Consistent with previous results, the increase in the composite score of self-location ($\beta = 0.36$,
340 $p < .001$) and in happiness ($\beta = 0.30$, $p < .006$) was significantly greater in the body scan
341 condition than in the two other conditions. As expected, the global change in self-location was
342 significantly and positively related to the increase in happiness ($r = 0.34$, $p < .002$). As
343 predicted, when change in self-location was statistically controlled for, the effect of body scan
344 meditation on change in happiness was no longer significant (direct effect: $b = 0.23$, $se =$
345 0.12 , $p = 0.06$; CI: -0.01; 0.47). This mediation was small but significant (indirect effect: $b =$
346 0.10 , $se = 0.06$; CI: 0.01; 0.26). The change in self-location significantly mediated the effect
347 of the body scan meditation on happiness. In addition, we found mixed support for the
348 reversed model in which happiness mediates the effect of the body scan on self-location. The
349 indirect effect was significant (indirect effect: $b = 0.16$, $se = 0.10$; CI: 0.02; 0.42). However,
350 when change in happiness was statistically controlled for, the effect of body scan meditation
351 on change in self-location still remained significant (direct effect: $b = 0.55$, $se = 0.22$, $p <$
352 0.02 ; CI: 0.12; 0.99).

353 **Discussion**

354
355 Study 1 revealed no significant effect of the one-week training on self-location when the
356 questionnaire was given one-week after the daily training. In contrast, there was an effect on
357 the self-location of a 30-min meditation exercise during the lab session. This suggests that the

358 change in the self-location with the meditation practice was the result of an immediate bodily
359 experience rather than “long-term” changes in the cognitive representation of self.

360 As regard to changes in the self-location, the practice of breath meditation leads to an
361 increase in self-location in the main areas involved in breathing (i.e. torso, abdomen), thus to
362 which attention is voluntarily directed during practice. Similar changes in self-location toward
363 torso and abdomen was observed following the practice of body scan meditation, but the
364 meditation effect extended to the limbs (e.g. legs, feet), i.e. at the periphery of the body. This
365 study reveals that self-location is very flexible and that meditation practice modifies it in a
366 substantial way. Therefore, it is not associated with a fixed body region.

367 Our study also showed that changes in self-location during meditation were associated
368 with changes in happiness. Indeed, when self-location was more important in different parts
369 of the body – excluding the head – happiness was increased. In addition, we found that, in the
370 body scan condition, the increase in happiness was mediated, in part, by an increase in self-
371 location in the abdomen, torso, and peripheral limbs, and we only found mixed support for the
372 reversed model. This seems consistent with research showing that practices, such as
373 mindfulness, which direct attention to the present moment via body awareness, promote
374 positive emotions and a state of well-being (e.g. Dambrun, 2016; 2019; van Geest et al.,
375 2021).

376 The aim of the next study was to replicate these effects observed in Study 1 while
377 removing the week of training. Indeed, the self-location changes were observed immediately
378 after a meditation exercise and not within our training session. However, the training session
379 might have affected performance on the testing session. In addition, we investigated one of
380 the potential explanatory processes: the reduction of the narrative self (i.e. self-related
381 thoughts) in favor of the bodily self. We predicted that the decrease in narrative self during
382 meditation practice should mediate the change in self-location.

Study 2

Method

Participants

The sample was composed of ninety-two undergraduate psychology students from University Clermont Auvergne (82 women and 10 men; $M_{\text{age}} = 19.6$, $SD = 1.58$), with 6 who had already practiced meditation at least once. Because this variable did not influence the results, it was not included in the statistical analyses. They all received course credit and signed a consent form to participate in this experiment approved by a French ethical committee (IRB 00011540-2020-10).

Procedure

The procedure was similar to that used in Study 1 except for the 1-week training before the testing session that was not present in that study and the duration of the practice session which was shorter. Participants were randomly assigned to one of three experimental conditions with a 21-min exercise in the laboratory: body scan meditation, breathing meditation, or active control (i.e. listening to a tale; S1 in Supplementary Materials). The session began with a 5-min rest period, lying on a mat with eyes closed, followed by the completion of the questionnaire (T1), and the 21-min exercise on the mat. At the end of this exercise, they completed the questionnaire for the second time (T2). As in Study 1, all the participants always completed the questionnaire after a similar period of lying on a floor mat, i.e. in comparable situations.

Measures

The questionnaire was composed of the (i) self-location scale while lying on the mat, but also of new scales assessing the (ii) frequency of thoughts, and (iii) the transition of self-location from the head to the whole body. We also assessed the sense of body ownership and agency, but they will be present elsewhere. The order of presentation was not

408 counterbalanced. The order was: frequency of thoughts, transition of self-location, perception
409 of body ownership and agency, and the same self-location scale as in Study 1.

410 **(i) Self-Location.** As in Study 1, participants were asked to indicate where they would say
411 they were located during the time they were lying down at rest. They were asked to evaluate 5
412 proposals (head, upper-torso/chest, abdomen, arms/hands, and legs/feet) by using a visual
413 analog scale ranging from 0 (no, not at all) to 93 (yes, totally) millimeters. Higher scores
414 indicated greater self-location in the concerned body area.

415 **(ii) Number of thoughts.** We developed a new measure to assess how busy participants
416 were with thoughts (Figure S2 in Supplementary Materials). The participants responded on a
417 continuous 150-millimeter line associated with 7 faces with a bubble containing more or less
418 thoughts. Scores ranged from 0 (very few thoughts) to 150 (a lot of thoughts).

419 **(iii) Self-location transition from the head to the rest of the body.** In this new scale
420 assessing the transition of self-location from the head to rest of the body, both the localization
421 in the head and the body were evoked in the same item (Figure S3 in Supplementary
422 Materials). Obviously, the head is a part of the body, but it symbolizes the seat of thought in
423 phenomenological terms. The participants rated their self-location transition from 0 “totally in
424 my body, not at all in my head” to 150 “totally in my head, not at all in my body” millimeters,
425 with "as much in my body as in my head" in the center.

426 *Data Analyses*

427 We followed the same statistical procedure as in Study 1 except that the power analysis
428 and the mixed-designed ANOVA (testing the effect of meditation of self-location) were
429 specified with two measurements (T1 and T2) instead of three.

430 **Results**

431 *Power analysis*

432 Based on the effect size of the 30-min practice exercise on self-location observed in Study
433 1 (i.e. $\eta^2_p =$ around 0.10; $f = 0.33$), a power analysis revealed that a total sample of 39
434 participants was required to achieve a power of 0.95.

435 ***Baseline self-location***

436 As in Study 1, the mixed-design ANOVA revealed a significant effect of body area on the
437 self-location score at T1 ($F(3.87, 344.42) = 72.04, p < 0.001, \eta^2_p = 0.45$). Participants located
438 themselves significantly more in the head ($M = 78.3$) than in the upper-torso ($M = 36.0; p_{\text{holm}} < 0.001$),
439 abdomen ($M = 37.9; p_{\text{holm}} < 0.001$), arms/hands ($M = 33.7; p_{\text{holm}} < 0.001$), and
440 legs/feet ($M = 28.0; p_{\text{holm}} < 0.001$). The self-location was also higher in their abdomen than in
441 their legs/feet ($p_{\text{holm}} < 0.013$). See Figure 2a and 2b (see also Table S2 in Supplementary
442 Materials).

443 ***Effect of meditation on Self-Location***

444 The mixed-design ANOVA with the experimental condition, the body area and the time
445 (T1 vs. T2) found a significant interaction between experimental condition, time and body
446 area ($F(7.39, 324.99) = 12.32, p < 0.001, \eta^2_p = 0.22$). Therefore, we analyzed the results for
447 each body part with a 3 (experimental condition) x 2 (time) ANOVA. Changes in self-
448 location are presented in Figure 2a and 2b (see also Table S2 in Supplementary Materials).

449 **Head.** The effect of time ($F(1.0, 89.0) = 23.33, p < 0.01, \eta^2_p < 0.21$) and time x condition
450 were significant ($F(2.0, 89.0) = 6.19, p = 0.003, \eta^2_p = 0.122$). The analyses on the T2-T1
451 difference score indicated that self-location in the head decreased significantly more in the
452 body scan condition ($M = -23.26$) than in the active control condition ($M = -1.65; t(89) = -$
453 $3.51, p_{\text{holm}} = 0.002, \text{Cohen's } d = 0.90$). The decrease in the breath meditation condition ($M = -$
454 11.40) did not differ from the two other conditions ($p > 0.10$).

455 **Upper-torso.** For locating the self in the upper-torso, there were also a time effect ($F(1.0,$
456 $89.0) = 10.22, p = 0.002, \eta^2_p < .10$), and a time x condition interaction ($F(2.0, 89.0) = 6.12, p$

457 = 0.003, $\eta^2_p = 0.12$). As indicated by the T2-T1 difference score, the increase in upper-torso's
458 self-location was significantly greater in both the body scan condition ($M = +19.40$) and the
459 breathing meditation condition ($M = +18.71$) than in the active control condition ($M = -5.95$;
460 respectively, $t(89) = 3.08$, $p_{\text{holm}} < 0.008$, Cohen's $d = 0.79$; and, $t(89) = 2.99$, $p_{\text{holm}} < 0.008$,
461 Cohen's $d = 0.77$).

462 **Abdomen.** The effect of time ($F(1.0, 89.0) = 13.6$, $p < 0.001$, $\eta^2_p = 0.13$), and the time x
463 condition interaction ($F(2.0, 89.0) = 18.5$, $p < 0.001$, $\eta^2_p = 0.29$) were also significant for
464 locating the self in the abdomen. Again, the increase in abdomen's self-location was greater in
465 both the body scan ($M = +24.2$) and the breathing ($M = +35.4$) conditions than in the active
466 control condition ($M = -18.1$; respectively, $t(89) = 4.58$, $p_{\text{holm}} < 0.001$, Cohen's $d = 1.17$; and
467 $t(89) = 5.78$, $p_{\text{holm}} < 0.001$, Cohen's $d = 1.48$).

468 **Arms and hands.** The results are similar for locating the self in the arms and hands:
469 significant time effect ($F(1.0, 88.0) = 7.69$, $p = 0.007$, $\eta^2_p < 0.08$), and time x condition
470 interaction ($F(2.0, 88.0) = 18.93$, $p < 0.001$, $\eta^2_p = 0.30$). The increase in self-location in both
471 arms and hands was greater in the body scan meditation condition ($M = +41.24$) compared to
472 the breathing meditation condition ($M = -0.34$; $t(88) = 4.71$, $p_{\text{holm}} < 0.001$, Cohen's $d = 1.20$)
473 and the active control condition ($M = -10.55$; $t(88) = 5.76$, $p_{\text{holm}} < 0.001$, Cohen's $d = 1.49$).

474 **Legs and feet.** Similarly, the time effect ($F(1.0, 89.0) = 19.2$, $p < 0.001$, $\eta^2_p = 0.18$), and
475 the time x condition interaction ($F(2.0, 89.0) = 15.6$, $p < 0.001$, $\eta^2_p = 0.26$) were significant.
476 The increase in self-location in both legs and feet was greater in the body scan meditation
477 condition ($M = +41.23$) than in the breathing meditation condition ($M = +4.37$; $t(89) = 4.48$,
478 $p_{\text{holm}} < 0.001$, Cohen's $d = 1.14$) and in the active control condition ($M = -1.15$; $t(89) = 5.11$,
479 $p_{\text{holm}} < 0.001$, Cohen's $d = 1.31$).

480 ***Number of thoughts***

481 The 3 x 2 mixed-design ANOVA on the scores of perceived number of thoughts revealed a
482 significant time effect ($F(1.0, 86.0) = 73.47, p < 0.001, \eta^2_p = 0.46$), and a significant time x
483 condition interaction ($F(2.0, 86.0) = 4.05, p = 0.021, \eta^2_p = 0.09$). The decrease in the number
484 of thoughts was greater in the body scan condition ($M = -51.4$) than in the breathing
485 meditation condition ($M = -22.7; t(86) = -2.82, p_{\text{holm}} < 0.018$, Cohen's $d = 0.73$; Figure 3). No
486 other differences were significant.

487 ***Self-location transition from the head to the rest of the body***

488 The analysis on the scores assessing self-location transition from the head to the rest of the
489 body also indicated a significant effect of time ($F(1.0, 89.0) = 11.7, p < 0.001, \eta^2_p = 0.12$), as
490 well as a significant time x condition interaction ($F(2.0, 89.0) = 14.6, p < 0.001, \eta^2_p = 0.25$).
491 The self-location transition from the head to the rest of the body was greater in both the body
492 scan ($M = -33.7$) and the breathing conditions ($M = -24.1; t(89) = -5.11, p_{\text{holm}} < 0.001$,
493 Cohen's $d = 1.31$) compared to the active control condition ($M = +16.6; t(89) = -4.13, p_{\text{holm}} <$
494 0.001 , Cohen's $d = 1.06$; Figure 4).

495 ***Relationships between change in self-location, change in the number of thoughts, and self-*** 496 ***location transition during the 21-min practice***

497 We computed Pearson correlation between the change in various scores during the 21-min
498 exercise (Figure S4 in Supplementary Materials). As expected, the increases in head's self-
499 location were negatively related to the increase in self-location in the upper-torso ($r = -0.25$),
500 the arms/hands ($r = -0.34$), the legs/feet ($r = -0.31$), the self-location transition to the body (r
501 $= -0.53$), and positively related to the increase in thoughts' frequency ($r = 0.41$). In addition,
502 increase in self-location transition from the head to the rest of the body was positively related
503 to the increase in self-location in the upper-torso ($r = 0.31$), the abdomen ($r = 0.34$), the
504 arms/hands ($r = 0.42$), and the legs/feet ($r = 0.43$). Decrease in thoughts' number was related
505 to an increase in self-location transition to the rest of the body ($r = -0.30$).

506 *Mediation analyses*

507 Because the number of thoughts during the breathing meditation did not differ from the
508 control condition, we based our mediation model on a contrast comparing the body scan
509 condition with the other two conditions (i.e. body scan meditation -> decrease in number of
510 thoughts -> change in self-location). We followed the same procedure as in Study 1.

511 We computed a mean score of change in self-location in the body (excluding the head) by
512 averaging the scores of self-location in torso, abdomen, arms/hands, and legs/feet. A contrast
513 was computed to test the effect of the body scan 21-min practice (i.e. body scan condition =
514 +2; breathing meditation condition = -1; active control condition = -1). Consistent with
515 previous results, the increase in torso, abdomen, arms/hands, and legs/feet self-location ($\beta =$
516 $0.46, p < .001$), the decrease in self-location in the head ($\beta = -0.31, p < .002$), and the decrease
517 in the number of thoughts ($\beta = -0.27, p < .01$) were significantly greater in the body scan
518 condition than in the two other conditions. As expected, the decrease in the number of
519 thoughts was negatively related to the global change in self-location (excluding the head; $r =$
520 $0.26, p < .015$) and positively related to the decrease in self-location in the head ($r = 0.41, p <$
521 $.001$). As predicted, when change in number of thoughts was statistically controlled for, the
522 effect of the body scan meditation on change in self-location in the head was no longer
523 significant (direct effect: $b = -3.46, se = 1.75, p = 0.051$; CI: -6.93; 0.018). This mediation
524 was significant (indirect effect: $b = -1.70, se = 0.72$; CI: -3.26; -0.42). The reduction in
525 number of thoughts significantly mediated the effect of the body scan meditation on decrease
526 of self-location in the head. However, the number of thoughts did not mediate the effect of the
527 body scan meditation on the increase in self-location in the rest of the body. The direct effect
528 was significant ($b = 9.17, se = 1.92, p < 0.001$; CI: 5.35; 12.99), and the indirect effect was
529 not significant ($b = 0.72, se = 0.54$; CI: -0.16; 1.96).

530 Finally, we also tested the model according to which the decrease in the number of
531 thoughts would mediate the effect of the body scan meditation on the transition from the head
532 to the rest of the body. When change in number of thoughts was statistically controlled for,
533 the effect of the body scan meditation on change in transition from the head to the rest of the
534 body still remained significant (direct effect: $b = 7.99$, $se = 3.16$, $p = 0.013$; CI: 1.700; 14.28;
535 total effect: $b = 9.87$, $se = 3.11$, $p = 0.002$; CI: 3.69; 16.05). This mediation was significant
536 (indirect effect: $b = 1.89$, $se = 1.14$; CI: 0.02; 4.43). The reduction in number of thoughts
537 significantly mediated the effect of the body scan meditation on increase in transition from the
538 head to the rest of the body.

539 **Discussion**

540
541 Study 2 replicates the results of Study 1 with larger effect sizes. There was a change in
542 self-location in both meditation conditions similar to what we observed in Study 1. In
543 addition, there was a decrease in self-location in the head in both breathing and body scan
544 meditations, which was greater in the body scan condition. This effect was not seen in Study
545 1.

546 These results are consistent with those obtained using the scale assessing more directly
547 self-location transition from the head to the rest of the body. However, they did not indicate
548 that participants no longer localized themselves in the head, but simply less in the head in
549 favor of the other parts of the body. As expected, this change in self-location was correlated
550 with a decrease in the number of thoughts. In addition, a greater reduction of thoughts during
551 meditation was linked to greater self-location transition from the head to the rest of the body.
552 However, the mediation analysis revealed that the decrease in thoughts mediated the
553 reduction of self-location in the head and the transition in the rest of the body, and not the
554 increase of self-location in the rest of the body, where another mechanism seems to be
555 involved.

556 Regarding self-location in other parts of the body, insofar as breath meditation and body
557 scan lead practitioners to focus their attention on their internal experiences, sensory
558 experiences of breathing, or other bodily sensations, the role of body awareness (e.g. Holzel et
559 al., 2011) and interoceptive awareness (e.g. Bornemann et al., 2015) should be investigated.
560 With this in mind, Study 3 was designed to examine the role of attention to internal body
561 experience. We therefore added a scale to the protocol to measure the areas of the body where
562 attention is directed during the practice, with the prediction that attention directed to a specific
563 area of the body would lead to an increase in self-location in that same area.

564 In studies 1 and 2, participants were asked where they located themselves without explicit
565 reference to the self (i.e., where do you locate yourself). In their study, Limanowski and
566 Hecht (2011) asked participants where "the self" (i.e., location of the "self"). However, the
567 self is an abstract object for individuals. We preferred not to mention the term "self" to avoid
568 participants activating a particular conception. However, it would be important to replicate
569 our findings with a procedure that activates a conception. We chose to use the term "Me" in
570 Study 3, which is less abstract than "self" in French.

571 **Study 3**

572 **Method**

573 *Participants*

574 The sample was composed of one hundred and twenty-seven undergraduate psychology
575 students from University Clermont Auvergne (113 women and 13 men; $M_{\text{age}} = 18.9$, $SD =$
576 1.8). They all received course credit and signed a consent form to participate in this
577 experiment approved by a French ethical committee (IRB00011540-2022-08).

578 *Procedure*

579 The procedure was similar to that of Study 2, with the exception that the audio tape
580 duration was shorter (11-minute instead of 21) and that they were no baseline questionnaire.

581 The experiment also was programmed remotely on Qualtrics with the same procedure. After
582 reading the information note and the consent form, participants were asked to listen to an
583 audio recording of the experimental induction for 11 minutes. At the end of the audio
584 recording, the participant was asked to answer a questionnaire to assess various constructs
585 including self-location and directed attention.

586 The participants were randomly assigned to a body scan meditation condition ($n = 42$), a
587 breathing meditation condition ($n = 42$), or a story condition ($n = 43$). During the practice,
588 participants were instructed to sit on a chair with their eyes closed and if possible with
589 headphones on. Unlike studies 1 and 2 where participants had to lie on the floor, in this study
590 the instructions for the audio tapes were adapted for listening/practicing in a sitting position.
591 In the body scan, participants were asked to focus their attention on the different parts of the
592 body sequentially. In the breathing meditation condition, the participants were asked to focus
593 their attention on their breathing (e.g. inhaling, exhaling). In the active listening control
594 condition, they listened to a 11-minute audio recording of a Hans Christian Andersen story
595 (i.e. “the snowman”). For further details, see S1 in Supplementary Materials.

596 *Measures*

597 The questionnaire was composed of the (i) self-location scale, and (ii) the directed
598 attention scale. The order of presentation of the self-location and attention measures was
599 automatically counterbalanced by Qualtrics, and the order of questions on each measure was
600 randomized.

601 **(i) Self-Location.** Participants were asked to indicate where they located their “Me” during
602 the time they were listening to the audio. They were asked to evaluate 5 proposals (head,
603 upper-torso/chest, abdomen, arms/hands, and legs/feet) by using a visual analog scale ranging
604 from 0 (no, not at all) to 10 (yes, totally). Higher scores indicated greater self-location in the
605 concerned body area.

606 **(ii) Directed attention.** We developed a new measure to assess how participants directed
607 their attention. Specifically, they were asked to indicate where their attention was directed
608 (i.e. where their mind was focused) while listening to the audio. They were asked to evaluate
609 5 proposals (head, upper-torso/chest, abdomen, arms/hands, and legs/feet) by using a visual
610 analog scale ranging from 0 (no, not at all) to 10 (yes, totally). Higher scores indicated greater
611 directed attention to the concerned body area.

612 *Data Analyses*

613 We followed the same statistical procedure as in Study 2.

614 **Results**

615 *Power analysis*

616 Based on the effect size of the 21-min practice exercise on self-location observed in Study
617 2 (i.e. minimum $\eta^2_p = 0.08$; Effect size $f = 0.294$), a power analysis was conducted. The
618 results indicated that a total sample of 48 participants was required to achieve a power of
619 0.95.

620 *Effect of meditation on self-location*

621 Figure 5 shows self-location as a function of the experimental condition (Table S3 in
622 Supplementary Materials). The effect of body areas was significant ($F(3.43, 425.73) = 56.33$,
623 $p < 0.001$, $\eta^2_p = 0.31$). Participants directed their attention preferentially to the head ($M =$
624 7.25 ; all $p_{holm} < 0.001$), followed equally by the upper-torso ($M = 5.40$) and the abdomen (M
625 $= 5.03$), and to a lesser extent (all $p_{holm} < 0.001$) to the Arms/hands ($M = 3.48$) and Legs/feet
626 ($M = 3.11$). The difference between these two areas was not significant ($p_{holm} > 0.10$). As
627 expected, the 3 (experimental conditions) x 5 (body areas) mixed-design ANOVA (with
628 Greenhouse-Geisser correction), found a significant interaction between experimental
629 condition and body area ($F(6.87, 425.73) = 6.76$, $p < 0.001$, $\eta^2_p = 0.10$). To decompose this

630 significant interaction, we conducted an ANOVA on the mean self-location score for each
631 body part separately with the experimental conditions as a factor.

632 **Head.** The ANOVA on the self-location scores in the head showed a non-significant effect
633 of condition ($F(2, 124) = 2.67, p = 0.073, \eta^2 = 0.04$).

634 **Upper-torso.** The same analysis for locating the self in the upper-torso revealed a
635 significant effect of condition ($F(2, 124) = 5.35, p < 0.001, \eta^2_p = 0.11$). Decomposition
636 indicated that self-location in the upper-torso was greater in the body scan meditation
637 condition ($M = 6.14$) and the breathing meditation condition ($M = 6.00$) compared to the
638 active control condition ($M = 4.07$; respectively, $t(124) = 3.56, p_{\text{holm}} = 0.002$, Cohen's $d =$
639 0.77 ; and $t(124) = 3.32, p_{\text{holm}} = 0.002$, Cohen's $d = 0.72$). The comparison between body-
640 scan and breathing conditions was not significant.

641 **Abdomen.** For the self-location in the abdomen, there also was a significant effect of
642 condition ($F(2, 124) = 15.0, p < 0.001, \eta^2_p = 0.20$). Self-location in the abdomen was greater
643 in the body scan meditation condition ($M = 5.26$) and the breathing meditation condition ($M =$
644 6.52) than in the active control condition ($M = 3.30$; respectively, $t(124) = 3.31, p_{\text{holm}} =$
645 0.002 , Cohen's $d = 0.72$; and $t(124) = 5.43, p_{\text{holm}} = 0.001$, Cohen's $d = 1.18$). In addition,
646 self-location in the abdomen was greater in the breathing meditation condition compared to
647 the body scan one ($t(124) = 2.12, p_{\text{holm}} = 0.04$, Cohen's $d = 0.46$).

648 **Arms and hands.** There was a non-significant effect of condition ($F(2, 124) = 2.38, p =$
649 $0.096, \eta^2_p = 0.04$) for the self-location in the arms and hands.

650 **Legs and feet.** For locating the self in the legs and feet, we found a significant effect of
651 condition ($F(2, 124) = 12.2, p < 0.001, \eta^2_p = 0.16$). Self-location in this body area was greater
652 in the body scan meditation condition ($M = 4.48$) than in the breathing meditation condition
653 ($M = 2.83$; $t(124) = 3.23, p_{\text{holm}} = 0.003$, Cohen's $d = 0.71$) and in the active control condition
654 ($M = 2.02$; $t(124) = 4.85, p_{\text{holm}} < 0.001$, Cohen's $d = 1.05$). There was no significant

655 difference between the breathing meditation and the active control conditions ($t(124) = 1.60$,
656 $p_{\text{holm}} = 0.11$).

657 *Effect of meditation on directed attention to the body*

658 Figure 5 showed directed attention as function of the experimental condition (Table S3 in
659 Supplementary Materials). The effect of body areas was significant ($F(3.24, 398.15) = 51.9$,
660 $p < 0.001$, $\eta^2_p = 0.30$). Participants directed their attention preferentially to the head ($M =$
661 7.21 ; all $p_{\text{holm}} < 0.001$), followed equally by the upper-torso ($M = 4.97$) and the abdomen (M
662 $= 4.94$), and to a lesser extent (all $p_{\text{holm}} < 0.001$) to the Arms/hands ($M = 3.51$) and Legs/feet
663 ($M = 3.00$). The difference between these two areas was not significant ($p_{\text{holm}} < 0.053$). As
664 expected, the 3 (experimental conditions) x 5 (body areas) mixed-design ANOVA, found a
665 significant interaction between experimental condition and body area ($F(6.47, 398.15) =$
666 12.4 , $p < 0.001$, $\eta^2_p = 0.17$). To decompose this significant interaction, we conducted an
667 ANOVA on the mean self-location score for each body part with the experimental conditions
668 as a factor.

669 **Head.** The ANOVA on directed attention to the head revealed a non-significant effect of
670 condition ($F(2, 124) = 1.95$, $p = 0.146$, $\eta^2 = 0.03$).

671 **Upper-torso.** The same analysis for directed attention to the upper-torso revealed a
672 significant effect of condition ($F(2, 124) = 21.7$, $p < 0.001$, $\eta^2_p = 0.26$). Decomposition
673 indicated that directed attention to the upper-torso was greater in the body scan meditation
674 condition ($M = 6.69$) and the breathing meditation condition ($M = 5.43$) than in the active
675 control condition ($M = 2.79$; respectively, $t(124) = 6.45$, $p_{\text{holm}} < 0.001$, Cohen's $d = 1.41$; and
676 $t(124) = 4.37$, $p_{\text{holm}} < 0.001$, Cohen's $d = 0.95$). The comparison between body-scan and
677 breathing conditions also was significant ($t(124) = 2.08$, $p_{\text{holm}} < 0.039$; Cohen's $d = 0.46$).

678 **Abdomen.** For directed attention to the abdomen, there also was a significant effect of
679 condition ($F(2, 124) = 33.5$, $p < 0.001$, $\eta^2_p = 0.35$). Directed attention to the abdomen was

680 greater in the body scan meditation condition ($M = 5.57$) and the breathing meditation
681 condition ($M = 6.88$) than in the active control condition ($M = 2.30$; respectively, $t(124) =$
682 5.66 , $p_{\text{holm}} < 0.001$, Cohen's $d = 1.23$; and $t(124) = 7.93$, $p_{\text{holm}} < 0.001$, Cohen's $d = 1.72$). In
683 addition, directed attention to this area was greater in the breathing meditation condition than
684 in the body scan one ($t(124) = 2.26$, $p_{\text{holm}} = 0.026$, Cohen's $d = 0.49$).

685 **Arms and hands.** There was a significant effect of condition ($F(2, 123) = 7.85$, $p < 0.001$,
686 $\eta^2_p = 0.11$) for the directed attention to the arms and hands. Directed attention to this area was
687 greater in the body scan meditation condition ($M = 4.81$) than in the breathing meditation
688 condition ($M = 2.64$) and the active control condition ($M = 3.07$; respectively, $t(123) = 3.74$,
689 $p_{\text{holm}} < 0.001$, Cohen's $d = 0.82$; and $t(123) = 3.00$, $p_{\text{holm}} = 0.007$, Cohen's $d = 0.65$). There
690 was no significant difference between the breathing meditation and the active control
691 conditions ($t(123) < 1$, $p_{\text{holm}} = 0.46$).

692 **Legs and feet.** For directed attention to the legs and feet, we found a significant effect of
693 condition ($F(2, 123) = 20.8$, $p < 0.001$, $\eta^2_p = 0.25$). Directed attention to this body area was
694 greater in the body scan meditation condition ($M = 4.81$) than in the breathing meditation
695 condition ($M = 2.24$; $t(123) = 5.26$, $p_{\text{holm}} < 0.001$, Cohen's $d = 1.15$) and in the active control
696 condition ($M = 1.95$; $t(123) = 5.85$, $p_{\text{holm}} < 0.001$, Cohen's $d = 1.28$). There was no
697 significant difference between the breathing meditation and the active control conditions (t
698 $(123) < 1$, $p_{\text{holm}} = 0.56$).

699 ***Relationships between self-location and directed attention***

700 We computed Pearson correlations between self-location and directed attention for each
701 body area. Both measures were strongly and positively correlated (i.e. head: $r = 0.64$, $p <$
702 0.001 ; upper-torso: $r = 0.73$, $p < 0.001$; abdomen: $r = 0.77$, $p < 0.001$; Arms/hands: $r = 0.70$, p
703 < 0.001 ; Legs/feet: $r = 0.77$, $p < 0.001$).

704 ***Mediation analyses***

705 We tested our predicted mediation model in which directed attention would mediate the
706 effect of the mindfulness practice on self-location using two contrasts depending of the body
707 area. For the upper-torso and the abdomen, that were significantly impacted by both body
708 scan and breathing meditations, we used the following contrast 1: body scan condition = +1;
709 breathing meditation condition = +1; active control condition = -2. Because only the body
710 scan meditation condition significantly impacted the “legs/feet” area in terms of both self-
711 location and directed attention, we used the following contrast 2: body scan condition = +2;
712 breathing meditation condition = -1; active control condition = -1.

713 As depicted in Table 1, whatever the body area, when directed attention was statistically
714 controlled for, the effect of the mindfulness meditation (i.e. contrast 1) or body scan
715 meditation (i.e. contrast 2) on self-location became non-significant (all direct effects became
716 non-significant while total effects were significant). In each case, the indirect effect was
717 significant providing evidence of a mediation. We also tested the reversed model in which
718 self-location would mediate the effect of mindfulness practice on directed attention. We also
719 found significant indirect effects, however, in each case, the direct effects still remained
720 strongly significant (see Table 1).

721 **Discussion**

722 Study 3 replicates the results of Study 1 and 2 with a new instruction regarding the self-
723 reported scale of self-location. Whereas in the first two studies, the instruction did not
724 explicitly refer to the concept of "self," in this study we chose to modify our instruction and
725 asked participants to locate their "Me". In French, the term "Me" is more common and less
726 abstract than the term "Self". The fact that the results are similar with this new instruction
727 seems to indicate that the latter does not have a significant impact, and when participants are
728 asked to locate themselves without explicit reference, they locate their "self/me".

729 The main contribution of Study 3 lies in the measurement of directed attention and the fact
730 that it covaries very strongly with self-location. As shown in Figure 5, the curves for self-
731 location and directed attention (as a function of body area and experimental condition) are
732 very similar. Correlation analyses confirm these initial results and reveal correlations with a
733 large size effect. Finally, the mediation analyses indicate that the data support the model that
734 directed attention mediates the effect of mindfulness practice on self-location. Therefore, self-
735 location seems to be closely related to the object of attention. As the latter is directly impacted
736 by certain meditation practices such as body scan or breathing meditation, self-location is then
737 directed towards these body regions.

738 **Mini-meta-analysis**

739 To help interpret the results as a whole, we performed a mini-meta-analysis of our three
740 studies on the effect of a practice of body scan meditation and breathing meditation on self-
741 location in different body parts (Table S4 and S5 in Supplementary Materials). We used
742 Hedges as a model estimator (with standardized mean difference). The breathing meditation
743 increased the self-location in the parts of the body related to the breath, where the practitioner
744 was invited to direct his/her attention during the practice (i.e. upper-torso and abdomen). The
745 effect was large in the case of the abdomen (Hedge's $g = 1.19$), and medium in the case of the
746 upper torso (Hedge's $g = 0.69$). The Q-test for heterogeneity (in these two body areas) was
747 not significant. In the body-scan meditation, all parts of the body are involved, the practitioner
748 being invited to pay attention sequentially to different parts of the body. Consistently, we
749 observe large increase in self-location within different areas of the body (i.e. upper-torso:
750 Hedge's $g = 0.81$; abdomen: Hedge's $g = 0.82$; arms-hands: Hedge's $g = 0.83$, and legs-feet:
751 Hedge's $g = 0.84$). The Q-test for heterogeneity was significant in the case of arms-hands and
752 legs-feet. Concerning the arms-hands area, Study 2 had a value larger than the two other
753 studies. This seems consistent with the fact that this was the body scan sequence where

754 participants were most invited to scan this area. Concerning the legs-feet area, Study 1 had a
755 value lower than the two other studies. It is difficult to explain this result insofar as the
756 different body scan sequences that we used did not differ concerning the scanning instructions
757 of this zone. Finally, regardless of the body scan exercise used, location in the head never
758 increased, but rather tended to decrease (Studies 2 and 3). The effect was small in size but
759 significant (Hedge's $g = -0.47$).

760 **General Discussion**

761 The main aim of this research was to examine the effect of mindfulness meditation on self-
762 location in novices. Results were consistent across our three studies. First, as in the literature,
763 participants' baseline self-location (T1; see Studies 1 and 2) was merely located in the head
764 and not so much in other parts of the body (e.g. Depraz et al., 2003; Limanowski & Hecht,
765 2011). Alsmith and Longo (2014) found that the upper torso area was the second preferred
766 area for self-location, which was not the case in the current studies. However, these authors
767 used a rather different methodology with a pointer, which may likely explain this difference.
768 Nevertheless, regardless of the methodology used, the head still stands out as the preferred
769 area.

770 In addition, our studies showed that the practice of body scan and breathing meditations
771 modified the location of the self. However, this seems a transitory and not a long-term effect.
772 Indeed, a one-week training session did not generate a significant change in the self-location
773 (Study 1), while a 30-minute (Study 1) and even 11-minute exercise (Study 3) immediately
774 change the self-location. Furthermore, as confirmed by the mini-meta-analysis, the bodily self-
775 location varied with the type of meditation exercise.

776 Our results on the changes in the awareness of the location of the self in the body raise the
777 question of what self-location really means and what is measured when an individual is asked
778 to locate his or her self? Of course, further studies are needed to tackle this question.

779 According to Limanowski and Hecht (2011), self-reported measures of self-location do not
780 measure true self-location, but rather individuals' subjective experience. Therefore, it is
781 important to question what underlies the subjective experience of self-location. In Study 2, the
782 frequency of thoughts correlated significantly with self-location. Specifically, the decrease in
783 ongoing thoughts during meditation practice was related to a decrease of self-location in the
784 head and an increase of self-location in the abdomen and the peripheral areas of the body at
785 least in the body scan meditation. In contrast, the participants were initially (T1) largely
786 engaged in thoughts and localized themselves in the head. Studies showed that individuals at
787 rest are often engaged in self-referential thoughts which is related to an increased neural
788 activity within the default mode network, and the medial prefrontal cortex, a brain area known
789 to support self-related experiences (e.g. autobiographical memory, imagination; Stawarczyk
790 & D'Argembeau, 2015; D'Argembeau, 2018). On the other hand, meditation practice has
791 been robustly linked both to activity in the dorsolateral prefrontal cortex, involved in the top-
792 down control of attention (i.e. DPFC; Fox et al., 2016), and in the insula (Fox et al., 2014;
793 2016), a region associated with awareness of inner body states (see Fox & Cahn, 2018 for a
794 review). In imagery studies, Farb et al. (2013) showed that one main component of a
795 mindfulness exercise is the development of interoceptive attention, i.e. increased bodily
796 sensations, as indicated by the altered functional connectivity between the DPFC and the
797 insula. This is entirely consistent with our results. Therefore, we can assume that the
798 mindfulness meditation decreases ongoing thoughts and increases interoceptive sensations as
799 indicated by the transfer reported by the participants of the self-location from the head to
800 other parts of the body. However, the area of body in the focus of attention depends on type of
801 meditation exercise, being not fixed but flexible.

802 Study 3 clearly reveals that self-location is oriented to the part of the body where attention
803 is directed during the practice. When the practice involves areas of the body such as the

804 upper-torso and abdomen (i.e. body scan or breathing meditation), the individual locates
805 himself in these parts. When the meditation involves peripheral areas of the body such as the
806 legs or feet, as is the case in body scan meditation, the self-location also goes into these parts.
807 It seems to follow irrevocably the attention and the area of the body on which it is focused.
808 This result is intriguing and raises questions. The nature of the self is a matter of debate in
809 psychological science and philosophy (e.g., Dambrun & Ricard, 2011; Varela et al., 1991).
810 Some approaches suggest that the self is inherently interdependent and impermanent (e.g.,
811 Varela et al., 1991). While it is generally accepted that a permanent, unified self is
812 unattainable (e.g., Bogen 1986; Sherrington, 1947), the existence of a transcendental self,
813 responsible for our sense of unity, may have been proposed (Kant, 1976). Our research
814 arguably indicates that participants do not find a permanent, unified self when asked to locate
815 themselves, and the fact that they locate themselves in an area of the body mobilized by their
816 attention (the head when thinking or listening, their abdomen when focusing on their
817 breathing) indicates that the experience of the self is underpinned, at least in part, by a
818 malleable location in the body, and by no means in a specific and unique seat.

819 **Limitations and Future Directions**

820 This research has several limitations. First, the participants were overwhelmingly of
821 French nationality, female, students, and novices in meditation, which limits the
822 generalizability of our results. Our studies should be replicated with more heterogeneous
823 samples. Second, the fact that several constructs were measured using multiple-item scales in
824 the same questionnaire may result in spurious effects due to the measurement instruments
825 rather than to the constructs being measured (Podsakoff et al., 2012). Third, our self-location
826 measure is relatively imprecise because it does not capture the exact body location. For
827 example, the torso is a fairly large area, which does not allow for any insight into whether or
828 not the heart was targeted by participants. However, this area has been judged relevant for

829 self-location (Alsmith & Longo, 2014; Limanowski & Hecht, 2011). Similarly, we did not
830 dissociate the arms from the hands, and the feet from the legs. This would require further
831 refinement. Replication with self-location on silhouettes, for example, would allow us to be
832 more precise and identify, for example, whether self-location overlaps with the path of the
833 breath during breath meditation practice.

834 In the two first studies, participants were asked where they located themselves without
835 explicit reference to the self. In their study, Limanowski and Hecht (2011) asked participants
836 where "the self" or "the phenomenal self" is located by explaining "the self" as the center of
837 phenomenal experience and found no effect on the location of self. However, the self is an
838 abstract object for individuals. Indeed, it is likely that the activation of a concept of the self
839 may lead more to the activation of beliefs (influenced by culture) than to immediate
840 experience. In Study 3, we changed our procedure by activating a conception (i.e., located
841 your "Me"), and observed very similar results. Although it would be necessary to compare
842 these two types of procedures more directly, these first data seem to indicate that they do not
843 generate different self-locations.

844 Of course, the changes in self-location that we observed in the body scan and breathing
845 meditation conditions do not allow us to infer that this can be generalized to other types of
846 meditation such as constructive or deconstructive meditation for example (Dahl et al., 2015).
847 Further research is needed.

848 Despite some limitations, our studies reveal that self-location is flexible and that the simple
849 practice of meditation session is sufficient to substantially modify it. What underlies self-
850 location needs to be further investigated. However, our results suggest that the mindfulness
851 meditation transfers the focus of self from head to other body parts, consistently to
852 development of an interoception attention.

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Declarations

Conflict of interest: Authors declare that they have no conflict of interest.

Ethical approval: All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. All studies were approved by the ethics committee of the University Clermont Auvergne.

Informed consent: Informed consent was obtained from all individual participants included in the studies.

Author Contributions: Michaël Dambrun: Conceptualization, Methodology, Software, Formal analysis, Investigation, Writing – Original Draft, Writing – Review & Editing, Visualization, Supervision, Project administration. Léa Martinon: Conceptualization, Writing – Original Draft, Writing – Review & Editing. Catherine Juneau: Investigation, Writing – Original Draft, Writing – Review & Editing. Sylvie Droit-Volet: Writing – Original Draft, Writing – Review & Editing. Maya Corman: Conceptualization, Writing – Original Draft. Pierre De Oliveira: Conceptualization, Validation, Formal analysis, Writing – Original Draft, Writing – Review & Editing. Nicolas Pellerin: Conceptualization, Validation, Formal analysis, Writing – Original Draft, Writing – Review & Editing.

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Table 1. Indirect, direct, and total effects of Predicted and Alternative Mediation Models (Study 3)

	Indirect effect	Direct effect	Total effect
<i>Predicted Model</i>			
Model 1:			
Contrast 1 -> Directed attention to Upper-torso -> Upper-torso self-location	$b = 0.70$ <i>CI: 0.43, 1.02</i>	$b = -0.01$ <i>CI: -0.28, 0.27</i>	$b = 0.70$ <i>CI: 0.37, 1.03</i>
Model 2:			
Contrast 1 -> Directed attention to abdomen -> Abdomen self-location	$b = 0.96$ <i>CI: 0.67, 1.29</i>	$b = -0.10$ <i>CI: -0.39, 0.19</i>	$b = 0.86$ <i>CI: 0.52, 1.21</i>
Model 3:			
Contrast 2 -> Directed attention to Legs/feet -> Legs/feet self-location	$b = 0.68$ <i>CI: 0.43, 0.93</i>	$b = 0.02$ <i>CI: -0.21, 0.26</i>	$b = 0.70$ <i>CI: 0.41, 0.99</i>
<i>Alternative Models</i>			
Alternative model 1:			
Contrast 1 -> Upper-torso self-location -> Directed attention to Upper-torso	$b = 0.50$ <i>CI: 0.23, 0.80</i>	$b = 0.59$ <i>CI: 0.31, 0.86</i>	$b = 1.09$ <i>CI: 0.74, 1.44</i>
Alternative model 2:			
Contrast 1 -> Abdomen self-location -> Directed attention to abdomen	$b = 0.60$ <i>CI: 0.35, 0.89</i>	$b = 0.70$ <i>CI: 0.45, 0.96</i>	$b = 1.31$ <i>CI: 0.97, 1.64</i>
Alternative model 3:			
Contrast 2 -> Legs/feet self-location -> Directed attention to Legs/feet ->	$b = 0.48$ <i>CI: 0.25, 0.74</i>	$b = 0.43$ <i>CI: 0.21, 0.64</i>	$b = 0.90$ <i>CI: 0.63, 1.18</i>

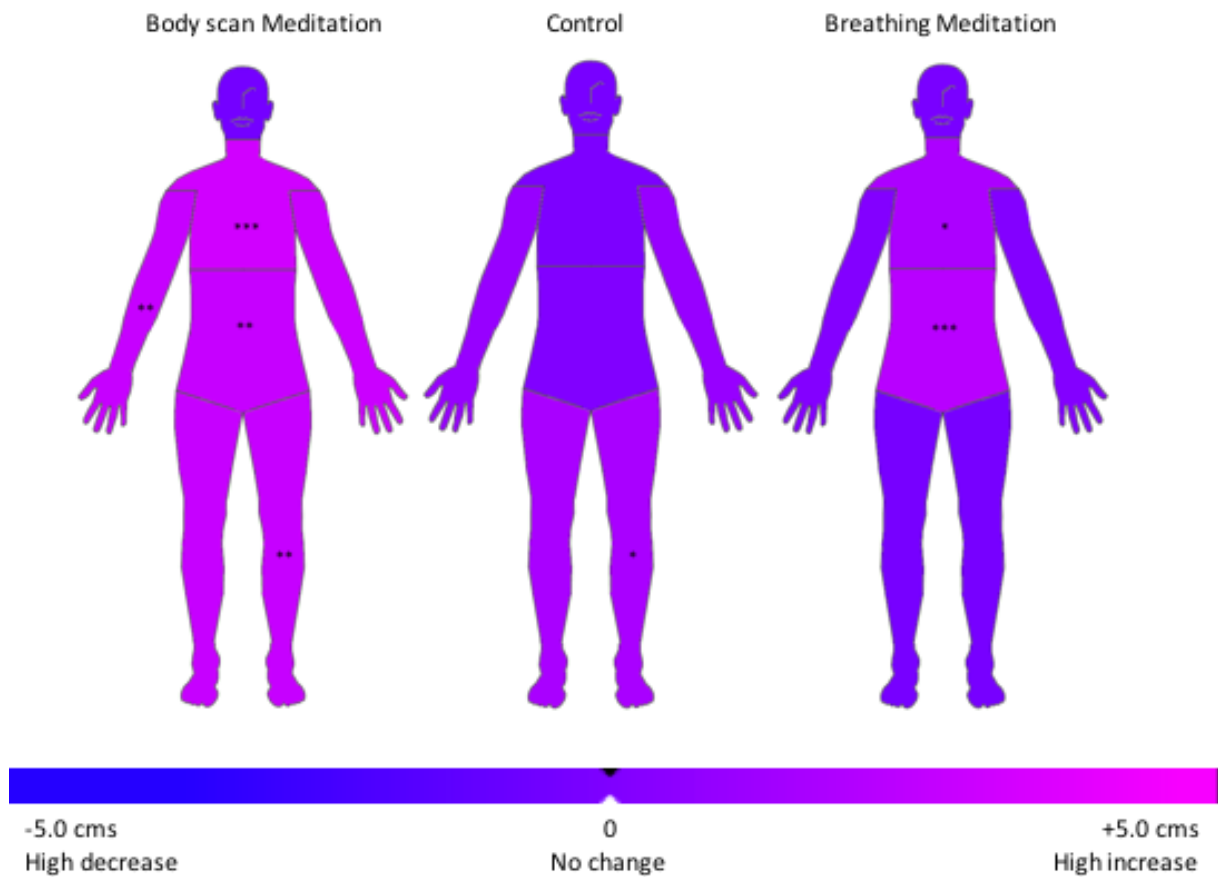
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Note: Contrast 1: Body Scan = 1; Breath meditation = 1; control = -2; Contrast 2: Body Scan = 2; Breath meditation = -1; control = -1. *b* = unstandardized beta coefficient; *CI* = 95% Confidence Interval (lower and upper bound).

Figure 1. Body map of the color gradient change in self-location during the 30-min practice as function of the experimental condition (a), means and confidence intervals (95%) of self-location as function of body area, time and experimental condition (b) (Study 1)

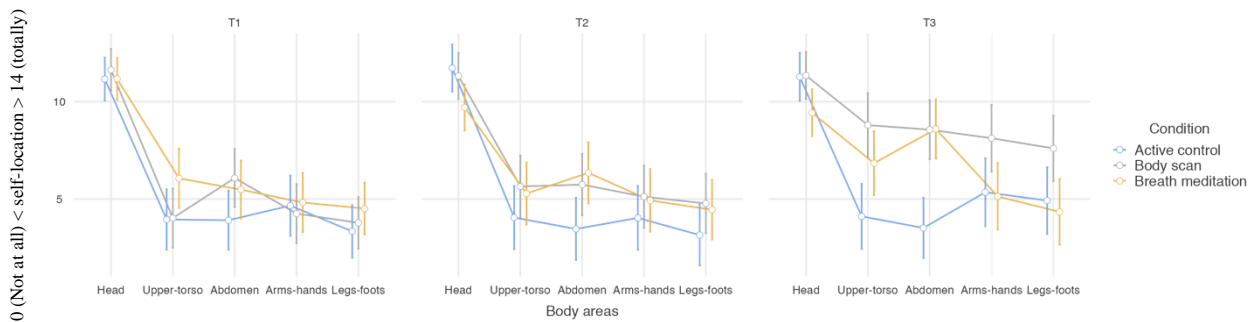
a.



*** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$

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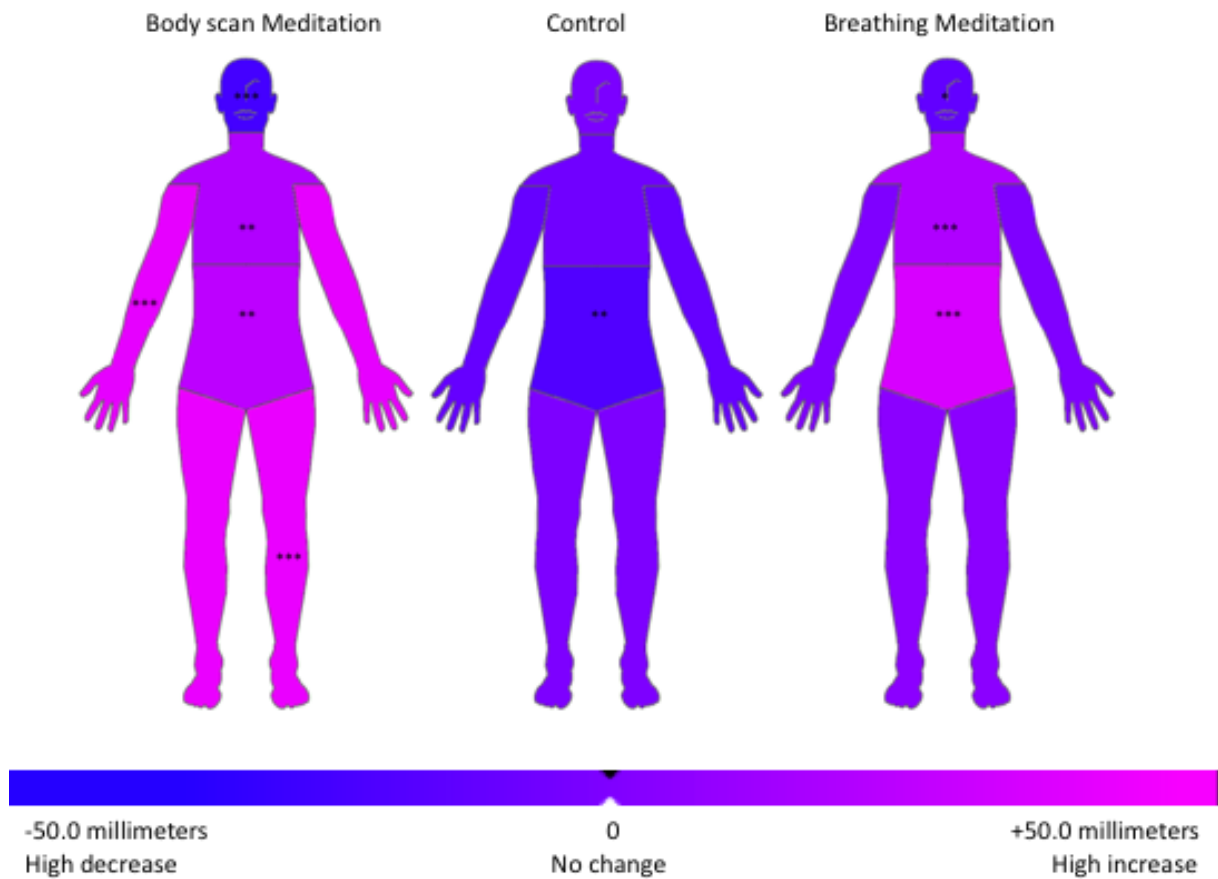


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Note: T1 = questionnaire completion after a 5-min rest period before the one-week training; T2: questionnaire completion after a 5-min rest period before the 30-minute lab practice session; T3: questionnaire completion at the end of the 30-minute lab practice session.

Figure 2. Body map of the color gradient change in self-location during the 21 minutes practice as function of the experimental condition (a), means and confidence intervals (95%) of self-location as function of body area, time and experimental condition (b) (Study 2)

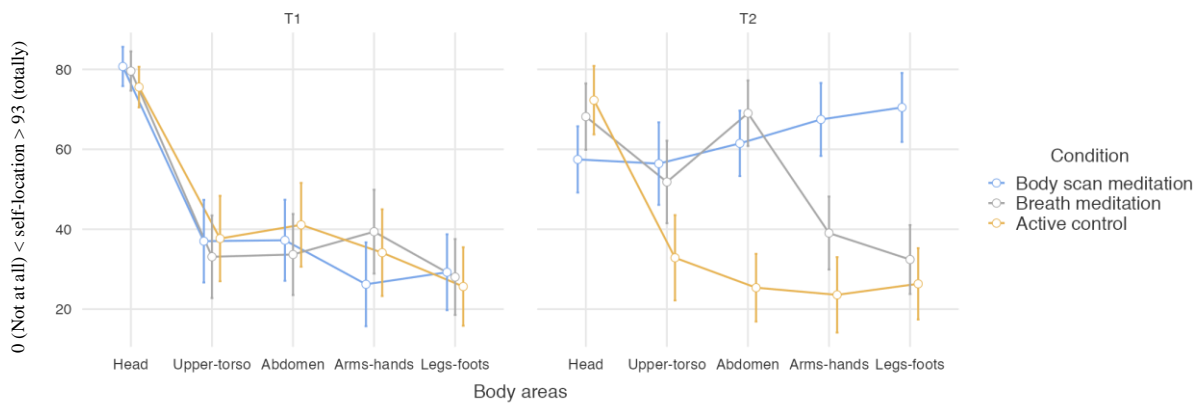
a



*** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$

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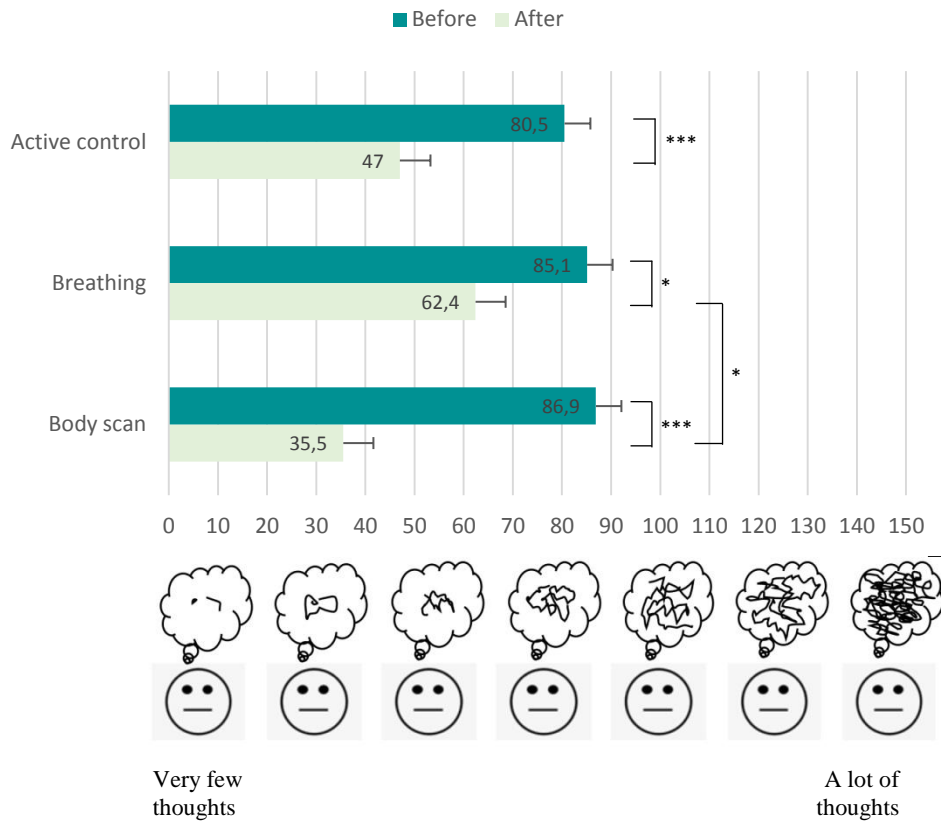
b.



Note: T1 = questionnaire completion at the beginning of the 21-minute lab practice session; T2: questionnaire completion at the end of the 21-minute lab practice session.

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Figure 3. Interaction between experimental condition (body scan meditation vs. breathing meditation vs. active control) and time (before vs. after the 21-minutes practice) on the perceived number of thoughts (group means and group standard error) (Study 2)



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Note: *** $p < 0.001$, * $p < 0.05$. A Holm correction was applied.

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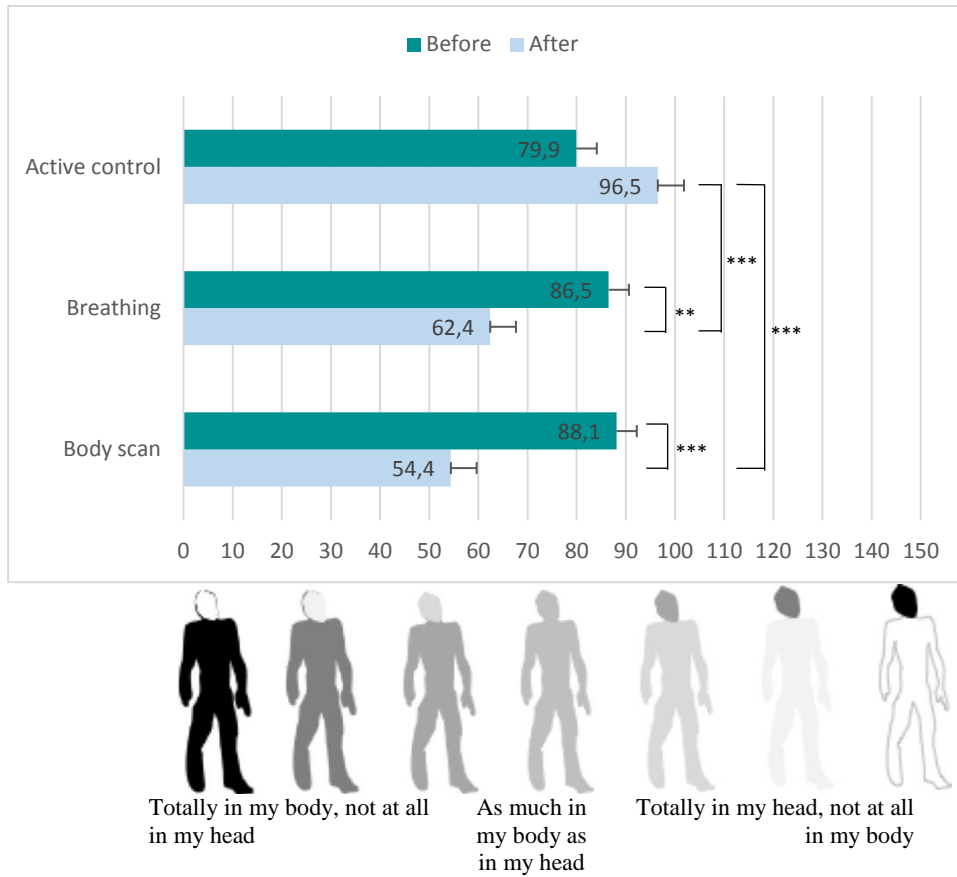
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Figure 4. Interaction between experimental condition (body scan meditation vs. breathing meditation vs. active control) and time (before vs. after the 21-minutes practice) on the measure of self-location transition from the head to the rest of the body (group means and group standard error) (Study 2)

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1159 Note: *** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$. A Holm correction was applied.

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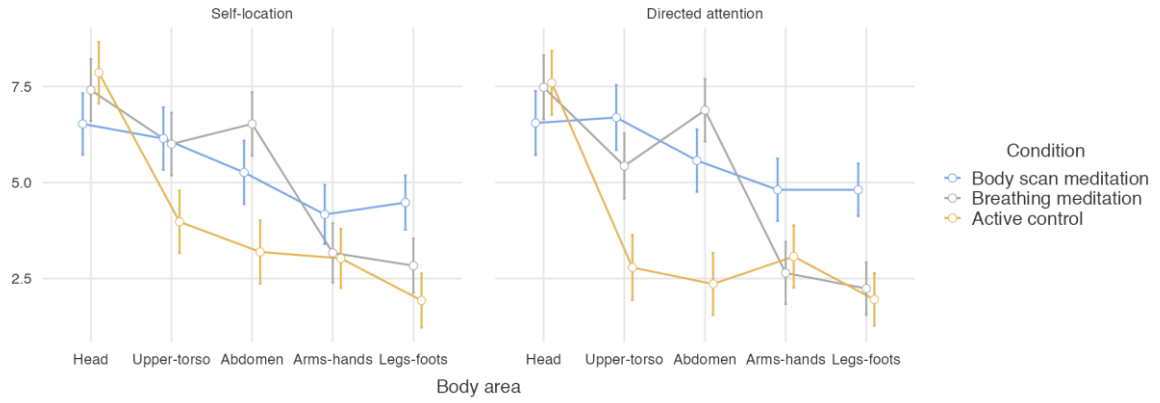
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1185 *Figure 5.* Means and confidence intervals (95%) of self-location and directed attention during the practice
 1186 session as function of body area and experimental condition (Study 3)
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if-location > 10 (totally)



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Note: T1 = questionnaire completion at the beginning of the 11-minute lab practice session; T2: questionnaire completion at the end of the 11-minute lab practice session.