Embodied Cognition in Meditation, Yoga, and Ethics
An Experimental Single-Case Study on Differential Effects of Four Treatments

Karin Matko¹, Peter Sedlmeier¹, and Holger C. Bringmann^{2,3}

¹Chemnitz University of Technology

²Institute for Social Medicine, Epidemiology and Health Economics, Charité-
Universitätsmedizin, Berlin, Germany, corporate member of Freie Universität Berlin, Humboldt-
Universität zu Berlin, and Berlin Institute of Health

³Department of Psychiatry, Psychosomatics and Psychotherapy, Diakoniekliniken
Zschadrass, Colditz, Germany

This is a preprint. It has not yet
undergone peer-review.

Author note

Karin Matko <https://orcid.org/0000-0002-2410-4774>

Peter Sedlmeier <https://orcid.org/0000-0002-7998-6313>

Holger C. Bringmann <https://orcid.org/0000-0001-8503-862X>

We have no known conflict of interest to disclose. Data will be made openly available at the Open Science Framework (<https://osf.io/wnxk6/>). This trial is registered on clinicaltrials.gov (NCT04252976).

Correspondence concerning this article should be addressed to Karin Matko, Department of Psychology, Chemnitz University of Technology, 09107 Chemnitz, Germany, Email: karin.matko@psychologie.tu-chemnitz.de

Contributions: KM designed and executed the study, analyzed the data, and wrote the paper. PS collaborated on the study design and data analysis. HCB conceptualized and supervised the interventions and collaborated with the study design and data analysis. All authors worked on the final version of the manuscript.

Acknowledgments: We thank Christin Block and Felix Neuhaus for assisting in the execution of the study. We also acknowledge their and Annika Sternkopf's help in preparing and screening the data. Thank you to Philipp Kanske for giving us access to the central experiment server of the Dresden University of Technology.

Funding: This work was supported by Karl and Veronica Carstens Foundation under Grant Number KVC 0/098/2018.

Abstract

Yoga is an embodied contemplative practice entailing multiple components, such as ethical teachings, postures, breathing practices, and meditation. Little is known to date how these different components affect aspects of embodied cognition. This single-case multiple-baseline study explored the differential and incremental effects of four different combinations of yoga components on body awareness, emotion regulation, affectivity, self-compassion, and distress tolerance. Fifty-seven healthy participants with no regular yoga or meditation practice were randomly assigned to three baselines (7, 14, and 21 days) and four conditions: Mantra meditation alone (MA), meditation plus physical yoga (MY), meditation plus ethical education (ME), and meditation plus yoga and ethical education (MYE). All the interventions lasted for 8 weeks. Forty-two participants completed the treatment and were included in the analyses that involved visual inspection, effect size estimation, and multilevel modeling. All four treatments improved body awareness, emotion regulation, self-compassion, and distress tolerance to a similar extent. Body awareness and emotion regulation developed continuously and simultaneously over time. The MA condition had the least favorable effect on affective experience, while the ME condition enhanced valence the most and the MY condition was the most effective in preventing negative affective responses. Even though mantra meditation on its own negatively influenced daily affect, it can be assumed the driving force behind the improvement of the other variables. This points to the central role of meditation in increasing interoception, self-awareness and the processing of bodily and emotional stimuli.

Keywords: embodied cognition, yoga components, mantra meditation, differential effects, single-case research

Introduction

Theories on “embodiment” or “embodied cognition” assume a complex reciprocal relationship between bodily states, emotion, cognition, and behavior (Niedenthal et al., 2005; Varela et al., 2016; Winkielman et al., 2015). However, embodied cognition is not a uniform concept and theories differ regarding the processes it entails (Gallagher, 2011). Among the processes labeled as embodied are body awareness (Impett et al., 2006), emotion and affect (Niedenthal & Maringer, 2009), emotion regulation (Pollatos & Ferentzi, 2018), compassion (Khouri, 2019), and stress (Francis, 2018). Yoga and other mind-body practices have been proposed to target these processes and facilitate the integration of both bottom-up physiological and top-down cognitive processes (Francis & Beemer, 2019; Gard et al., 2014; Schmalzl et al., 2015). Thus, they might enhance practitioners’ experience of unity between the body and the self or of an “embodied self” (Mehling et al., 2011). Deficits or problems in emotion regulation, body awareness, or an embodied sense of self are associated with a variety of forms of psychopathology (Fuchs & Schlimme, 2009; Gross & Muñoz, 1995; Phillips et al., 2003). This also applies to two other embodied processes closely related to emotion regulation. Self-compassion and distress tolerance have been identified as important protective factors of mental health (MacBeth & Gumley, 2012; Zvolensky et al., 2011) and possible mediators of yoga interventions (Medina et al., 2015; Riley & Park, 2015). However, little is known about how exactly yoga works and which differential health benefit is associated with which yoga component.

Traditional yoga encompasses a multiplicity of components (Feuerstein, 2012) that have been proposed to contribute differentially to processes of (embodied) cognition. Gard et al. (2014) posited that the ethical component of yoga encourages the top-down initiation, monitoring, and maintenance of behavioral change, whereas postures, breathing regulation, and meditation stimulate top-down attentional control as well as bottom-up interoceptive processing. Schmalzl et al. (2015) delineated how the movement-related aspects of yoga positively influence the neurocircuitry involved in mind-body integration and self-regulation. Yogic breathing, on the other hand, improves autonomic regulation and executive functioning, and meditation increases interoceptive

and metacognitive awareness. However, there have been only few comparative or dismantling studies investigating explicitly how each of these components or their combinations work (Matko, Bringmann, et al., 2021). Specifically the ethical component of yoga has often been neglected in the past (Cramer et al., 2014). In addition, there is a scarcity of studies examining the differential effects of different yoga components on processes of embodied cognition, such as body awareness, affectivity, and emotion regulation.

Body awareness denotes the sensory awareness of bodily states, processes and actions including both proprioception (perception of self-movement and body position) and interoception (perception of internal bodily signals) (Mehling et al., 2009). It is closely related to feelings, emotions, and affectivity (Bechara & Naqvi, 2004; Damasio, 2006). Research has shown that effective emotion regulation is highly dependent on a person's ability to accurately detect and evaluate sensory information (Füstös et al., 2013; Price & Hooven, 2018; Sze et al., 2010). Emotion regulation can involve different regulatory strategies, such as suppression of expressive behavior, attentional control, cognitive reinterpretation (*reappraisal*), or reversal of stimulus-response associations (*extinction*) (Ochsner & Gross, 2005). Recently, Chambers et al. (2009) proposed that mindfulness practice might train another type of regulatory strategy, that is, nonreactively observing all emotions and refraining from any appraisal processes. Particularly this type of emotion regulation is closely related to body awareness. It remains unclear, though, how body awareness and emotion regulation develop over time and how they influence daily affective experience when a person engages in contemplative practices, such as yoga. Interestingly, emotion regulation was associated with top-down strategies (e.g., reappraisal) in novice meditators, but with bottom-up strategies (e.g., interoceptive awareness) in long-term meditators (Chiesa et al., 2013).

Regarding comparative studies, Park et al. (2017) contrasted a complex yoga intervention to a cognitive-behavioral stress-management course and found that only yoga improved interoceptive awareness and emotion regulation. Sauer-Zavala et al. (2013) juxtaposed the body scan, sitting meditation and physical yoga and found that all treatments improved self-compassion, but

the latter two were more effective in improving emotion regulation. Kok and Singer (2017) examined four different types of meditation and discovered that all practices enhanced positivity of affect, but the body scan led to the greatest state increase in interoceptive awareness. In a cross-sectional survey, yoga practitioners reported higher levels of body awareness compared to meditators, but both groups did not differ regarding emotion regulation (Daubenmier et al., 2012). For well-being, stress, depression, and anxiety, treatments combining several yoga components often yielded better results than simple treatments (Matko, Bringmann, et al., 2021). Still, it remains unclear which specific benefit can be attributed to which component, or which combination of practices might be the most helpful, specifically regarding processes related to embodied cognition. Thus, a detailed investigation of yoga components is imperative for advancing scientific research. Furthermore, this endeavor is valuable for developing programs tailored to the specific needs of respective clinical or healthy populations (Gard et al., 2012; Schmalzl et al., 2015).

Besides the lack of differentiation and systematic investigation, the methodological quality of yoga studies has often been poor (Cramer et al., 2013; Kinser & Robins, 2013). Dismantling or comparative studies employing mixed-methods and/or repeated measures, such as experience sampling or single-case research designs (Lindsay et al., 2018; May et al., 2014), provide a promising approach in this regard. Thus, in the present study we used a single-case multiple-baseline design to evaluate four different combinations of yoga components. The components were based on the new mind-body program Meditation-Based Lifestyle Modification (MBLM; Bringmann et al., 2020). We chose this design as it has strong internal validity and allows for a more detailed examination of individual responses and processes of change (Barlow et al., 2009). This makes it suitable for explorative research questions such as ours. With this, we hope to determine which combination of components might be particularly beneficial for improving body awareness, emotion regulation, affectivity, self-compassion, and distress tolerance in healthy participants.

From theory and the literature reviewed above, we assume differential effects for different combinations and stronger (incremental) effects for combined interventions. It seems plausible that both physical yoga and meditation, and specifically their combination, enhance our variables

of interest. The physical yoga component might even have a slightly bigger impact on body awareness than meditation alone. Ethical education, and specifically its combination with other practices, might be particularly beneficial for developing emotion regulatory skills (Menezes et al., 2015). However, as this field of investigation is relatively new and no other study has contrasted all of these different combinations before, we refrained from formulating predefined hypotheses and chose an exploratory approach instead. We combined quantitative and qualitative methods to explore interindividual differences, incremental differences between conditions, and interactions between our dependent variables.

Method

Procedure

We conducted an extensive single-case multiple-baseline study of the effects of different combinations of yoga practices on affectivity, body awareness, emotion regulation, distress tolerance, and self-compassion over the course of four different eight-week treatments. During baseline, participants engaged in their usual daily activities and received no treatment. The treatment conditions were mantra meditation alone (MA), mantra meditation plus physical Hatha yoga (MY), mantra meditation plus ethical education (ME), and mantra meditation plus physical yoga and ethical education (MYE). We randomized participants across these four conditions and across three baseline lengths (7, 14 or 21 days) using simple random sampling without replacement. Participants received daily online questionnaires throughout their entire baseline and treatment phases. Furthermore, they completed online questionnaires at pretest, posttest and follow-up (8 weeks and 12 months). A detailed breakdown of the study methods and the four treatments can be found in Matko et al. (2021).

Participants

Forty-two participants, 83% women, $M (SD)_{\text{age}} = 26.62 (8.37)$, were recruited from the Dresden general community through public and web-based advertising. Individuals were excluded from participation if they (1) had preexisting psychiatric conditions or acute psychological issues, (2) had a regular yoga or meditation practice during the last 6 months, (3)

were younger than 18 years, or (4) did not have daily access to web-enabled devices. Participation was voluntarily and all participants provided written consent to participate in the study. Participants were fully disclosed about the nature of the study prior to randomization and data collection, but could not choose or switch treatments. There was no financial or other compensation for participation in the study, but the opportunity to win one of ten €50 gift coupons. The institutional review board of the Chemnitz University of Technology approved the experimental protocol. We excluded two participants from the analysis of pre–post variables, but not the daily measurements, as they failed to respond at posttest and/or follow-up.

Treatment

All treatments were jointly led by HCB, an accredited psychiatrist and psychotherapist, and KM, a psychologist and certified yoga instructor with 700 hrs of teacher training. The length of the weekly sessions varied across conditions, but each condition included a group sharing at the beginning and end of each session as well as a 25-min silent (i.e., non-guided) mantra meditation practice. During the physical Hatha yoga practice, participants learned a set of simple yoga postures, simple breathing techniques, the sun salutation, and relaxation techniques. Ethical education followed the protocol developed for the MBLM mind–body program (Bringmann et al., 2020), introducing and discussing a new topic of the yogic *yamas* and *niyamas* each week. We asked all participants to practice their respective treatment practices daily, that is, 20 min of mantra meditation, 20 min of yoga exercises, and/or engage in mindful living activities related to the ethical topic of the week.

Measures

All measures were taken online using SoSci Survey (Leiner, 2019). We assessed the multi-layered construct of body awareness with the help of a newly developed questionnaire that enabled us to measure basic body awareness twice weekly. For this means, we extracted the 11 most suited items from four established questionnaires (FFMQ; Baer et al., 2006; MAIA; Mehling et al., 2012; PBCS; Miller et al., 1981; BAQ; Shields et al., 1989). The final set of items can be found in Supplementary Material—Table S1. We measured emotion regulation weekly with a shortened

version of the Difficulties in Emotion Regulation Scale (DERS; Gratz & Roemer, 2003). This scale is a well-validated and widely used self-report measure with excellent psychometric properties (internal consistency $\alpha = .93$). Higher scores indicate higher levels of emotion *dys*regulation. As the DERS is a very long scale for regular measurements, we decided to shorten it by extracting the two items with the highest factor loadings per subscale, resulting in altogether 12 items (see Supplementary Material—Table S2). Affective experience of participants was measured daily with the economic single-item measure Affective Grid (Russell et al., 1989) which was specifically developed for repeated observations. The Affective Grid assesses affect along the two dimensions pleasure-displeasure and arousal-sleepiness and has shown adequate reliability and validity (Killgore, 1998). We assessed distress tolerance with the Distress Tolerance Scale (DTS; Simons & Gaher, 2005). It is a 15-item self-report questionnaire examining the degree to which individuals experience negative emotions as intolerable. The DTS has shown good internal consistency ($\alpha = .89$) and was employed during pretest, posttest and follow-up. Self-compassion was measured during pre- and posttest with the Self-Compassion Scale (SCS; Neff, 2003), which assesses one's ability to be kind and forgiving to oneself in difficult circumstances. The SCS has been shown to be valid and reliable. To reduce response burden, we decided to shorten the original 26-item scale by extracting the two items with the highest factor loadings per subscale, reducing it to 12 items (see Supplementary Material—Table S3). All questionnaires (except the Affective Grid) were rated on a 5-point Likert scale.

Data Analysis

Single-case data can be analyzed in multiple ways (Machalicek & Horner, 2018; Shadish, 2014), the most common being visual inspection of dependent-variable-by-time plots (Lane & Gast, 2014). Often, multiple analysis strategies are chosen to increase the reliability and generalizability of findings. Accordingly, we analyzed data in three ways—by visual inspection, calculating effect sizes using Tau-*U*, and multilevel modeling. Additionally, we supplemented our analyses with qualitative findings to explore possible reasons for interindividual differences.

During visual inspection, we assessed trends in the baseline or the treatment phase, differences between the means and the variability of data in each phase, and the consistency of patterns across individuals and conditions. We kept our analysis relatively simple, as our sample was exceptionally large for an experimental single-case study. Tau-*U* is a non-parametric effect size estimate that allows controlling trends observed in both phases (Parker et al., 2011). We calculated Tau-*U* coefficients for each participant and each dependent variable, and corrected trends in any phase when they were statistically significant or larger than .40. An effect size of less than 0.28 indicated a small effect; 0.29–0.47 a moderate effect; 0.48–0.57 a large effect; and 0.58 or above a very large effect (Solomon et al., 2015).

Multilevel modeling (or hierarchical linear modeling) is a powerful tool for examining both individual change and group differences (Dedrick et al., 2009; Hox, 2010). In this study, we modeled changes over time within each individual on one level and differences between individuals on a second level. We standardized all variables to obtain standardized regression coefficients. Time was coded with zero for the baseline phase and a logarithmic trend starting at the beginning of the treatment phase. We modeled time as a random slope and applied one-tailed tests to it as we expected all treatments to improve our dependent variables. To assess the proportion of explained variance in each model, we assessed marginal R^2 and conditional R^2 (Nakagawa & Schielzeth, 2013). All models were estimated using the restricted maximum likelihood estimation procedure.

We examined the incremental effects of the four conditions in an exploratory manner with (1) three dummy variables coding the four conditions (condition model), and (2) two other dummy variables coding the inclusion of the physical yoga or ethical education component (component model). These dummy variables were entered as predictors into two sets of regression models. First, we estimated simple regression models with the Tau-*U* effect sizes as criterion. Second, consistent with the first procedure, we modeled cross-level interactions between time and condition in our multilevel models with the continuous measures of our dependent variables as criterion. Both analyses produce comparable results. All models included individual practice time, age, gender, occupation, and baseline length to control their influence

statistically. To estimate individual practice time, we calculated sum scores of the reported length of each practice participants engaged with at home. We applied one-tailed tests of significance as we expected combined interventions to have stronger effects than the simple meditation intervention. We considered $p < .05$ to be statistically significant.

All statistical analyses were performed using R 3.6.3 (R Core Team, 2020) and the statistical packages *lattice* (Sarkar, 2008), *ggpubr* (Kassambara, 2020), *scan* (Wilbert & Lueke, 2019), and *nlme* (Pinheiro et al., 2020). Proportion of explained variance in multilevel models was calculated using the R-based online application *mimosa* (Titz, 2020). All scripts and data that support the results can be found at <https://osf.io/wnxk6/>.

Results

For the three continuously measured variables (body awareness, emotion regulation, affectivity), we report the results of our visual inspection, effect size estimation, and multilevel modeling on the general as well as on the incremental effects we observed. Then, we explore the relations between these three dependent variables before reporting results on distress tolerance and self-compassion. Finally, we elaborate on observations of specific single cases and possible explanations of these.

Body Awareness

Figure 1 illustrates the development of body awareness scores of each participant over time. Most participants' body awareness did not fluctuate much, indicating that this construct was relatively stable and not subject to daily variation. Overall, there were observable interindividual differences in the general level and slope of the curves.

Figure 1

Body Awareness Scores in Four Conditions During Baseline and Treatment Phases for Each Participant With Regression Lines for Each Phase

Note. MA = Mantra meditation only; ME = meditation and ethical education; MY = meditation and physical yoga; MYE = meditation, physical yoga, and ethical education.

During baseline, most participants showed no change or a decrease in body awareness. A few participants' body awareness increased during baseline. Both increases and decreases in baseline could be due to a heightened sensitivity to the instrument. Nevertheless, the majority of participants showed a steady improvement of body awareness over the course of the treatment with effect sizes ranging from 0.30 to 0.70 (for full tables see Supplementary Material—Table S4). The increase was gradual for most participants starting with the beginning of the treatment or after a small delay. It seems as if being introduced to meditative practices influenced body awareness quite quickly, but continuous practice lead to steady improvements. Only two participants showed no observable changes and had effect sizes close to zero. Nine participants experienced a moderate deterioration of body awareness with effect sizes ranging from -0.28 to -0.59. Moreover, we examined whether these changes persisted until follow-up two months later. Therefore, we compared the mean body awareness scores from phase B ($M_B = 3.42$, $SD_B = 0.71$) with the follow-up measurements ($M_{FU} = 3.62$, $SD_{FU} = 0.84$), and found significant improvements, $t(39) = 2.58$, $p = .014$. Interestingly, this did not apply to participants who stopped meditating after the study—their body awareness was generally lower ($M_B = 3.01$, $SD_B = 0.75$) and remained so at follow-up ($M_{FU} = 3.06$, $SD_{FU} = 0.99$).

Then, we investigated possible differences between the four conditions. Participants whose body awareness did not change or declined were found in every condition, but particularly in the MA condition. The most improvements were found in the ME and MY conditions. We further explored incremental effects of our treatments by grouping all Tau- U effect size estimates by condition and generating four box plots (Figure 2).

Figure 2

Box Plots for Averaged Tau-U Body Awareness Effect Size Estimates in Each Condition. Individual Estimates are Scattered Across the Box Plots

Note. MA = Mantra meditation only; ME = meditation and ethical education; MY = meditation and physical yoga; MYE = meditation, physical yoga, and ethical education. Whiskers represent the largest and lowest values within a distance of 1.5 times the interquartile range.

According to Figure 2, all conditions led to an improvement in body awareness with the greatest enhancement in the MY condition ($Mdn = 0.49$, interquartile range [IQR] = 0.32), followed by the ME condition ($Mdn = 0.43$, IQR = 0.47) and the MYE condition ($Mdn = 0.38$, IQR = 0.32). The MA condition had the smallest effect ($Mdn = 0.21$, IQR = 0.71). When we estimated the total effect of group differences in multiple regression analysis, we found no differences between the conditions, $F(3, 33) = 0.52$, $p = .675$. None of the conditions or components nor practice time, age, gender, occupation or baseline significantly predicted changes in body awareness over time. Multiple R^2 was .13 and .11 for the condition and component model, respectively. In the multilevel

model estimating the overall effects, there was a significant effect of time, $F(1, 677) = 10.23$, $p = .001$, but no significant cross-level interaction, $F(3, 677) = 0.47$, $p = .702$. Both models predicted a significant enhancement of body awareness over time, $\beta = 0.15$, $SE = 0.05$, $p = .001$ (condition and component model). Yet, there were no significant other effects and no cross-level interactions. The effect sizes for both models were marginal $R^2 = .07$ and conditional $R^2 = .86$. All regression tables can be found in the Supplementary Material—Tables S5 to S8.

In sum, although there was substantial interindividual variation between participants, all four treatments helped participants to enhance their body awareness. This finding is supported by all of our three analyses and is independent of other potentially influential variables.

Emotion Regulation

Figure 3 displays how the difficulties with emotion regulation scores developed over time for each participant. As body awareness, emotion regulation did not fluctuate much, but slopes and levels varied between participants. It was difficult to make reliable inferences on baseline trends, as there were only few baseline reference points. Three participants had to be excluded from the statistical analysis because of missing baseline data.

Figure 3

Difficulties with Emotion Regulation Scores in Four Conditions During Baseline and Treatment

Phases for Each Participant With Regression Lines for Each Phase

Note. MA = Mantra meditation only; ME = meditation and ethical education; MY = meditation and physical yoga; MYE = meditation, physical yoga, and ethical education.

Cautiously comparing both phases, most participants exhibited a clear downward trend regarding their difficulties with emotion regulation, indicating that they improved their ability to become aware of and regulate their feelings. A reduction of experienced difficulties was desirable—thus, a negative sign in effect sizes represented a change in the expected direction. Three quarters of the effect size estimates ranged from -0.30 to -0.90 indicating moderate to very large effects (see Supplementary Material—Table S9). For most participants, this amelioration became gradually stronger over time. Very few participants showed no observable changes or increased difficulties with emotion regulation. When we compared the mean scores from phase B ($M = 2.21$, $SD = 0.52$) with the follow-up measurements ($M = 2.14$, $SD = 0.60$), we found no significant differences, $t(37) = -1.16$, $p = .255$, indicating a stability of the effect.

All conditions comprised participants with large effect sizes, yet, the conditions ME and MY comprised the most. In every condition, we found one participant whose emotion regulation skills weakened over time. Figure 4 depicts box plots with effect size estimates grouped by condition.

Figure 4

Box Plots for Averaged Tau-U Difficulties with Emotion Regulation Effect Size Estimates in Each Condition. Individual Estimates are Scattered Across the Box Plots

Note. MA = Mantra meditation only; ME = meditation and ethical education; MY = meditation and physical yoga; MYE = meditation, physical yoga, and ethical education. Whiskers represent the largest and lowest values within a distance of 1.5 times the interquartile range.

Figure 4 demonstrates that all four conditions helped participants to improve their emotion regulation considerably: ME condition ($Mdn = -0.52$, $IQR = 0.44$), MY condition ($Mdn = -0.50$, $IQR = 0.34$), MA condition ($Mdn = -0.48$, $IQR = 0.42$), and MYE condition ($Mdn = -0.43$, $IQR = 0.31$). The overall regression estimation indicated no significant between-group effect, $F(3, 30) = 0.23$, $p = .873$. None of the conditions/components nor any of the moderators significantly predicted changes in emotion regulation over. Multiple R^2 was .10 and .09 for the condition and component model, respectively. In the overall multilevel model, there was an effect of time, $F(1, 334) = 30.62$, $p < .001$, but no significant cross-level interaction, $F(3,$

334) = 0.60, $p = .617$. Both models predicted a significant improvement of emotion regulation over time, $\beta = -0.26$, $SE = 0.05$, $p < .001$. Again, there were no significant predictors nor significant cross-level interactions, suggesting that all conditions enhanced regulatory skills equally well. Effect sizes for both models were marginal $R^2 = .19$ and conditional $R^2 = .81$. For full regression tables see the Supplementary Material—Tables S10 to S13. Summarizing the three analyses, all four treatments strengthened participants' abilities to regulate their emotional responses.

Affectivity

The variable-by-time plots for valence and arousal are depicted in Figures 5 and 6, respectively. A thin horizontal line was drawn into each graph at the score 5 to delineate a neutral valence or arousal that is neither high/positive nor low/negative (Russell et al., 1989).

Figure 5

Valence Scores in Four Conditions During Baseline and Treatment Phases for Each Participant

With Regression Lines for Each Phase

Note. Thin horizontal line represents a neutral valence (value = 5); MA = mantra meditation only; ME = meditation and ethical education; MY = meditation and physical yoga; MYE = meditation, physical yoga, and ethical education.

Figure 6

Arousal Scores in Four Conditions During Baseline and Treatment Phases for Each Participant

With Regression Lines for Each Phase

Note. Thin horizontal line represents a neutral arousal (value = 5); MA = mantra meditation only; ME = meditation and ethical education; MY = meditation and physical yoga; MYE = meditation, physical yoga, and ethical education.

The visual inspection of these plots indicated strong inter- and intraindividual fluctuations in both affective dimensions over time. In most cases, the baseline phase displayed a stronger upward or downward trend than the treatment phase. These trends reversed or leveled out during the treatment phase. The variability of scores was comparable across both phases. Effects were inconsistent across individuals. Both arousal and valence either increased, decreased or stayed the same from baseline to treatment. A majority of effect size estimates ranged from -0.25 to 0.35 for valence, and -0.30 to 0.40 for arousal, indicating a great variability in the results (see Supplementary Material—Table S14). Valence declined for a majority of participants from the MA condition, but improved for many participants from the ME condition. Figure 7 displays the grouped effect sizes of all four treatments on both variables.

Figure 7

Box Plots for Averaged Tau-U Arousal and Valence Estimates in Each Condition. Individual Arousal and Valence Estimates are Scattered Across the Box Plots

Note. MA = Mantra meditation only; ME = meditation and ethical education; MY = meditation and physical yoga; MYE = meditation, physical yoga, and ethical education. Whiskers represent the largest and lowest values within a distance of 1.5 times the interquartile range.

The average effect sizes for arousal were close to zero and differed not much between conditions—MA ($Mdn = 0.07$, $IQR = 0.18$), ME ($Mdn = 0.05$, $IQR = 0.39$), MY ($Mdn = -0.02$, $IQR = 0.11$), and MYE ($Mdn = -0.09$, $IQR = 0.42$). However, there was a discernible difference in valence effect sizes between the conditions MA ($Mdn = -0.14$, $IQR = 0.31$) and ME ($Mdn = 0.10$, $IQR = 0.37$). The average effect size for valence in the other two conditions was close to zero—MY ($Mdn = -0.00$, $IQR = 0.18$), and MYE ($Mdn = 0.03$, $IQR = 0.28$). The aggregated effect of all four conditions for valence and arousal was $F(3, 33) = 1.17$, $p = .334$, and $F(3, 32) = 0.73$, $p = .543$, respectively, suggesting no relevant differences between conditions. In the condition model of valence, receiving the treatment ME significantly predicted an increase in valence over time, $\beta = 0.41$, $p = .041$, suggesting that this condition improved positive affect. Neither ethical education or physical yoga nor any other variable significantly predicted changes in valence and arousal. However, in the condition model of arousal, being employed (compared to being a student) was a significant predictor of increased arousal over time, $\beta = 0.45$, $p = .038$. Multiple R^2 was .12 and .07 for valence (condition/component model), and .27 and .22 for arousal.

In the overall multilevel model, we found no interaction effect for valence or arousal, $F(3, 2492) = 1.89$, $p = .129$, and $F(3, 2454) = 0.00$, $p = .708$, respectively. There were no significant predictors in the arousal models. In the condition model of valence, there were two significant cross-level interactions between time and the ME condition, $\beta = 0.08$, $SE = 0.03$, $p = .013$, and time and the MY condition, $\beta = 0.06$, $SE = 0.03$, $p = .033$, indicating an increase in valence over time. Neither the yoga nor the ethical component predicted valence in the component model. Thus, the positive effect was limited to the two conditions that involved meditation plus one additional component, but did not depend on a specific component. Interestingly, the only (other) significant predictor of valence in both models was the total practice time individuals completed, $\beta = 0.17$, $SE = 0.08$, $p = .033/.031$. Hence, it seems that the more participants engaged in a regular home practice the more their valence increased independent of their specific condition. Obviously, total practice time was longer in more extensive conditions, but still varied across participants. The effect sizes for the final component models for valence/arousal were marginal $R^2 = .04$ / $R^2 = .04$

and conditional $R^2 = .22/R^2 = 0.15$. Full regression tables can be found in the Supplementary Material—Tables S15 to S22.

Next, we considered both dimensions simultaneously, both visually and by placing effect sizes of both variables side by side in a combined figure (Figure 8). As a result, we developed five main categories of affective responses to our treatment depicted with different symbols in Figure 8. The majority of participants experienced a positive change of affect, a small group of participants showed no observable changes, and some participants felt more stressed.

Figure 8

Stacked Bar Chart of Tau-U Valence and Arousal Estimates with Qualitatively Classified Affective Responses per Participant

Note. Numbers denote participants; MA = mantra meditation only; ME = meditation and ethical education; MY = meditation and physical yoga; MYE = meditation, physical yoga, and ethical education.

Next, we compared the frequencies of each category of affective response in each condition (see Supplementary Material—Table S23). Around two-thirds of participants in the MA condition felt more stressed over the course of time. Half of the participants from the MY condition experienced no change in their affect. However, no one from this group was classified as being more stressed suggesting a stress-relieving effect of physical yoga. Participants from both groups that received ethical education (ME and MYE) were either more energetic, more relaxed or more stressed during the intervention. Thus, the ethical education component elicited multilayered responses. This contrasts and complements our analyses above where the MY and specifically the ME condition had a favorable effect on valence while the MA condition was less advantageous.

Relations between Affectivity, Body Awareness, and Emotion Regulation

Research literature postulates a close connection between body awareness and emotion regulation (Price & Hooven, 2018). Therefore, we explored this connection by correlating effect size estimates of both variables. We found a moderate correlation ($r = -.24$), indicating that when participants' body awareness increased, their difficulties with emotion regulation decreased, too. We found similar patterns and trajectories for both variables during visual inspection, indicating that both skills develop simultaneously during contemplative training.

Next, we looked whether there were any differences between conditions regarding this relation. Interestingly, correlations were much higher in the MA ($r = -.53$) and MY ($r = -.43$) conditions compared to both conditions that received ethical education: ME ($r = .20$) and MYE ($r = -.15$). Thus, in treatments where participants were mainly focused on observing rather than actively changing themselves, increases in body awareness were more strongly related to increases in emotion regulation.

We were also interested in how changes in both skills related to changes in daily affect. We found that decreases in difficulties with emotion regulation were higher when the affective response was classified as positive ($Med = -0.52$, $IQR = 0.31$), compared to no change ($Med = -0.38$, $IQR = 0.37$) or negative ($Med = -0.29$, $IQR = 0.66$). In contrast, enhancements in body awareness were highest when participants experienced no change in affectivity ($Med = 0.59$, $IQR = 0.79$),

compared to positive ($Med = 0.43$, $IQR = 0.36$) or negative ($Med = 0.24$, $IQR = 0.75$). This indicates that emotion regulation and affective experience co-varied, whereas body awareness and affective experience did not.

Distress Tolerance

For distress tolerance, a mixed two-way ANOVA showed a significant effect of time, $F(2, 72) = 23.01$, $p < .001$, with a large effect size, $\eta^2 = 0.13$. There were no significant differences between the four conditions, $F(3, 36) = 1.27$, $p = .299$, nor a significant interaction between time and condition, $F(6, 72) = 0.51$, $p = .746$. The mean distress tolerance across all conditions was $M_{pre} = 3.42$ ($SD = 0.74$) before the study, $M_{post} = 3.95$ ($SD = 0.72$) at completion of the study, and $M_{fu} = 3.99$ ($SD = 0.70$) 2 months later. Thus, all treatments markedly enhanced distress tolerance from pre- to posttest, which was sustained until follow-up.

Self-Compassion

Another mixed two-way ANOVA yielded a significant effect of time for self-compassion, $F(1, 37) = 26.25$, $p < .001$, with a medium effect size, $\eta^2 = 0.08$. Again, there were no significant differences between the four conditions, $F(3, 37) = 1.23$, $p = .311$, nor a significant interaction between time and condition, $F(3, 37) = 1.57$, $p = .213$. The mean self-compassion across all conditions increased from $M_{pre} = 3.00$ ($SD = 0.60$) before the study to $M_{post} = 3.37$ ($SD = 0.64$) at completion of the study. Accordingly, all treatments helped participants to cultivate their ability to be kind and forgiving to themselves.

Selected Single-Cases

Subsequently, we looked at potential explanations for the negative effects we found for body awareness and emotion regulation. Participants 5, 29, 31, and 35 experienced a considerable decline in body awareness throughout the treatment. Participant 5 (MA) was classified as becoming more stressed throughout the treatment, but markedly improved his distress tolerance over time. At 12-month follow-up, he stated being very grateful for the course, as he had learned a valuable relaxation technique that he could rely on, especially when things were getting

stressful. He had meditated regularly during the course and had continued to meditate until the present. We had considered excluding Participant 29 (MY) as she was not very conscientious in responding to our daily questionnaires and stopped responding in Week 5 of the treatment. Nevertheless, she regularly attended her class although she did not seem very enthusiastic during class and did not practice at home very often neither during the study nor afterwards. Interestingly, her affective experience did not change, her self-compassion declined, but her distress tolerance improved. Participant 31 (MY), on the other hand, was very enthusiastic about her course, even in retrospective, and reported that particularly yoga became part of her daily routine up to the present. She had high levels of distress tolerance from the beginning, her affective experience did not change, and her self-compassion increased over the course of the study. Participant 35 (MYE) conscientiously practiced yoga and meditation during the study, but lost motivation to continue even though he was still interested. He found working out and being in nature more helpful. Throughout the study, he became more energetic, but his self-compassion or distress tolerance did not change much. In sum, although all four participants experienced a decline in body awareness, they responded quite differently (and often positively) to the treatment in other variables.

Only two participants reported increased difficulties with emotion regulation over time. Interestingly, Participant 4 (MA) was the only participant who exhibited a deterioration in all three continuous dependent variables (affect, body awareness, emotion regulation). Yet, her distress tolerance improved. Participant 38 (MYE) was classified as becoming more stressed and her distress tolerance declined, but her body awareness and self-compassion increased. We identified and discussed these two participants in another publication as they also experienced a considerable decline in well-being (Matko, Sedlmeier, et al., 2021). Indeed, effect sizes of difficulties in emotion regulation and well-being were highly correlated ($r = -.41$). Nevertheless, both participants retrospectively appreciated their course and continued to meditate regularly. This might be an indication that the treatment led to an initial worsening during the process of change.

Discussion

The present study investigated the specific and incremental benefits of adding physical Hatha yoga and ethical education to a mantra meditation intervention in healthy participants. It evaluated processes related to embodied cognition in four different combinations of yoga components, which are part of the new yoga-based mind–body therapy MBLM (Bringmann et al., 2020). The single-case multiple-baseline design gave detailed access to individual responses and trajectories of change. All four treatments had positive effects on body awareness, emotion regulation skills, distress tolerance, and self-compassion. Effects were strongest for emotion regulation and distress tolerance. Surprisingly, there were no significant between-group differences regarding these variables although the treatments differed considerably in session duration and complexity. In contrast, findings on daily affect were more differentiated, but also less conclusive. The MA condition had the least favorable effect on valence and overall affectivity while the ME condition improved valence the most and the MY condition elicited no negative change in affectivity.

These results complement and extend our previously reported findings on well-being and stress (Matko, Sedlmeier, et al., 2021). In this earlier publication, we elucidated that the simple meditation treatment was the least effective and led to increased stress and decreased well-being in a sizeable number of participants. Furthermore, the two less extensive combinations of yoga components, that is, the ME and MY condition were the most helpful in enhancing well-being (ME) and reducing stress (MY). This is in line with the abovementioned results on affectivity. Nevertheless, the condition-independent positive effects on the other dependent variables seem somewhat puzzling. These indicate that factors common to all four interventions were responsible for the observed changes in these variables. These factors might be unspecific, such as group dynamics, social support, or attention from study staff (Kinser & Robins, 2013; Stein & Witkiewitz, 2020). Yet, the latter is unlikely as most effects persisted until follow-up. Thus, it seems more plausible to assume that these effects were caused by the specific shared component of mantra meditation.

Previous studies have substantiated the positive effects of mantra meditation on mental health and affectivity in healthy populations, although methodological flaws limit the validity of

these findings (Lynch et al., 2018; Sedlmeier et al., 2012). Our study provides methodologically sound evidence for the positive effects of mantra meditation on body awareness, emotion regulation, self-compassion, and distress tolerance, but not necessarily on positive affect. Interestingly, the former variables were neither influenced by differences in session duration nor by the fact that participants were fully informed about the experimental procedure. Thus, mantra meditation seems to have a quite powerful impact. Fittingly, meditation is regarded as the key element in classical yoga (*ashtanga* yoga) as outlined by Patanjali, with ethics, postures and breathing practices being considered prerequisites or preparatory exercises (Bryant, 2015).

Schmalzl et al. (2015) proposed that meditation leads to an increase in interoception and metacognitive awareness. Accordingly, interoception has been suggested as one of the central mechanisms of meditation (Farb et al., 2015; Gibson, 2019). Furthermore, neuroscientific studies have shown consistent activations in brain regions associated with interoceptive processes (e.g., insula) across many different kinds of meditation (Fox et al., 2016). In a recent comparative study, walking meditation, humming meditation, concentration on an object, and observing-thoughts meditation led to similar increases in body awareness and emotion regulation in novice meditators (Weinstabl, 2020). According to a recent classification system, mantra meditation does not have a strong orientation towards the body (Matko & Sedlmeier, 2019). Nevertheless, it encourages meditators to turn their attention inwards, which might explain why it enhanced the processing of bodily and emotional stimuli in the present study. Likewise, the sustained focus on a simple, repetitive stimulus (mantra) resembles states of sensory deprivation and perceptual isolation (Lindahl et al., 2014). These states have been shown to intensify or alter sensory perceptions and make them more salient (Lloyd et al., 2012). Additionally, participants were instructed to be kind and friendly toward themselves and their experiences during meditation. This might have enhanced their self-compassion and tolerance of negative emotions (Hölzel et al., 2011). Consequently, the strong focus of meditation on internal processes and on increasing self-awareness might be a central mechanism underlying the observed changes.

In contrast, mantra meditation alone exhibited a partly negative effect on participants' daily affect. In this respect, adding other yoga components to the treatment proved to be a valuable extension and possibly provided participants with additional inspiration and a frame of reference (Matko, Sedlmeier, et al., 2021). Moreover, additional treatment components tended to increase the effectiveness of the intervention on body awareness. Remarkably, it mostly did not matter which component was added or practiced in this regard. Physical Hatha yoga emphasizes becoming aware of the (moving) body and has been found to increase vagal/parasympathetic activity (Gard et al., 2014; Riley & Park, 2015). This might explain its balancing effect on affectivity. Ethical education, on the other hand, encourages the development of value-oriented behavior (Sullivan et al., 2017), and is associated with improved well-being, self-compassion, and anxiety (Bayot et al., 2020; Smith et al., 2011). This is in accordance with its positive effects on valence as reported above.

Whereas daily affect fluctuated a lot, body awareness and emotion regulation developed steadily and continuously over time. This indicates that the latter are important skills and possible mechanisms of action that develop simultaneously over time. We found stronger correlations between changes in both skills in the non-ethical than in the ethical conditions. This provides evidence for the notion that postures, breathing and meditation encourage an integrated and embodied way of processing and modulating of bodily and emotional responses (Gard et al., 2014). The ethical education component, on the other hand, might have strengthened top-down processing and, thus, a decoupling of body awareness and emotion regulation. This corresponds to the finding that an (embodied) yoga intervention was more effective than a (non-embodied) cognitive-behavioral stress-management course in enhancing interoceptive awareness and emotion regulation (Park et al., 2017).

We observed substantial interindividual variation in response to the treatments. While the majority of participants benefitted from the treatments, a few participants became more stressed or experienced a decline in their body awareness and/or emotion regulatory skills. As we know

from psychotherapeutic contexts, change is not always easy and often leads to an initial impairment of symptoms (Stulz et al., 2007). This might have happened to some of our participants, too, as most of them were quite grateful for their course 12 months later. A decrease in body awareness might also indicate a shift in participants' frame of reference. In other words, participants might become more aware or more mindful towards their inner experience during the treatment and, hence, adjust their responses (Belzer et al., 2013; Krägeloh et al., 2018). Similarly, individual characteristics might influence a participant's response to the different yoga components (Hölzel et al., 2011; Schmalzl et al., 2015).

Although our study employed rigorous methodology, it has some limitations, too. First, our sample cannot be considered representative of the general public and we have to assume that participants were intrinsically motivated to participate in this study. Second, the intense data gathering was very demanding for participants and led to a relatively high number of dropouts and high amounts of missing data. Thus, providing financial or other compensation might help to increase participant commitment. Third, our sample size was somewhat limited for certain aspects of the evaluation. In single-case research, a sample of 42 participants is considered exceptionally large. With up to 85 measurements per participant for daily measures, findings and effect size estimates should be very robust. This applies less to measures collected less often and to pre-post comparisons. Thus, more research with larger subgroups is needed to validate our findings. Furthermore, dependent variables should be collected more frequently. Thereby, questionnaires could be shortened and at the same time be made more specific. For example, daily affect could be assessed with simple questions such as "To what extent did you feel happy/sad/calm/stressed today?" Also, specific emotion regulatory strategies, including the proposed mindful emotion regulation (Chambers et al., 2009), or specific embodiment processes could be assessed in more detail. Alternatively, experience-sampling methods or ecological momentary assessment (Shiffman et al., 2008) provide an intriguing means to capture immediate (affective) experiences at different times of the day.

Interestingly, the meditation-only condition, which served as an appropriate control group, produced the same effects for most variables as the more extensive conditions. Future studies could evaluate whether these effects generalize to different types of meditation (Matko & Sedlmeier, 2019). Likewise, future studies could match conditions by session length and dismantle the effects of yoga components in an even more detailed way. This could mean comparing treatments incorporating only ethics, only physical postures, only breathing techniques, or only meditation to diverse combinations of these. Similarly, they could include an active non-yoga and non-meditation (placebo) control group (see, e.g., Hunt et al., 2018). In sum, all of these research efforts could help to develop a deeper understanding of the working mechanisms of the multifaceted practice of yoga.

References

- Baer, R. A., Smith, G. T., Hopkins, J., Krietemeyer, J., & Toney, L. (2006). Using Self-Report Assessment Methods to Explore Facets of Mindfulness. *Assessment*, 13(1), 27–45.
- Barlow, D. H., Nock, M., & Hersen, M. (2009). *Single case experimental designs: Strategies for studying behavior for change* (3rd ed.). Pearson.
- Bayot, M., Vermeulen, N., Kever, A., & Mikolajczak, M. (2020). Mindfulness and empathy: Differential effects of explicit and implicit Buddhist teachings. *Mindfulness*, 11(1), 5–17. <https://doi.org/10.1007/s12671-018-0966-4>
- Bechara, A., & Naqvi, N. (2004). Listening to your heart: Interoceptive awareness as a gateway to feeling. *Nature Neuroscience*, 7(2), 102–103. <https://doi.org/10.1038/nn0204-102>
- Belzer, F., Schmidt, S., Lucius-Hoene, G., Schneider, J. F., Orellana-Rios, C. L., & Sauer, S. (2013). Challenging the construct validity of mindfulness assessment—A cognitive interview study of the Freiburg Mindfulness Inventory. *Mindfulness*, 4(1), 33–44. <https://doi.org/10.1007/s12671-012-0165-7>
- Bringmann, H. C., Bringmann, N., Jeitler, M., Brunnhuber, S., Michalsen, A., & Sedlmeier, P. (2020). Meditation-Based Lifestyle Modification: Development of an integrative mind-body program for mental health and human flourishing. *Complementary Medicine Research*, 1–11. <https://doi.org/10.1159/000512333>
- Chambers, R., Gullone, E., & Allen, N. B. (2009). Mindful emotion regulation: An integrative review. *Clinical Psychology Review*, 29(6), 560–572.
- Chiesa, A., Serretti, A., & Jakobsen, J. C. (2013). Mindfulness: Top-down or bottom-up emotion regulation strategy? *Clinical Psychology Review*, 33(1), 82–96.
- Cramer, H., Lauche, R., & Dobos, G. (2014). Characteristics of randomized controlled trials of yoga: A bibliometric analysis. *BMC Complementary and Alternative Medicine*, 14(1), Article 328. <https://doi.org/10.1186/1472-6882-14-328>
- Cramer, H., Lauche, R., Langhorst, J., & Dobos, G. (2013). Yoga for depression: A systematic review and meta-analysis. *Depression and Anxiety*, 30(11), 1068–1083.
- Damasio, A. R. (2006). *Descartes' error: Emotion, reason, and the human brain*. Random House.

- Daubenmier, J., Mehling, W., Price, C., Bartmess-Levasseur, E., Acree, M., & Stewart, A. (2012). OA14.02. Exploration of body awareness and pain and emotion regulation among yoga and meditation practitioners: Does type of mind-body practice matter? *BMC Complementary and Alternative Medicine*, 12(1), 054. <https://doi.org/10.1186/1472-6882-12-S1-054>
- Dedrick, R. F., Ferron, J. M., Hess, M. R., Hogarty, K. Y., Kromrey, J. D., Lang, T. R., Niles, J. D., & Lee, R. S. (2009). Multilevel modeling: A review of methodological issues and applications. *Review of Educational Research*, 79(1), 69–102.
- Farb, N., Daubenmier, J., Price, C. J., Gard, T., Kerr, C., Dunn, B. D., Klein, A. C., Paulus, M. P., & Mehling, W. E. (2015). Interoception, contemplative practice, and health. *Frontiers in Psychology*, 6, Article 763. <https://doi.org/10.3389/fpsyg.2015.00763>
- Feuerstein, G. (2012). *The yoga tradition: Its history, literature, philosophy and practice*. SCB Distributors.
- Fox, K. C. R., Dixon, M. L., Nijboer, S., Girn, M., Floman, J. L., Lifshitz, M., Ellamil, M., Sedlmeier, P., & Christoff, K. (2016). Functional neuroanatomy of meditation: A review and meta-analysis of 78 functional neuroimaging investigations. *Neuroscience & Biobehavioral Reviews*, 65, 208–228. <https://doi.org/10.1016/j.neubiorev.2016.03.021>
- Francis, A. L. (2018). The embodied theory of stress: A constructionist perspective on the experience of stress. *Review of General Psychology*, 22(4), 398–405.
- Francis, A. L., & Beemer, R. C. (2019). How does yoga reduce stress? Embodied cognition and emotion highlight the influence of the musculoskeletal system. *Complementary Therapies in Medicine*, 43, 170–175. <https://doi.org/10.1016/j.ctim.2019.01.024>
- Fuchs, T., & Schlimme, J. E. (2009). Embodiment and psychopathology: A phenomenological perspective. *Current Opinion in Psychiatry*, 22(6), 570–575.
- Füstös, J., Gramann, K., Herbert, B. M., & Pollatos, O. (2013). On the embodiment of emotion regulation: Interoceptive awareness facilitates reappraisal. *Social Cognitive and Affective Neuroscience*, 8(8), 911–917. <https://doi.org/10.1093/scan/nss089>

- Gallagher, S. (2011). Interpretations of embodied cognition. In *The implications of embodiment: Cognition and communication* (pp. 59–71). Imprint Academic.
- Gard, T., Brach, N., Hölzel, B. K., Noggle, J. J., Conboy, L. A., & Lazar, S. W. (2012). Effects of a yoga-based intervention for young adults on quality of life and perceived stress: The potential mediating roles of mindfulness and self-compassion. *The Journal of Positive Psychology*, 7(3), 165–175.
- Gard, T., Noggle, J. J., Park, C. L., Vago, D. R., & Wilson, A. (2014). Potential self-regulatory mechanisms of yoga for psychological health. *Frontiers in Human Neuroscience*, 8, Article 770. <https://doi.org/10.3389/fnhum.2014.00770>
- Gibson, J. (2019). Mindfulness, interoception, and the body: A contemporary perspective. *Frontiers in Psychology*, 10, Article 2012. <https://doi.org/10.3389/fpsyg.2019.02012>
- Gratz, K. L., & Roemer, L. (2003). Multidimensional assessment of emotion regulation and dysregulation: Development, factor structure, and initial validation of the Difficulties in Emotion Regulation Scale. *Journal of Psychopathology and Behavioral Assessment*, 26(1), 41–54.
- Gross, J. J., & Muñoz, R. F. (1995). Emotion regulation and mental health. *Clinical Psychology: Science and Practice*, 2(2), 151–164.
- Hölzel, B. K., Lazar, S. W., Gard, T., Schuman-Olivier, Z., Vago, D. R., & Ott, U. (2011). How does mindfulness meditation work? Proposing mechanisms of action from a conceptual and neural perspective. *Perspectives on Psychological Science*, 6(6), 537–559. <https://doi.org/10.1177/1745691611419671>
- Hox, J. J. (2010). *Multilevel analysis: Techniques and applications* (2nd ed.). Routledge.
- Hunt, M., Al-Braiki, F., Dailey, S., Russell, R., & Simon, K. (2018). Mindfulness training, yoga, or both? Dismantling the active components of a Mindfulness-Based Stress Reduction intervention. *Mindfulness*, 9(2), 512–520. <https://doi.org/10.1007/s12671-017-0793-z>
- Impett, E. A., Daubenmier, J. J., & Hirschman, A. L. (2006). Minding the body: Yoga, embodiment, and well-being. *Sexuality Research & Social Policy*, 3(4), 39–48.
- Kassambara, A. (2020). *ggpubr: “ggplot2” based publication ready plots* (R package version 0.4.0) [Computer software]. <https://CRAN.R-project.org/package=ggpubr>

- Khoury, B. (2019). Compassion: Embodied and embedded. *Mindfulness*, 10(11), 2363–2374.
<https://doi.org/10.1007/s12671-019-01211-w>
- Killgore, W. D. S. (1998). The Affect Grid: A moderately valid, nonspecific measure of pleasure and arousal. *Psychological Reports*, 83, 639–642.
- Kinser, P. A., & Robins, J. L. (2013). Control group design: Enhancing rigor in research of mind-body therapies for depression. *Evidence-Based Complementary and Alternative Medicine*, 2013, Article e140467. <https://doi.org/10.1155/2013/140467>
- Kok, B. E., & Singer, T. (2017). Phenomenological fingerprints of four meditations: Differential state changes in affect, mind-wandering, meta-cognition, and interoception before and after daily practice across 9 months of training. *Mindfulness*, 8(1), 218–231.
<https://doi.org/10.1007/s12671-016-0594-9>
- Krägeloh, C. U., Bergomi, C., Siegert, R. J., & Medvedev, O. N. (2018). Response shift after a mindfulness-based intervention: Measurement invariance testing of the Comprehensive Inventory of Mindfulness Experiences. *Mindfulness*, 9(1), 212–220.
<https://doi.org/10.1007/s12671-017-0764-4>
- Lane, J. D., & Gast, D. L. (2014). Visual analysis in single case experimental design studies: Brief review and guidelines. *Neuropsychological Rehabilitation*, 24(3–4), 445–463.
- Leiner, D. J. (2019). *SoSci Survey* (Version 3.1.06) [Computer software]. <https://www.soscisurvey.de>
- Lindahl, J. R., Kaplan, C. T., Winget, E. M., & Britton, W. B. (2014). A phenomenology of meditation-induced light experiences: Traditional Buddhist and neurobiological perspectives. *Frontiers in Psychology*, 4, 973.
- Lindsay, E. K., Chin, B., Greco, C. M., Young, S., Brown, K. W., Wright, A. G. C., Smyth, J. M., Burkett, D., & Creswell, J. D. (2018). How mindfulness training promotes positive emotions: Dis-mantling acceptance skills training in two randomized controlled trials. *Journal of Personality and Social Psychology*, 115(6), 944–973. <https://doi.org/10.1037/pspa0000134>

- Lloyd, D. M., Lewis, E., Payne, J., & Wilson, L. (2012). A qualitative analysis of sensory phenomena induced by perceptual deprivation. *Phenomenology and the Cognitive Sciences*, 11(1), 95–112. <https://doi.org/10.1007/s11097-011-9233-z>
- Lynch, J., Prihodova, L., Dunne, P. J., Carroll, Á., Walsh, C., McMahon, G., & White, B. (2018). Mantra meditation for mental health in the general population: A systematic review. *European Journal of Integrative Medicine*, 23, 101–108. <https://doi.org/10.1016/j.eujim.2018.09.010>
- MacBeth, A., & Gumley, A. (2012). Exploring compassion: A meta-analysis of the association between self-compassion and psychopathology. *Clinical Psychology Review*, 32(6), 545–552. <https://doi.org/10.1016/j.cpr.2012.06.003>
- Machalicek, W., & Horner, R. H. (2018). Special issue on advances in single-case research design and analysis. *Developmental Neuropsychology*, 21(4), 209–211. <https://doi.org/10.1080/17518423.2018.1468600>
- Matko, K., Bringmann, H. C., & Sedlmeier, P. (2021). Effects of different components of yoga: A meta-synthesis. *OBM Integrative and Complementary Medicine*, 6(3), Article 26. <https://doi.org/10.21926/obm.icm.2103030>
- Matko, K., & Sedlmeier, P. (2019). What is meditation? Proposing an empirically derived classification system. *Frontiers in Psychology*, 10, Article 2276. <https://doi.org/10.3389/fpsyg.2019.02276>
- Matko, K., Sedlmeier, P., & Bringmann, H. C. (2021). Differential effects of ethical education, physical Hatha yoga, and mantra meditation on well-being and stress in healthy participants – An experimental single-case study. *Frontiers in Psychology*, 12, Article 672301. <https://doi.org/10.3389/fpsyg.2021.672301>
- May, C. J., Weyker, J. R., Spengel, S. K., Finkler, L. J., & Hendrix, S. E. (2014). Tracking longitudinal changes in affect and mindfulness caused by concentration and loving-kindness meditation with hierarchical linear modeling. *Mindfulness*, 5(3), 249–258. <https://doi.org/10.1007/s12671-012-0172-8>

- Medina, J., Hopkins, L., Powers, M., Baird, S. O., & Smits, J. (2015). The effects of Hatha yoga intervention on facets of distress tolerance. *Cognitive Behaviour Therapy*, 44(4), 288–300. <https://doi.org/10.1080/16506073.2015.1028433>
- Mehling, W. E., Gopisetty, V., Daubenmier, J., Price, C. J., Hecht, F. M., & Stewart, A. (2009). Body awareness: Construct and self-report measures. *PLoS One*, 4(5), e5614. <https://doi.org/10.1371/journal.pone.0005614>
- Mehling, W. E., Price, C., Daubenmier, J. J., Acree, M., Bartmess, E., & Stewart, A. (2012). The Multi-dimensional Assessment of Interoceptive Awareness (MAIA). *PloS One*, 7(11), Article e48230.
- Mehling, W. E., Wrubel, J., Daubenmier, J. J., Price, C. J., Kerr, C. E., Silow, T., Gopisetty, V., & Stewart, A. L. (2011). Body awareness: A phenomenological inquiry into the common ground of mind-body therapies. *Philosophy, Ethics, and Humanities in Medicine*, 6(1), 6. <https://doi.org/10.1186/1747-5341-6-6>
- Menezes, C. B., Dalpiaz, N. R., Kiesow, L. G., Sperb, W., Hertzberg, J., & Oliveira, A. A. (2015). Yoga and emotion regulation: A review of primary psychological outcomes and their physiological correlates. *Psychology & Neuroscience*, 8(1), 82–101. <https://doi.org/10.1037/h0100353>
- Miller, L. C., Murphy, R., & Buss, A. H. (1981). Consciousness of body: Private and public. *Journal of Personality and Social Psychology*, 41(2), 397–406. <https://doi.org/10.1037/0022-3514.41.2.397>
- Nakagawa, S., & Schielzeth, H. (2013). A general and simple method for obtaining R² from generalized linear mixed-effects models. *Methods in Ecology and Evolution*, 4(2), 133–142. <https://doi.org/10.1111/j.2041-210x.2012.00261.x>
- Neff, K. D. (2003). The development and validation of a scale to measure self-compassion. *Self and Identity*, 2(3), 223–250.
- Niedenthal, P. M., Barsalou, L. W., Winkielman, P., Krauth-Gruber, S., & Ric, F. (2005). Embodiment in attitudes, social perception, and emotion. *Personality and Social Psychology Review*, 9(3), 184–211.

- Niedenthal, P. M., & Maringer, M. (2009). Embodied emotion considered. *Emotion Review*, 1(2), 122–128.
- Ochsner, K. N., & Gross, J. J. (2005). The cognitive control of emotion. *Trends in Cognitive Sciences*, 9(5), 242–249.
- Park, C. L., Riley, K. E., Braun, T. D., Jung, J. Y., Suh, H. G., Pescatello, L. S., & Antoni, M. H. (2017). Yoga and cognitive-behavioral interventions to reduce stress in incoming college students: A pilot study. *Journal of Applied Biobehavioral Research*, 22(4), Article e12068. <https://doi.org/10.1111/jabr.12068>
- Parker, R. I., Vannest, K. J., Davis, J. L., & Sauber, S. B. (2011). Combining nonoverlap and trend for single-case research: Tau-U. *Behavior Therapy*, 42(2), 284–299.
- Phillips, M. L., Drevets, W. C., Rauch, S. L., & Lane, R. (2003). Neurobiology of emotion perception II: Implications for major psychiatric disorders. *Biological Psychiatry*, 54(5), 515–528. [https://doi.org/10.1016/S0006-3223\(03\)00171-9](https://doi.org/10.1016/S0006-3223(03)00171-9)
- Pinheiro, J., Bates, D., DebRoy, S., Sarkar, D., & R Core Team. (2020). *nlme: Linear and nonlinear mixed effects models* (R package version 3.1-144) [Computer software]. <https://CRAN.R-project.org/package=nlme>
- Pollatos, O., & Ferentzi, E. (2018). Embodiment of emotion regulation. In G. Hauke & A. Kritikos (Eds.), *Embodiment in Psychotherapy: A Practitioner's Guide* (pp. 43–55). Springer International Publishing. https://doi.org/10.1007/978-3-319-92889-0_4
- Price, C. J., & Hooven, C. (2018). Interoceptive awareness skills for emotion regulation: Theory and approach of Mindful Awareness in Body-Oriented Therapy (MABT). *Frontiers in Psychology*, 9, 798. <https://doi.org/10.3389/fpsyg.2018.00798>
- R Core Team. (2020). *R: A language and environment for statistical computing*. R Foundation for Statistical Computing. <https://www.R-project.org/>
- Riley, K. E., & Park, C. L. (2015). How does yoga reduce stress? A systematic review of mechanisms of change and guide to future inquiry. *Health Psychology Review*, 9(3), 379–396.
- Russell, J. A., Weiss, A., & Mendelsohn, G. A. (1989). Affect grid: A single-item scale of pleasure and arousal. *Journal of Personality and Social Psychology*, 57(3), 493–502.

- Sarkar, D. (2008). *lattice: Multivariate data visualization with R*. Springer. <http://lmdvr.r-forge.r-project.org>
- Sauer-Zavala, S. E., Walsh, E. C., Eisenlohr-Moul, T. A., & Lykins, E. L. B. (2013). Comparing mindfulness-based intervention strategies: Differential effects of sitting meditation, body scan, and mindful yoga. *Mindfulness*, 4(4), 383–388. <https://doi.org/10.1007/s12671-012-0139-9>
- Schmalzl, L., Powers, C., & Henje Blom, E. (2015). Neurophysiological and neurocognitive mechanisms underlying the effects of yoga-based practices: Towards a comprehensive theoretical framework. *Frontiers in Human Neuroscience*, 9, Article 235. <https://doi.org/10.3389/fnhum.2015.00235>
- Sedlmeier, P., Eberth, J., Schwarz, M., Zimmermann, D., Haarig, F., Jaeger, S., & Kunze, S. (2012). The psychological effects of meditation: A meta-analysis. *Psychological Bulletin*, 138(6), 1139–1171. <https://doi.org/10.1037/a0028168>
- Shadish, W. R. (2014). Analysis and meta-analysis of single-case designs: An introduction. *Journal of School Psychology*, 52(2), 109–122.
- Shields, S. A., Mallory, M. E., & Simon, A. (1989). The Body Awareness Questionnaire: Reliability and validity. *Journal of Personality Assessment*, 53(4), 802–815. https://doi.org/10.1207/s15327752jpa5304_16
- Shiffman, S., Stone, A. A., & Hufford, M. R. (2008). Ecological momentary assessment. *Annual Review of Clinical Psychology*, 4(1), 1–32. <https://doi.org/10.1146/annurev.clinpsy.3.022806.091415>
- Simons, J. S., & Gaher, R. M. (2005). The Distress Tolerance Scale: Development and validation of a self-report measure. *Motivation and Emotion*, 29(2), 83–102. <https://doi.org/10.1007/s11031-005-7955-3>
- Smith, J. A., Greer, T., Sheets, T., & Watson, S. (2011). Is there more to yoga than exercise? *Alternative Therapies in Health and Medicine*, 17(3), 22–29.

- Solomon, B. G., Howard, T. K., & Stein, B. L. (2015). Critical assumptions and distribution features pertaining to contemporary single-case effect sizes. *Journal of Behavioral Education*, 24(4), 438–458. <https://doi.org/10.1007/s10864-015-9221-4>
- Stein, E., & Witkiewitz, K. (2020). Dismantling mindfulness-based programs: A systematic review to identify active components of treatment. *Mindfulness*, 11, 2470–2485. <https://doi.org/10.1007/s12671-020-01444-0>
- Stulz, N., Lutz, W., Leach, C., Lucock, M., & Barkham, M. (2007). Shapes of early change in psychotherapy under routine outpatient conditions. *Journal of Consulting and Clinical Psychology*, 75(6), 864.
- Sullivan, M. B., Moonaz, S., Weber, K., Taylor, J. N., & Schmalzl, L. (2017). Toward an explanatory framework for yoga therapy informed by philosophical and ethical perspectives. *Alternative Therapies in Health and Medicine*, 23(7), 38–47.
- Sze, J. A., Gyurak, A., Yuan, J. W., & Levenson, R. W. (2010). Coherence between emotional experience and physiology: Does body awareness training have an impact? *Emotion*, 10(6), 803–814. <https://doi.org/10.1037/a0020146>
- Titz, J. (2020). mimosa: A modern graphical user interface for 2-level mixed models. *Journal of Open Source Software*, 5(49), Article 2116. <https://doi.org/10.21105/joss.02116>
- Varela, F. J., Thompson, E., & Rosch, E. (2016). *The embodied mind: Cognitive science and human experience* (rev. ed.). MIT Press.
- Weinstabl, J. (2020). *Der Einfluss unterschiedlicher Meditationsarten auf Körperwahrnehmung und Emotionsregulation* [Unpublished Master's thesis].
- Wilbert, J., & Lueke, T. (2019). *scan: Single-case data analyses for single and multiple baseline designs* (R package version 0.40) [Computer software]. <https://CRAN.R-project.org/package=scan>
- Winkielman, P., Niedenthal, P., Wielgosz, J., Eelen, J., & Kavanagh, L. C. (2015). Embodiment of cognition and emotion. *APA Handbook of Personality and Social Psychology*, 1, 151–175.
- Zvolensky, M. J., Bernstein, A., & Vujanovic, A. A. (2011). *Distress tolerance: Theory, research, and clinical applications*. Guilford Press.