



## Altered processing of self-related emotional stimuli in mindfulness meditators



J. Lutz<sup>a,b,\*</sup>, A.B. Brühl<sup>a,c</sup>, N. Doerig<sup>d,1</sup>, H. Scheerer<sup>a</sup>, R. Achermann<sup>e</sup>, A. Weibel<sup>d</sup>, L. Jäncke<sup>b</sup>, U. Herwig<sup>a,f</sup>

<sup>a</sup> Department of Psychiatry, Psychotherapy and Psychosomatics, Psychiatric Hospital, University of Zurich, Switzerland

<sup>b</sup> Division Neuropsychology, Department of Psychology, University of Zurich, Zurich, Switzerland

<sup>c</sup> Department of Psychiatry and Behavioural and Clinical Neuroscience Institute, University of Cambridge, Cambridge, Great Britain, UK

<sup>d</sup> Department of Psychology, University of Zurich, Zurich, Switzerland

<sup>e</sup> Psychological Methods, Evaluation and Statistics, Department of Psychology, University of Zurich, Zurich, Switzerland

<sup>f</sup> Clinic for Psychiatry and Psychotherapy III, University of Ulm, Ulm, Germany

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### ABSTRACT

Mental health benefits of mindfulness techniques are thought to involve changes in self-processing, such as decreased attachment to the self, higher self-compassion and lower emotional reactivity to inner experience. However, self-related emotion processing in regular mindfulness practitioners is not extensively studied. In the current work we investigate differential neural and behavioral correlates of self-criticism and self-praise in 22 mid-to-long-term mindfulness meditators (LTM) compared to 22 matched meditation-naïve participants (MNP). In an fMRI experiment, participants were presented with blocks of individually selected positive (self-praise, SP), negative (self-critical, SC), negative but not-self-critical (NNSC), and general, neutral (NT) adjectives, and reported their affective state after the blocks.

On the neural level, both SP and SC yielded more activation in the dorso-medial prefrontal cortex (DMPFC) in LTM compared to MNP. Activation in this region correlated positively with non-react scores of the Five Facets Mindfulness Questionnaire (FFMQ) and showed decreased functional connectivity to posterior midline and parietal regions in LTM compared to MNP during both self-related appraisals. Further, we found evidence for emotional reactivity in LTM on the neural level, particularly during SP. On the behavioral level, a mixed effects analysis revealed significantly higher differences in affective ratings after blocks of SC compared to SP in MNP compared to LTM.

Differences in DMPFC activation and affective ratings point towards increased awareness, potentially mindful regulation of SC and SP in LTM, while decreased connectivity to other regions of the default mode network could reflect a decreased self-focus in this group. As such, our results illustrate differences in self-related emotional processes in meditators and offer clinically relevant insights into mechanisms of mindful emotion regulation when facing self-criticism and self-praise.

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### Introduction

Self-related emotional processes are often disturbed in affective disorders. For example, depressed patients display a stronger and more negative self-focus (Greenberg and Pyszczynski, 1986; Joermann and Gotlib, 2010; Northoff, 2007) and increased rumination about negative aspects of the self (Nolen-Hoeksema et al., 2008), while excessive self-critical thinking represents a vulnerability factor to depressive symptoms (Sherry et al., 2012). Despite the fundamental role of such self-related processes for mental health, research has only started to investigate

disturbances of the self in affective disorders and possible mechanisms of change (Northoff, 2007).

At the same time, concepts like mindfulness and self-compassion have been increasingly incorporated into psychotherapy programs with the goal of facilitating healthier self-related processes (Baer et al., 2006; Keng et al., 2011). Mindfulness is often defined as *purposeful attention on momentary experiences in a non-judgemental way* (Brown et al., 2007; Kabat-Zinn, 1990). Such a mindful state can be trained through meditation techniques and is believed to ultimately increase mindful behavior in everyday life (Kiken et al., 2015), for example in the facets: *acting with awareness, non-judging and non-reacting* to inner experiences, *describing experiences, and observing* (Baer et al., 2006). In relation to self-referential processes, a mindful present-moment focus can lead to a less attached and biased relation towards the self (Bishop et al., 2004) and less concerns with self-esteem (Brown et al., 2007). Moreover, self-related emotions might be faced less judgmentally

\* Corresponding author at: Department of Psychiatry, Psychotherapy and Psychosomatics, Psychiatric Hospital, University of Zurich, Switzerland.

E-mail addresses: [jacqueline.lutz@puk.zh.ch](mailto:jacqueline.lutz@puk.zh.ch), [9luja9@gmail.com](mailto:9luja9@gmail.com) (J. Lutz).

<sup>1</sup> This person now works at: Clinical Center for Psychosomatics, Sanatorium Kilchberg, Zurich, Switzerland.

and in a more accepting (Linehan, 1994), self-compassionate way (Neff, 2003; Thompson and Waltz, 2008). Thus, mindfulness and self-compassion presumably lead to better emotion regulation skills with regards to self-related emotions, like dampening the negative effects of excessive self-critical thinking (Bishop et al., 2004; Hollis-Walker and Colosimo, 2011). Similarly, theoretical frameworks of mindfulness and neurobiological correlates propose changes in self-related functions as key mechanisms of salutary effects of mindfulness (Hölzel et al., 2011; Vago and Silbersweig, 2012).

Despite these proposed mechanisms and the clinical necessity to understand mindfulness related changes in self-related processes, research in this area is scarce, particularly regarding the neural level (Hölzel et al., 2011). One influential study on mindful self-referential processing after a mindfulness course found a shift from a narrative self-focus, associated with cortical mid-line areas like the dorso-medial prefrontal cortex (DMPFC) towards a more experiential body awareness (Farb et al., 2007). However, other studies report increases in mid-line areas related to mindfulness, as during mindful affect labeling (Creswell et al., 2007; Lieberman et al., 2007), mindful self-awareness (Herwig et al., 2010), and mindful perception of emotional stimuli in meditation-naïve participants (Lutz et al., 2014), and also in mindfulness meditators during mindful breathing (Hölzel et al., 2007).

Many studies on self-related processes contain a factor of decision making, i.e., participants judge whether a particular adjective describes themselves versus someone else (Northoff et al., 2006). Studying self-referential processes and particularly self-related emotions in this way involves decision making aspects, which arguably occur to a much lesser degree in every-day self-appraisals. A recent study therefore investigated negative and positive self-appraisals in the form of individual inner talk (Brühl et al., 2014). Both conditions activated the DMPFC and dorso-lateral prefrontal (DLPFC) regions, while positive appraisals showed stronger activations in emotion generative regions (amygdala/ventral striatum). This study, being close to every-day self-appraising thoughts, has high ecological validity, but the appraisals were not reported to the experimenters, thus the emotional involvement and relevance for the individual was not fully controlled. A study by Doerig et al. (2014), used self-critical stimuli that had been individually chosen and evaluated by each participant before a block-designed fMRI experiment. For self-critical stimuli, they reported neural activity in regions involved in emotion generation (anterior insula/hippocampus/amygdala formation), and bilateral frontal areas, presumably representing cognitive reappraisal of the evoked negative affect. They further reported activations in mid-line prefrontal areas for self-criticism. However, the study was limited to negative aspects of the self and no behavioral measure complemented the results.

The goal of the current study is to extend the clinically relevant but limited knowledge on mindful processing of self-related emotions. By extending Doerig et al. (2014)'s paradigm, we studied differential neural and behavioral correlates of individualized self-criticism (SC) and self-praise (SP) in meditators with experience in Vipassana and closely related mindfulness practices (Lutz et al., 2008) compared to matched meditation-naïve controls. We focused on the Vipassana tradition, because it influenced current secular, clinical programs like Mindfulness-Based Stress Reduction (MBSR) or Cognitive Therapy (MBCT) (Chiesa and Malinowski, 2011), and would potentially allow first translational insights into altered self-related emotional processes through mindfulness training.

We hypothesized that 1) mid-to-long-term, regular mindfulness meditators (LTM) would show decreased habitual emotional reactivity to emotional, self-referential stimuli (SC and SP) both by decreased activity in emotion processing areas (extended amygdala/hippocampus region) and/or differential affective experience based on affective ratings after blocks of SC and SP. Similarly, we hypothesized 2) differential activity in prefrontal, self-referential and regulative areas, mainly DLPFC and DMPFC regions. Given the mixed findings for prefrontal areas, we

formulated this hypothesis non-directional. In addition, we explored neural correlations with particular aspects of trait mindfulness and differences in the functional connectivity between LTM and MNP.

## Materials and methods

### Subjects

Mid-to-long-term meditation practitioners (LTM) were recruited via local meditation groups and personal contacts. We required meditators to have more than one year of meditation experience with at least one year of regular Vipassana training, Vipassana retreat experience and a current meditation practice of at least one hour per week. We included 22 LTM (ages: 28–67, *mean* = 47, *SD* = 11.11, 10 female) with an average of 4861.50 lifetime practice hours in Vipassana or closely related open monitoring meditation techniques (Lutz et al., 2008) (range 281–18,325), and an average of 5971 h (range 506–18,805) when considering all meditation experience in this group (see Supplementary Material for full disclosure of LTM's mindfulness related experience and current practice).

LTM were matched with 22 nearly or completely meditation-naïve participants (MNP, ages: 29–64, *mean* = 45.45, *SD* = 10.94, 8 female), recruited via mailing lists and personal contacts. For matching statistics see Supplementary Material, Tables 4 and 5. MNP did not have a current or recent meditation practice (Supplementary Material, Table 3). Matching variables were age, gender, years of education and highest degree of education, general field of occupation, and crystalline intelligence measured with Mehrfachwahl-Wortschatz-Intelligenztest (MWT-B, Lehrl, 1977).

All subjects were right-handed according to a handedness questionnaire (Annett, 1970) and without self-declared mental or neurological disorders. Further exclusion criteria were intake of psychotropic drugs, consumption of alcohol > 7 units/week, cigarettes > 10 units/day, or coffee (> 10 cups/day) (see Supplementary Material, Table 6 for characteristics of the sample) and general contraindications against MRI examinations.

The study was approved by the ethics committee of the canton of Zurich and conducted in compliance with the Declaration of Helsinki (World Medical Association, 1992). All participants gave written informed consent and received a financial compensation.

### Experimental design

#### Questionnaires

Within a week before scanning, participants completed a set of questionnaires via an online investigation tool (Unipark, QuestBack).

Of particular interest for this study were trait mindfulness and self-compassion. Mindfulness was assessed by the *Five Facets Mindfulness Questionnaire* (Baer et al. (2006), German version: Translation by Stroehle et al. (2010), KIMS-D-Items, 2010; Michalak et al. (2008)), with the facets: 1) observing and 2) describing sensations, perceptions, thoughts and feelings, 3) acting with awareness, 4) non-judging of, and 5) non-reactivity to inner experience. For self-compassion we administered the *Self-Compassion Scale* (Neff, 2003, German version: Hupfeld and Ruffieux, 2011).

Further, we assessed the ability to identify and describe emotions with the *Toronto Alexithymia Scale* (TAS, Taylor et al. (1985), German version: Bach et al. (1996)), participant's sociodemographics, and experience with meditation and mindfulness related techniques.

Before scanning we administered the *Positive and Negative Affect Schedule PANAS* (Watson et al., 1988, German version: Krohne et al., 1996) to control for mood before scanning. After scanning, participants were asked in a structured interview about fatigue, general experience, pain, and discomfort during scanning.

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