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REVIEW PAPER

The Effects of Mindfulness Meditation: A Meta-Analysis

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Abstract Previous meta-analyses on the effects of mindfulness meditation were predominantly concerned with clinical research. In contrast, the present study aims at giving a comprehensive overview of the effects of mindfulness meditation on various psychological variables, for meditators in nonclinical settings. Included are 39 studies that fulfilled our six selection criteria: (1) a mindfulness meditation treatment, (2) the existence of an inactive control group, (3) a population of nonclinical adults, (4) the investigation of psychological measures that were (5) assessed at temporal distance from a meditation session, and (6) the availability of sufficient data to calculate effect sizes. The dependent variables examined included, among others, attention, intelligence, self-attributed mindfulness, positive and negative emotions, emotion regulation, personality traits, self-concept, self-realization, stress, and well-being. We found an effect size of $\bar{r} = 0.27$ averaged across all studies and dependent variables. The effects differed widely across dependent variables. Moreover, we found large differences between the effect sizes reported for complete Mindfulness-based Stress Reduction (MBSR) programs vs. "pure" meditation. MBSR seems to have its most powerful effect on attaining higher psychological well-being, whereas pure mindfulness meditation studies reported the largest effects on variables associated with the concept of mindfulness. This raises the question if some effect sizes found for MBSR might be partly inflated by effects that are not attributable to its mindfulness meditation component. Future theorizing should address meditation-specific concepts more extensively to account for the changes in healthy practitioners.

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Introduction

In recent years, there has been a growing interest in the field of mindfulness meditation. This has yielded a rich collection of research results, and a quantitative overview of the effects of mindfulness meditation seems to be overdue. Our aim in the present paper is to summarize the effects found so far, with the focus on the impact of meditation for nonclinical meditators.

The term mindfulness meditation, as used in this paper, describes a special subfamily of meditation techniques that can be traced back to Buddhist traditions. Vipassana and Zen/Chan are typical examples of mindfulness meditation. Mindfulness meditation is meant to develop a special kind of mental quality: mindfulness. Mindfulness refers to the self-regulation of attention to the conscious awareness of one's immediate experiences while adopting an attitude of curiosity, openness, and acceptance (Bishop et al. 2004). Mindfulness meditation entails sitting quietly and is mainly characterized by just observing one's experiences, not creating or modifying them. The object of this observation can differ depending on the concrete meditation technique.

What effects can be expected from practicing mindfulness meditation? Since the central aim of mindfulness meditation is attaining mindfulness, this should be the main effect, yet there could well be others. These might include, for example, greater well-being, the ability to concentrate better, stress release, or developing higher mental states, such as clarity or insight. These effects might be a by-product of mindfulness meditation practice, intermediate steps on the way to becoming mindful or they might just as easily be after-effects of having developed the intended mindfulness.

To date, more than 10 qualitative and quantitative review papers on the effects of mindfulness meditation on special variables and populations have been published. The majority of these review papers refer to a medical context. We attribute this to the fact that clinical programs such as Mindfulness-based Stress Reduction (MBSR; Kabat-Zinn 1994) have been successfully used with patients with different diseases and disorders. Meanwhile, derivates of MBSR for distinct problems have evolved, such as Mindfulness-based Cognitive Therapy, which is adapted to the special needs of patients with depression (Segal et al. 2002a, b). In the following, all such interventions will be referred to as mindfulness-based interventions.

While Bishop (2002, p. 76) concluded that there is "insufficient evidence based on rigorous scientific methods to strongly recommend it [MBSR] at this time," but that "there is some preliminary evidence that suggests that this approach should be evaluated," later summaries found stronger evidence of the benefits of MBSR. Baer (2003) computed the mean effect of mindfulness-based interventions on several populations in 21 studies. She found small effect sizes for pain and other medical symptoms and medium to large effect sizes for anxiety, depression, stress, psychological functioning, and objective medical measures such as skin and urine analysis. All in all, she arrived at a mean weighted effect size of d=0.59. However, Baer also criticized methodological flaws in the literature of that time, which restricted the explanatory power of the study. Grossman et al. (2004) conducted a meta-analysis of 20 studies with different patient populations. They found medium effect sizes of MBSR on mental as well as physical health.

Hofmann et al. (2010) analyzed 39 studies on mindfulness-based therapy in respect to depression and anxiety. In a general analysis not restricted to studies with a control group but including different patient populations, they found a medium reduction in anxiety and depression. When applied to patients with anxiety or mood disorders, the effects were even larger. In contrast, only small reductions in anxiety and depression were reported in a separate analysis of studies with wait-list control groups or control groups with treatment as usual, which might, however, be the more realistic figure due to the impact of correlated measurements and additional causal factors that could have had a severe impact on the internal validity in the studies without control groups. Bohlmeijer et al. (2010), who analyzed eight randomized controlled trials on MBSR conducted with patients with chronic medical diseases (almost identical with the studies with control groups by Hofmann et al. 2010), also found quite small effects on anxiety, depression, and stress. They argued that these contrasting results might be due to their more methodologically rigorous procedure or to possible ceiling effects reported by the authors of the primary studies.

In support of this conclusion, Toneatto and Nguyen (2007) stated in a review of 15 studies with wait-list control groups on MBSR that significant effects were exclusively found in studies without an active control group. These authors stated that this could be due to the fact that MBSR operates though nonspecific effects (which might be improvements induced by meeting in a group, thinking about mental health, or expectations regarding the effects of the treatment), rather than through the postulated specific effects of the mindfulness intervention.

Two of the articles mentioned above included some studies with nonclinical populations. Baer (2003) reported an overall mean effect size of d=0.92 (four studies) averaged over all dependent measures included. Grossman et al. (2004) analyzed five studies with nonclinical samples and found a mean effect size of d=0.54 for changes in mental health. After analyzing randomized controlled trials regarding stress management in healthy people, Chiesa and Serretti (2009) concluded that MBSR had a significant effect on reduction of stress levels compared with wait-list control groups. In addition to these three meta-analyses, there are a number of narrative review papers (e.g., Chiesa et al. 2011; Ivanovski & Mahli 2007; Keng et al. 2011) that looked at nonclinical populations and found evidence of positive effects of mindfulness meditation on adaptive psychological functioning as well as on the development of attentional abilities and several cognitive measures.

Prior meta-analyses usually evaluated mindfulness meditation in the context of a mindfulness-based program such as MBSR. MBSR uses meditation as one element among others (e.g., psychoeducation). Hence, the observed effects are not unequivocally attributable to the meditation component. Additionally, MBSR evokes specific expectations since it is constructed for a specific purpose and entitled accordingly. Finally, the subjects who take part in an MBSR program are mostly meditation inexperienced.

Unfortunately, none of the prior meta-analyses examined the effects of mindfulness meditation apart from mindfulness-based interventions. Additionally, most of the previous meta-analyses were done in a clinical context. They found small to medium effects on different variables. Some of them, however, included studies with lower methodological quality, and when only studies with a control group were considered, meta-analyses found mainly small effects.

The aim of the present study is to give a comprehensive overview of the effects of mindfulness meditation on all kinds of psychological variables, focusing on meditators in nonclinical settings. Since mindfulness-based interventions consist of several elements, there may be elements other than the meditation component that are effective. Therefore, we will distinguish between studies on mindfulness-based interventions and studies on "pure" mindfulness meditation. To avoid a confusion of labels, in the following, we refer to

the latter subgroup of studies simply as "meditation" and not as "mindfulness meditation" which we use for MBSR and meditation studies combined.

Method

Data Selection

In our meta-analysis, we wanted to combine the results of studies that examined the psychological effects of mindfulness meditation in a nonclinical population. For that reason, we reanalyzed in more detail a subset of the data Sedlmeier et al. (2012) used for their meta-analysis of the psychological effects of meditation in general.

We searched for publications in the major psychological databases (PsychLit, PsychInfo, and PsychArticles) and other related databases (e.g., SSCI, Web of Science, The Cochrane Library, Academic Search Premier, ProQuest Dissertations, Google, and Google Scholar) with the descriptors "meditation," "mindfulness training," and "MBSR" as well as "mindfulness-based stress reduction." In addition, we scanned the references and citations of important (theoretical) papers, reviews, and meta-analyses. When we found references of dissertations, we additionally checked if they had been published in the meantime. We included all studies that had been published by March 2010.

To ensure the internal validity of our results, we only included studies with a control group. On the one hand, effect sizes of dependent measurements are poorly comparable to effect sizes of independent measurements as long as the correlation between the two points of measurement is not known. On the other hand, effects found in mere pre–post comparisons may be partly a result of learning or cohort effects. For that reasons, we excluded studies without a control group. Control groups in our sample were either "active" (e.g., relaxation training, cognitive therapy, etc.) or "inactive." However, the active control treatments differed strongly regarding the nonspecific effects they aim to control for and, to avoid comparing apples with oranges, these studies would have to be treated separately. Because the number of studies with an active control group was too small for a separate analysis (N=6), we only report the results for studies with inactive control groups (readers interested in a synthesis of studies comparing different kinds of meditation groups with relaxation and other active control groups may consult Sedlmeier et al. 2012). Moreover, we analyzed only studies that did not gather their data immediately after a meditation session to avoid a confounding of immediate (but short lasting) and long-term effects.

All in all, we applied the following selection criteria to the studies we could locate:

1. The study evaluated mindfulness meditation or a mindfulness-based intervention.
2. The main population consisted of nonclinical adult persons.
3. The study incorporated an inactive control group.
4. The study investigated at least one psychological measure.
5. The measurement was not taken right after a meditation session.
6. The publication provided enough data to compute effect sizes.

A flowchart of the study selection process is depicted in Fig. 1. We tried our best to include as many unpublished dissertations as possible. All in all, we found references for 66 dissertations that could have met our selection criteria. Of these, four had already been published. For 47 dissertations, it was not possible to get the manuscript. This was especially the case for older dissertations from the era of no Internet. Fifteen dissertations could be located and were examined further. Of these, four met our selection criteria and were included in the final analysis.

Data Extraction

All in all, we found 39 studies that fulfilled our six selection criteria. We recorded the following data for every analyzed study: information about the treatment under investigation (e.g., the duration of the treatment), information about the population (e.g., the meditation experience of the persons under investigation), information about the study (e.g., publication outlet, publication year, and whether the study was randomized), and information about the dependent measures used. Unfortunately, for most of the studies, we could not determine the motivation of the participants (whether they meditated for religious, spiritual, or health-related reasons), and drop-out rates were often not reported. Also the concrete treatment procedure, the topics discussed in group meetings (if applicable), and information about the frequency of meetings were not available for many studies.

The dependent variables were first categorized into specific codes by two independent raters. The resulting list of 68 codes was then summarized into 14 categories so that every category was meaningful and was used in at least three studies. Table 1 shows the 14 resulting categories.

Effect Size Calculation

For every dependent variable of every study, we computed an effect size. Because of its higher flexibility, we chose r (the correlation between group membership—meditation vs. control group—and dependent variable) over a standardized difference measure such as d. Note that measures of

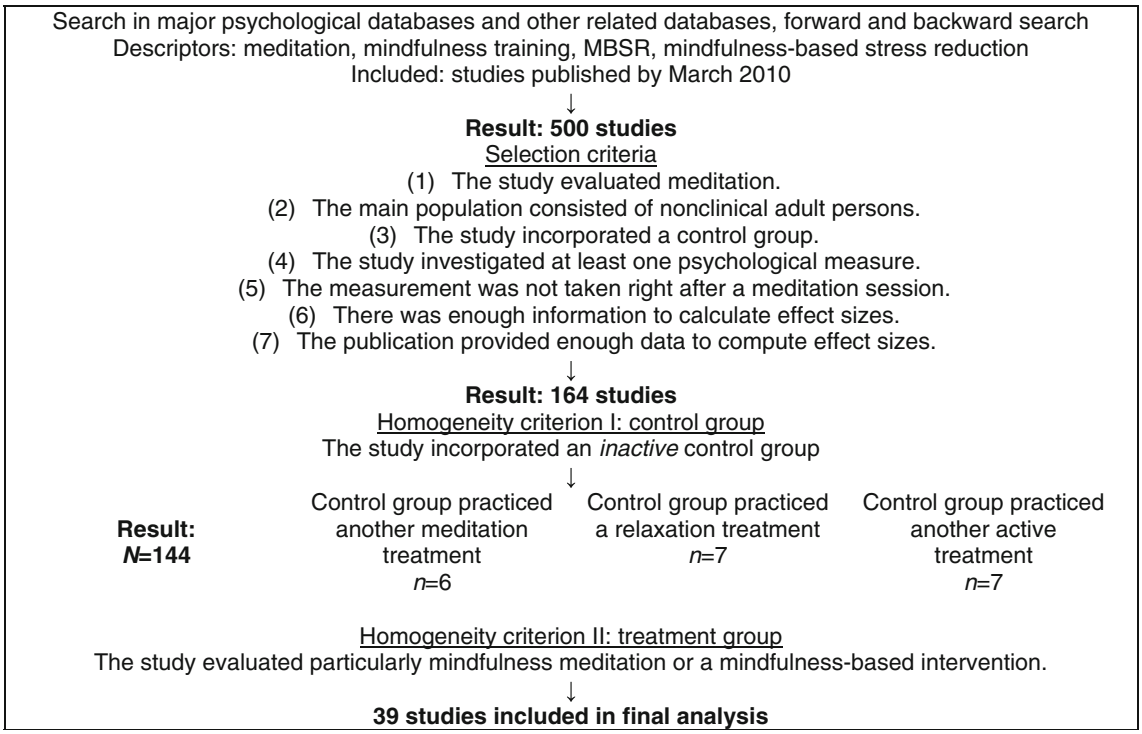

Fig. 1 Flow chart of study inclusion/exclusion process

standardized difference (g and d) can be treated as equivalent to r (e.g., Rosnow & Rosenthal 2009; Sedlmeier & Renkewitz 2008), and can be transformed into each other as illustrated in formula 4 (see below). Because r was mentioned in only a few publications, we had to compute it from the information provided.

We calculated correlations in different ways. When detailed results of significance tests were provided, we transformed these into r in the following ways. We treated results of t tests with Eq. 1. In addition, we used F tests if they compared no more than two groups, F tests of interaction (pre–post×treatment–control), and F tests from analyses of covariance (pretest as covariate) as stated in Eq. 2.

$$r = \sqrt{\frac{t^2}{t^2 + df}} \tag{1}$$

$$r = \sqrt{\frac{F}{F + df_{\text{error}}}} \tag{2}$$

If nonparametric test results had been reported, we determined the appropriate p value (one-sided) and converted it into the respective t value. Then we calculated $r_{\text{equivalent}}$ (Rosenthal & Rubin 2003), as can be seen in Eq. 3.

$$r_{\text{equivalent}} = \sqrt{\frac{t^2}{t^2 + (n-2)}} \tag{3}$$

Studies that reported standardized differences (d) were treated with Eq. 4.

$$r = \frac{d}{\sqrt{d^2 + \frac{1}{pq}}}, \tag{4}$$

where p and q are the proportional sizes of the meditation and the control group compared to the total sample size of the study (e.g., if $n_{\text{meditation}}=40$ and $n_{\text{control}}=60$, $p=0.4$ and $q=0.6$).

For studies that reported means and standard deviations, we calculated standardized differences between groups and transformed these into a correlation afterward (Eqs. 4 and 5).

$$d = \frac{\bar{x}_a - \bar{x}_b}{s_{ab}}, \text{with } s_{ab} = \sqrt{\frac{n_a s_a^2 + n_b s_b^2}{n_a + n_b}}, \tag{5}$$

where the indices a and b refer to the two groups compared.

If for mixed designs means and standard deviations for change were given, we calculated the standard differences out of these change scores and transformed them into correlations accordingly.

If for a mixed design, only means and standard deviations were given separately per point of measurement, we had to apply a more complex procedure. For the meditation group as well as the control group, we transformed the change scores into t values (for dependent means), determined their one-sided p values, and converted them into z values (Sedlmeier & Renkewitz 2008). Then, we calculated the

Table 1 Categories for the dependent measures used in the 39 studies, with the examined variables grouped into these categories

Category	Dependent measures
Anxiety (trait)	Trait anxiety
Attention	Concentration/attention, sustained attention, orienting, alerting, conflict monitoring, executive processing
Cognition	Long-term memory, working memory, learning
Emotion regulation	Emotion reactivity, positive coping strategies, positive religious coping, negative coping strategies, negative religious coping, relaxation ability
Intelligence	Intelligence, mental rotation, verbal fluency
Mindfulness	Mindfulness, state mindfulness, trait mindfulness, nonreactivity to inner experience/observing/noticing/attending to sensations, perceptions, thoughts, feelings, acting with awareness/automatic pilot/concentration/nondistraction, describing/labeling with words, nonjudging of experience, decentering
Negative emotions	Anxiety (state), negative affect (from Positive and Negative Affect Scale), Profile of Moods, anger, worry
Negative personality traits	Dominance, capacity for status, psychoticism, rigidity, other negative personality traits
Neuroticism	Neuroticism, emotional stability
Positive emotions	Positive affect (from Positive and Negative Affect Scale)
Self-concept	Self-concept, locus of control, self-compassion
Self-realization	Spirituality/spiritual experiences
Stress	Stress
Well-being	Well-being, life satisfaction, psychological well-being, depression, rumination, vigor/activity, fatigue, optimism
Other	Hope, forgiveness, cognitive distortion, financial desire discrepancy, materialistic aspirations, nonmaterialistic aspirations, reflection, various negative personality traits, psychoticism, empathy, relationship satisfaction, acceptance, relationship distress, burnout, relatedness/autonomy/closeness/sense of coherence

difference of the change scores between meditation and control groups with Eq. 6, suggested by Rosenthal and Rubin (1979). Afterward, we calculated the correlation out of the z statistic (Eq. 7).

$$z_{\text{diff}} = \frac{z_{\text{a}} - z_{\text{b}}}{\sqrt{2}} \tag{6}$$

$$r = \frac{z_{\text{diff}}}{\sqrt{N}}, \tag{7}$$

where N is the total sample size.

To compute the t values for dependent means out of means and standard deviations, the correlation between the first and the second point of measurement has to be estimated. We set this correlation to r=0.5, which allows for a rather conservative estimate of effect sizes.

Data Integration

We computed a separate meta-analysis for every dependent variable. Every sample was used no more than once per analysis. If there was more than one effect per dependent variable reported in a study, we averaged these and used the averaged score for further calculations. We tried to identify publications that used the same samples (e.g., when a research group published several papers on the same experiment under different research questions) and treated them accordingly. The main result of our analyses was the sample-size weighted mean correlation shown in Eq. 8.

$$\overline{r} = \frac{\sum_i^k N_i r_i}{\sum_i^k N_i}. \tag{8}$$

Analyses Regarding Reliability of Obtained Results

We conducted a psychometric meta-analysis as introduced by Hunter and Schmidt (1990, 2004). Note that this kind of meta-analysis is a random-effects model that does not assume all effect sizes stemming from a single population (e.g., Hedges & Olkin 1985, p. 242; Hunter & Schmidt 2000). According to that approach (and similar to the basic model in classical test theory—therefore the name of the method), the variance of the obtained effect sizes (Eq. 9) can be split into the variance due to sampling error (Eq. 10) and the variance in the "true" effect size (population variance, Eq. 11).

$$s_r^2 = \frac{\sum \left[N_i \left(r_i - \overline{r} \right)^2 \right]}{\sum N_i} \tag{9}$$

$$\sigma_e^2 = \frac{\left(1 - \overline{r}^2\right)^2}{\overline{N} - 1} \tag{10}$$

$$\sigma_\rho^2 = s_r^2 - \sigma_e^2 \tag{11}$$

If all effect sizes stem from one single population, then there should be no population variance. This means that the obtained variance of effect sizes is completely attributable to the sampling error. In this case, the model simplifies to a fixed-effects model, which assumes that there is only one population effect that underlies all studies in the meta-analysis (e.g., Hunter & Schmidt 2004, p. 202). A substantial population variance indicates that different population effects have been combined in the analysis. If this is the case, one has to conduct a theory-guided search for subgroups and analyze these again. If this analysis then yields substantially smaller population variances, statements about the respective populations can be made.

Funnel Plot

To display potential selection biases, we additionally used a graphical method, the funnel plot (Egger et al. 1997). A funnel plot is a scatterplot that shows the distribution of studies for the variables effect size (on the *x*-axis) and sample size (on the *y*-axis). Since larger samples provide better estimates of the "true" effect than smaller samples, one would expect the emerging pattern to be similar to a reversed funnel. Deviations from that pattern indicate biases, for example, a publication bias, if studies with small sample size and low-effect size are missing.

Illustration of Variable Relationships

Where applicable, we created scatterplots with locally weighted scatterplot smoother (LOWESS) curves to investigate the specific relationships between variables. LOWESS is a procedure to fit a curve into a linearly or nonlinearly associated pair of variables (see Cleveland 1985). For every data point, an individual regression line is calculated that takes into account a specified percentage of neighboring data points (we used 99 %) and weighs their influence by their distance to that point. The regression lines are then used to adjust the value of each single data point, resulting in a "smoothed" regression line across all the data points that need not be linear. The usual regression line can be seen as a special case of a LOWESS curve where all data points are used and where the distance between neighboring points is not taken into account.

Statistical Inference

Statistical inference does not make so much sense in a meta-analysis because the effect sizes that go into the analysis already provide an empirical sampling distribution (see also Hunter & Schmidt 1990). However, confidence intervals for combined effect sizes, especially if they are graphically displayed, might be regarded as a useful method of statistical inference in a meta-analysis. We calculated 95 % confidence intervals (CIs) using Eq. 12, as suggested by Schmidt et al. (2009).

$$\mathrm{CI}_{95\,\%} = \bar{r} \pm 1.96 \frac{s_r^2}{\sqrt{k}} \tag{12}$$

In Eq. 12, s^2_r denotes the obtained variance of effect sizes in the sample of effect sizes in the meta-analysis taken from the psychometric meta-analysis introduced by Hunter and Schmidt (1990), and k designates the number of studies included.

An inspection of the graphically displayed CIs also provides a means for "visual significance testing." As a rule, if CIs do not overlap by more than 50 %, this is equivalent to obtaining a significant test result at α=0.05, and if intervals do not overlap at all, one could conclude that the respective test would be significant at an α=0.01 (see Cumming 2012; Cumming and Finch 2005). Thus, non-overlapping CIs for comparisons of any kind can be seen as providing convincing evidence for respective population differences.

Results

The aim of this study was to give a broad overview over the psychological effects obtained in mindfulness meditation. In all, we found 39 studies that met our selection criteria. They reported a weighted mean effect size of $\bar{r} = 0.25$ ($\sigma^2_\rho = 0.0043$).

We wanted to know if the obtained mean effect size might be biased by selective publishing or other influences. The funnel plot (Fig. 2) shows a single large study on the left side of the mean. Because this might have been an outlier, we performed a psychometric meta-analysis without it and obtained $\sigma^2_\rho = 0.0013$, which indicates that the result found in this single study was responsible for 70 % of the originally obtained population variance. This, in turn, indicates that it might stem from a different population. This study (for detailed information see the entry for Kobarg (2007) in Table 3) also had a methodological particularity: half of the participants were recruited by e-mail and completed the questionnaire online. Still, this is an unusual procedure in meditation research, which might have been responsible for the deviating results (Birnbaum 2000). For the sake of homogeneity, we excluded the study from further analyses. Without the excluded study, the overall effect of meditation is $\bar{r} = 0.27$.

Next, we wanted to examine if there was a publication bias in our data. Publication bias means that small studies with low or opposite effects are less likely to be published, because either researchers do not submit them or reviewers reject them for methodological reasons or restricted validity. In contrast, small studies with very high effect sizes have a

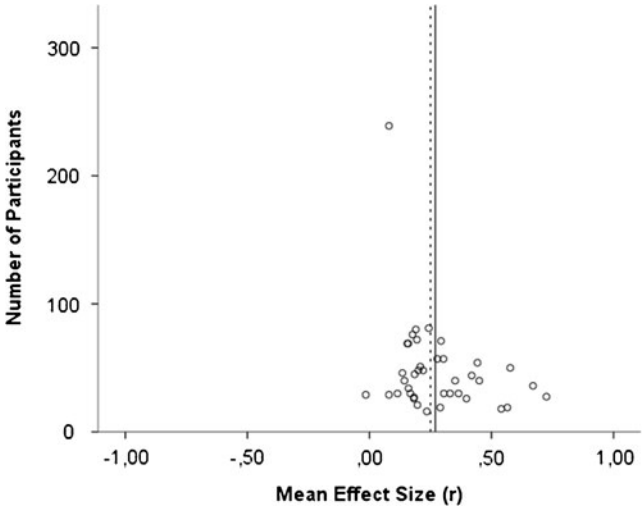

Fig. 2 Funnel plot of all effect sizes (n=39). The x-axis represents the weighted mean correlation of a study and the y-axis represents the sample size. The weighted mean effect size is represented by a *broken line* for all studies included and by a *solid line* for all studies except the outlier in the *top-left corner*

higher probability of getting published. A publication bias can be recognized by a missing left tail of a funnel plot. Our funnel plot (Fig. 2) indicates a small publication bias. Negative effects especially seem not to have been published.

The overall mean effect size is not very meaningful since this index includes a number of different dependent variables. For a better understanding of the effects of meditation, we conducted separate meta-analyses for different categories of dependent variables. As can be seen in Fig. 3, the effect that mindfulness meditation (all k=38 studies) exerts on the different psychological variables is consistently small to medium sized. The strongest effects can be observed in improvements of negative personality traits ($\overline{r} = 0.40$), stress reduction ($\overline{r} = 0.37$), self-attributed mindfulness ($\overline{r} = 0.34$), intelligence $\overline{r} = 0.34$, neuroticism $\overline{r} = 0.32$, well-being ($\overline{r} = 0.31$), and attention ($\overline{r} = 0.30$). The precise results of all categories with their corresponding sample sizes and variances are listed in Table 4.

Moderator Analyses

As already mentioned above, we conducted a psychometric meta-analysis on the overall effect and obtained a population variance of $\sigma_\rho^2 = 0.0013$, which is relatively low. Nevertheless, we analyzed the data regarding possible moderators for the magnitude of the effect sizes. The most evident possible moderator is the kind of treatment.

About half of the studies evaluated the MBSR program or derivates of it (to simplify matters, hereafter referred to as MBSR). The second half studied "pure" mindfulness meditation by taking "real"/"authentic" meditators from meditation centers or by having participants meditate within an experimental setting. Because meditation is just one component of a full MBSR program, and therefore, additional active elements can be assumed, we report both the effects for all studies and the effects for the two groups separately. The overall weighted mean effect of MBSR found in the included studies is $\overline{r} = 0.31\,(k = 17)$. Studies investigating meditation reported a weighted mean effect of $\overline{r} = 0.25\,(k = 21)$, which is far below the results of MBSR. The included studies and their details are listed in Table 2 for the MBSR-studies and in Table 3 the for meditation studies.

If the two kinds of treatment, MBSR and meditation, are looked at separately, the population variance drops to $\sigma_\rho^2 < 0$ for MBSR and $\sigma_\rho^2 = 0.0011$ for the meditation treatments. We conducted separate analyses of the dependent variables in the two conditions. The results for all variables studied in more than three investigations are shown in Fig. 4. The dependent variables that were examined in at least three

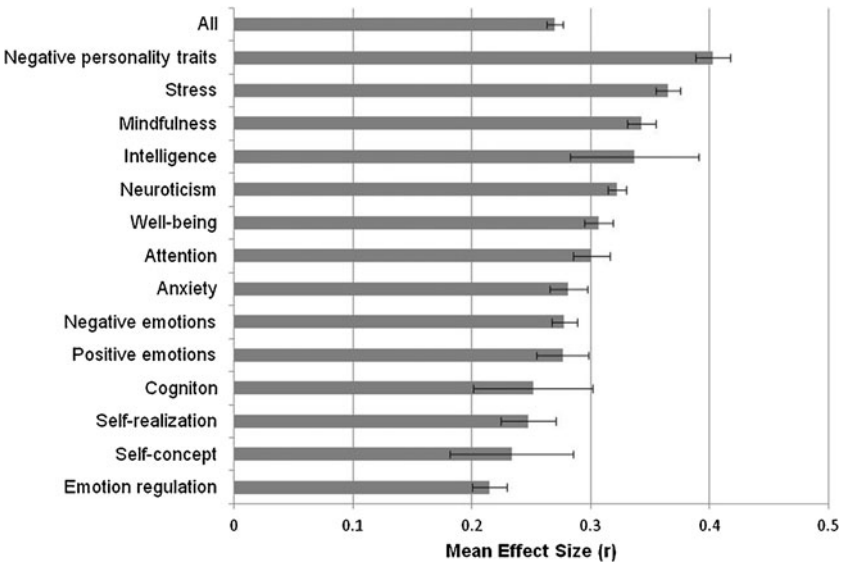

Fig. 3 Effects of mindfulness meditation for specific categories of dependent measures. Shown are effect sizes ($\overline{r}$) and 95 % confidence intervals (CIs) for all dependent measures that were used in three or more studies. Please note that inferences on significance are somewhat limited if the sizes of the two CIs to be compared differ by more than a factor of 2 (Cumming and Finch 2005). The category mindfulness comprises different questionnaires of self-attributed mindfulness

Table 2 Included studies on MBSR with the respective study characteristics

Study	Method	Mean meditation experience (months)	Duration of treatment (days)	Randomization	Source	Mean effect size (*r*)	*N*
Anderson et al. (2007)	MBSR	0	56	Yes	Journal	0.19	72
Astin (1997)	Mindfulness meditation, in the style of MBSR	0	56	Yes	Journal	0.57	19
Carson et al. (2004)	MBSR, adapted to the specific needs of couples	0	56	Yes	Journal	0.42	44
Ernst (2008)	MBSR, adapted to the specific needs of disabled persons	0	56	No	Dissertation	0.24	16
Heeren et al. (2009)	MBCT	0	49	No	Journal	0.67	36
Jain et al. (2007)	Shortened version of MBSR	0	28	Yes	Journal	0.28	57
Jha et al. (2010)	MBSR, adapted to the specific needs of athleths	0	56	No	Journal	0.13	46
Klatt et al. (2009)	Shortened version of MBSR	0	42	Yes	Journal	0.22	48
MacKenzie et al. (2006)	Shortened version of MBSR	0	28	Yes	Journal	0.33	30
Morone et al. (2008)	MBSR	0	56	Yes	Journal	0.17	30
Nyklicek & Kuipers (2008)	MBSR	0	56	Yes	Journal	0.30	57
Oman et al. (2008)	MBSR	60 % had none	56	Yes	Journal	0.12	30
Shapiro et al. (1998)	MBSR	0	56	Yes	Journal	0.29	71
Shapiro et al. (2007)	MBSR	0	56	No	Journal	0.44	54
Shapiro et al. (2008)	MBSR without retreat day	68 % had none	56	Yes	Journal	0.31	30
Tacon et al. (2003)	MBSR	0	56	Yes	Journal	0.54	18
Walach et al. (2007)	MBSR, adapted to the specific needs of working people	No data	56	No	Journal	0.18	27

MBCT Mindfulness-based Cognitive Therapy

MBSR studies were stress reduction, well-being, positive and negative emotions, anxiety, self-attributed mindfulness, self-realization and emotion regulation. For attention, self-concept, and cognition there were not enough studies for a separate analysis. MBSR exerts the strongest effects on well-being ($\bar{r} = 0.37$, $k = 10$), stress ($\bar{r} = 0.37$, $k = 6$), negative emotions ($\bar{r} = 0.32$, $k = 9$), and anxiety ($\bar{r} = 0.30$, $k = 5$). For the meditation studies, the examined dependent variables were well-being, negative emotions, anxiety, self-attributed mindfulness, attention, self-concept, and cognition. Stress reduction, positive emotions, self-realization, and emotion regulation were not considered in more than two studies. The strongest effects can be observed with self-attributed mindfulness ($\bar{r} = 0.37$, $k = 7$), attention ($\bar{r} = 0.30$, $k = 8$), and anxiety ($\bar{r} = 0.26$, $k = 4$). The exact values can be found in Table 4.

To detect the impact of further moderator variables, we regressed the mean effect size of every study to all information that was obtainable for most of the studies. This included publication year, the source of publication (journal or other), the number of participants, whether the participants were randomly assigned to treatment or control group, the kind of treatment (MBSR or other), the duration of the treatment, and the meditation experience of the meditation group. Table 5 lists the standardized regression coefficients of these variables for all studies combined and, additionally, separated by the kind of treatment. The source of publication is excluded in the analyses of MBSR and meditation studies, because almost all of the studies were published in journals. In the combined analysis, the two experience variables, duration of meditation treatment, and prior meditation experience were excluded because of multicollinearity with other variables. Table 5 shows four moderators with $\beta > 0.3$, though not significant (due to low statistical power): publication year, randomization of the study, meditation experience, and duration of the treatment. The effect sizes of newer studies seem to be lower, as well as the effect sizes of randomized studies. In addition, studies with longer treatments and studies with more experienced practitioners reported lower effect sizes. It clearly made no difference which source reported the study (journal or dissertation). Furthermore, in this general analysis with all dependent measures combined, it made no difference which kind of treatment (MBSR or meditation) was applied. In the following paragraphs, we will describe the possible moderators ($\beta > |0.3|$) in more detail.

Publication Year The reported effect sizes decrease over time ($r = -0.28$, $p = 0.084$, see Fig. 5). More precisely, summed up to the year 2000 the mean weighted effect size was $\bar{r} = 0.34$ ($k = 8$ studies) and in the following 5 years, it was even higher ($\bar{r} = 0.42$, $k = 3$). Afterward, it dropped to $\bar{r} = 0.26$ ($k = 11$) between the years 2005 and 2007 and to $\bar{r} = 0.24$ ($k = 16$) in the interval from 2008 to 2010. This

Table 3 Included studies on meditation with the respective study characteristics

Study	Method	Mean meditation experience (months)	Duration of treatment (days)	Randomization	Source	Mean Effect Size (*r*)	*N*
Alexander et al. (1989)	Instructions according Meditation Society	0	91	Yes	Journal	0.37	30
Brown et al. (1984)	Sayadaw retreat	58.10	91	No	Journal	0.20	48
Brown et al. (2009)	Retreat	13.5	30	Yes	Journal	0.16	69
Chambers et al. (2008)	Meditation course in a meditation center	No data	10	No	Journal	0.35	40
Chan & Woollacott (2007)	Vipassana, Tibetan Buddhist meditations	No data	–	No	Journal	0.14	40
Chang et al. (2004)	Chan (Zen) meditation	0	56	Yes	Journal	0.29	19
Cowger & Torrance (1982)	Zazen	No data	28	No	Journal	0.16	34
De Grace (1976)	Zen meditation	No data	154	No	Journal	0.73	28
Falkenström (2010)	Vipassana	162	6	No	Journal	0.18	76
Grant & Rainville (2009)	Zen	208	–	No	Journal	0.18	26
Jha et al. (2007)	Mindfulness of breathing, to bodily sensations, and while walking	0	56	No	Journal	0.21	51
Kobarg (2007)[a]	Shamatha, Vipshyana	135	–	No	Dissertation	0.08	239
Kozhevnikov et al. (2009)	Open presence	180	–	No data	Journal	−0.02	29
Lesh (1970)	Zazen	No data	28	Yes	Journal	0.20	21
Moore and Malinowski (2009)	Buddhist meditators from a local Buddhist center	No data	–	No	Journal	0.58	50
Ortner et al. (2007)	Mindfulness of breathing or use of mantra, watching thoughts and emotions with acceptance and without judgment	No data	–	Yes	Journal	0.19	45
Orzech et al. (2009)	Retreat	162	30	No	Journal	0.16	69
Pagnoni and Cekic (2007)	Zen	Min. 36	–	No	Journal	0.40	26
Reis (2008)	Mindfulness meditation	119	–	No	Dissertation	0.24	81
Sears & Kraus (2009)	Mindful attention practice focused on awareness of breath, sounds, and bodily sensations	No data	84	No	Journal	0.08	29
Valentine & Sweet (1999)	Member of a Buddhist center	25	–	No	Journal	0.45	40
Wilson (2009)	Zen	189	–	No	Dissertation	0.19	80

[a] Study had to be excluded

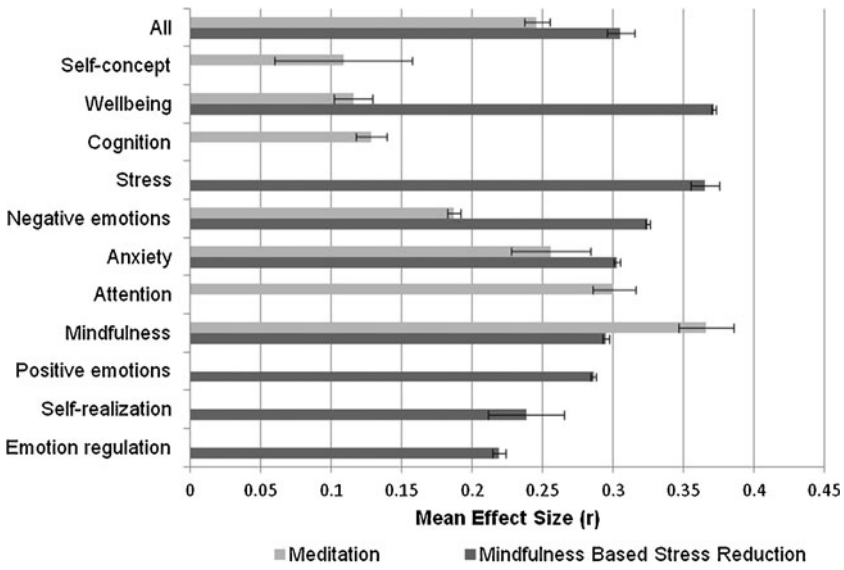

Fig. 4 Differential effects of the kind of treatment (MBSR vs. meditation) for specific categories of dependent measures. Shown are effect sizes ($\bar{r}$) and 95 % CIs for all dependent measures that were used in three or more studies. Please note that inferences on significance are somewhat limited if the sizes of the two CIs to be compared differ by more than a factor of 2 (Cumming and Finch 2005). The category mindfulness comprises different questionnaires of self-attributed mindfulness

Table 4 Mean weighted effect sizes ($\bar{r}$), number of studies (k), total sample size (N), and the three components of psychometric meta-analysis (s^2, σ_e^2, and σ_ρ^2) separately for all categories of dependent variables used in the meta-analysis for all studies, MBSR studies, and meditation studies

Variable	All						MBSR						Meditation					
	$\bar{r}$	k	N	s_r^2	σ^2_e	σ^2_ρ	$\bar{r}$	k	N	s_r^2	σ^2_e	σ^2_ρ	$\bar{r}$	k	N	s_r^2	σ^2_e	σ^2_ρ
All	0.2698	38	1616	0.0220	0.0207	0.0013	0.3053	17	668	0.0203	0.0215	<0[a]	0.2458	21	948	0.0211	0.0200	0.0011
Anxiety	0.2810	9	454	0.0244	0.0172	0.0072	0.3026	5	245	0.0195	0.0172	0.0023	0.2557	4	209	0.0289	0.0170	0.0118
Attention	0.3006	8	347	0.0223	0.0195	0.0028							0.3006	8	347	0.0223	0.0195	0.0028
Cognition	0.2513	4	141	0.0509	0.0256	0.0253							0.1284	3	105	0.0096	0.0284	<0[a]
Emotion regulation	0.2148	6	205	0.0186	0.0274	<0[a]	0.2189	5	160	0.0238	0.0292	<0[a]						
Intelligence	0.3365	3	146	0.0478	0.0165	0.0313												
Negative emotions	0.2778	13	663	0.0203	0.0171	0.0033	0.3244	9	438	0.0228	0.0168	0.0060	0.1871	4	225	0.0045	0.0169	<0[a]
Negative personality traits	0.4028	3	97	0.0127	0.0224	<0[a]												
Neuroticism	0.3219	3	144	0.0067	0.0171	<0[a]												
Positive emotions	0.2762	5	257	0.0194	0.0169	0.0025	0.286	4	212	0.0230	0.0162	0.0068						
Self-attributed mindfulness	0.3427	11	576	0.0199	0.0152	0.0047	0.2949	4	189	0.0035	0.0180	<0[a]	0.3661	7	387	0.0263	0.0138	0.0125
Self-concept	0.2335	6	238	0.0648	0.0228	0.0421							0.1087	4	165	0.0496	0.0243	0.0253
Self-realization	0.2472	6	242	0.0289	0.0224	0.0065	0.2384	5	221	0.0307	0.0206	0.0101						
Stress	0.3653	6	331	0.0128	0.0139	<0[a]	0.3653	6	331	0.0128	0.0139	<0[a]						
Wellbeing	0.3066	13	604	0.0215	0.0181	0.0035	0.3718	10	450	0.0080	0.0169	<0[a]	0.1158	3	154	0.0120	0.0193	<0[a]

[a] A drop in the unexplained variance below zero is technically possible with the kind of calculation used. It can, however, be interpreted as all variance is explained by sampling error and there is no additional variance due to other sources, e.g., moderators (see Hunter & Schmidt 1990, p. 109)

Table 5 Standardized coefficients of the moderator analysis

	All studies		MBSR studies		Meditation studies	
	N=38		N=17		N=13[a], N=8[b]	
	R^2=15.8 %		R^2=31.5 %		R^2=57.1 %[a], 93.2 %[b]	
	Beta	p	Beta	p	Beta	p
Publication year	−0.297	0.124	−0.534	0.079	−0.582[a]	0.143[a]
					−0.445[b]	0.105[b]
Source of publication	0.084	0.641				
Number of participants	−0.120	0.518	−0.121	0.649	−0.396[a]	0.302[a]
					−0.231[b]	0.255[b]
Randomization	−0.185	0.350	−0.351	0.275	0.106[a]	0.741[a]
					−0.443[b]	0.071[b]
Kind of treatment	0.263	0.206				
Duration of treatment			−0.372	0.204	−0.665[a]	0.091[a]
Meditation experience					−0.424[b]	0.108[b]

[a]Model 1 includes studies evaluating a meditation course or retreat

[b]Model 2 includes studies comparing meditators to nonmeditators

analysis used all available variables. For the five variables measured in every period of time, we analyzed the relationship between the magnitude of the effect sizes and the year of publication separately. For anxiety and well-being, the influence that the year of publication exerts on the magnitude of the reported effect size is even stronger than its influence on the overall effect (r=−0.40 and r=−0.53 with k=13 and k=9, respectively). For attention, negative emotions, and stress reduction, an effect of this kind was not found (r=−0.03, r=+0.01, r=−0.05 with k=8, k=13 and k=6, respectively). Thus, it seems that the overall negative relationship between year of publication and effect size (effect sizes decrease over the years) might be in part an artifact obtained by aggregating over all kinds of dependent variables. On the level of single dependent variables, the effect of the publication year seems to depend on variable contents.

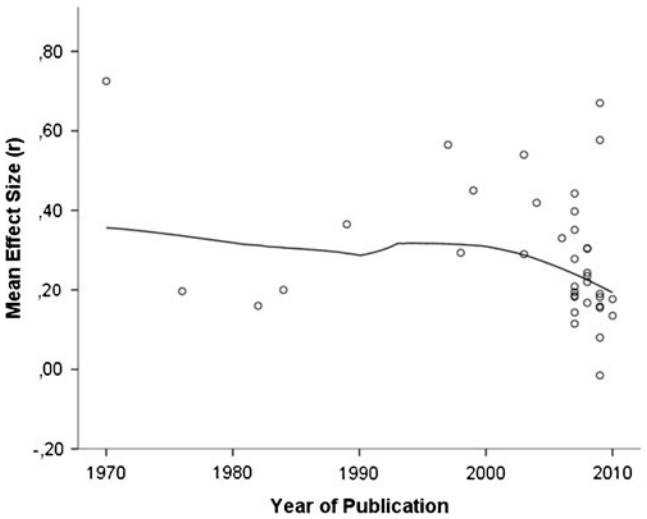

Fig. 5 Relationship between year of publication and effect sizes. Shown is a LOWESS curve for the n=38 studies (tension=0.99)

Randomization In the sample of the studies we analyzed, randomized studies reported a lower mean effect size than studies that were not randomized. Figure 6 shows the difference between the weighted mean effect sizes for randomized and nonrandomized studies, separately for MBSR and meditation studies. The mean weighted effect size for randomized studies was $\bar{r} = 0.29$ (MBSR evaluations, k=12) and $\bar{r} = 0.22$ (meditation studies, k=5) whereas the mean weighted effect size for nonrandomized studies was $\bar{r} = 0.36$ (MBSR evaluations, k=5) and $\bar{r} = 0.26$ (meditation studies, k=15). For both randomized and nonrandomized studies overall and within the two treatment categories, the difference is significant, as can be seen by the confidence intervals that do not overlap. However, the influence of randomization was remarkably smaller when we controlled for other potential moderator variables (β=−0.19, p=0.35, k=38).

Meditation Experience The duration of the treatment applied to participants and the meditation experience of the practitioners under investigation seem to be substantial predictors in terms of effect sizes (but not in terms of statistical significance, due to low power) when controlled for publication year, number of participants, randomization, and the kind of treatment examined. The duration of treatment had an influence corresponding to β=−0.37 for MBSR studies (p=0.2, k=17) and to β=−0.67 for meditation studies (p=0.09, k=13) whereas the prior meditation experience of participants had an influence amounting to β=−0.42 in cross-sectional meditation studies (p=0.11, k=8). The

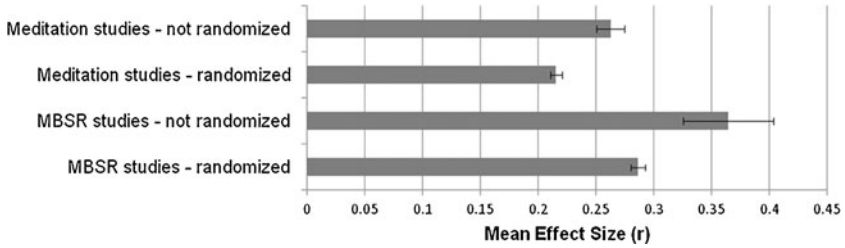

Fig. 6 Effects (averaged over all available dependent measures) of meditation separated by the kind of treatment (MBSR vs. meditation) and whether studies used randomized groups or not. Shown are weighted mean effect sizes (correlations) and 95 % CIs. Please note that inferences on significance are somewhat limited if the sizes of the two CIs to be compared differ by more than a factor of 2

missing significance is not surprising when we take the low sample size into account (see Table 5). Interestingly, the influence shows an unexpected direction. In Fig. 7, we plotted the mean effect size of a study against the treatment duration. Additionally, we made a distinction between MBSR and meditation treatments. It turns out that at least the negative relationship for the MBSR studies could be a methodological artifact due to one outlier: a single long-term study that reported lower effects (see Fig. 7). For the meditation studies, the uncorrected correlation is close to zero (r=−0.12, k=12, see Fig. 7) but if other variables are controlled for the relationship becomes markedly negative (see Table 5). For meditation experience, we provide no scatterplot because there were not enough data. The uncorrected correlation between meditation experience and the effect observed in a study was r=−0.34, p=0.41 (k=8 studies). This negative relationship even increased, but did not become significant, when controlled for the other potential moderator variables (β=−0.42, p=0.11).

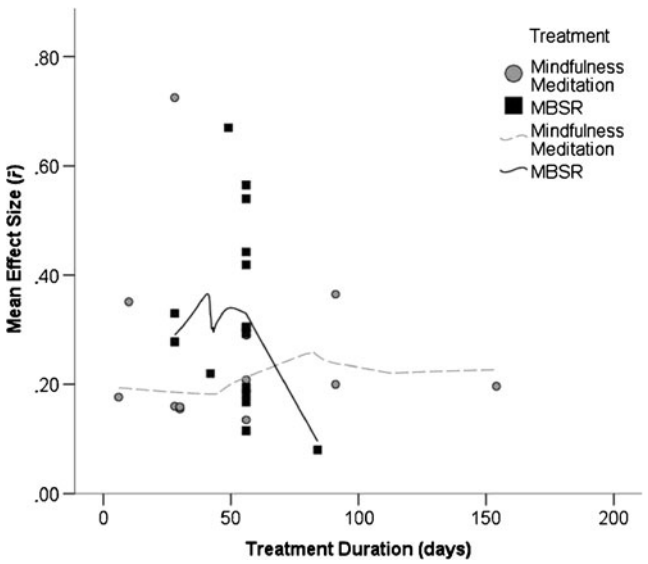

Fig. 7 Relationship between the duration of treatment in days and the effect sizes that express the differences in gains for treatment (meditators) and no-treatment groups. Shown is a LOWESS curve for the n=17 studies that evaluated an MBSR program and the n=12 studies that evaluated a particular meditation treatment (tension=0.99)

Discussion

What have we learned about the effects of mindfulness meditation by now? In our meta-analysis, we found a weighted mean correlation of $\bar{r} = 0.27$, which corresponds to d=0.56 (for comparison with earlier summaries that mainly used d, we occasionally report both effect sizes). The studies included in our meta-analysis examined 14 categories of psychological effects of meditation: anxiety, attention, cognition, emotion regulation, intelligence, self-attributed mindfulness, negative emotions, negative personality traits, neuroticism, well-being, positive emotions, self-concept, self-realization, and stress. Regarding the dependent variables, the effects range from $\bar{r} = 0.21$ for improvements in emotion regulation to $\bar{r} = 0.40$ for improvements in negative personality traits. The effects might have been moderated by the year of publication and the treatment under investigation as well as meditation experience.

Probably the most interesting finding is the large difference in the effect sizes reported for MBSR versus mindfulness meditation offered by meditation centers or by the researchers themselves. The larger effects of MBSR might indicate that MBSR does not exclusively work through the mindfulness intervention but also through additional factors such as psychoeducation or specific expectations of the participants. A second reason for this difference might be methodological variations in the studies investigating the two kinds of treatment. Studies evaluating MBSR more often use inexperienced participants (100 % vs. 17 % in the meditation studies reported here) who still had a high potential for improvement, and they examined particular variables. In addition, people attending an MBSR course advertised for stress reduction might also differ from people visiting a meditation center to attain wisdom or higher mental states. This bias might even be increased by the fact that most of the examined variables do not focus on higher mental states but on psychological health. A psychologically healthy person who prefers an “authentic” meditation

course over an MBSR course might not be able to improve much on these variables due to a ceiling effect.

With these differences in mind, let us look at the main effects of the two treatments. MBSR seems to have its main effect on attaining higher psychological well-being. Strong effects were reported regarding stress reduction, experiencing less negative emotions and greater well-being, and suffering less from anxiety. In studies on pure mindfulness meditation, the main effects were found with variables concerned with the concept of mindfulness, that is, self-attributed mindfulness as operationalized in several mindfulness scales, attention, and anxiety. Far smaller effects were observed regarding negative emotions and well-being, which were very strong for MBSR. The large effects for MBSR on these variables could perhaps be attributed to other effective components of MBSR than mindfulness meditation. In the following, we will deal with these findings in more detail. Thereafter, we will discuss some methodological problems in the primary studies underlying this meta-analysis.

Stress Reduction Our analysis reveals that one of the strongest effects of MBSR is on stress reduction. Unfortunately, we cannot compare the effects reported in MBSR evaluations to the effects reported in meditation studies, because there were too few relevant studies in the latter category. Our result is partly consistent with the findings of Bohlmeijer et al. (2010), who also found an effect of MBSR on stress reduction in randomized controlled trials with patients suffering from chronic diseases, although a somewhat smaller one (d=0.32 in their analysis vs. d=0.78 in our analysis). Carmody and Baer (2009) reported an effect of MBSR on stress reduction in nonclinical populations almost similar to ours (d=0.66). Apart from that one should keep in mind that MBSR deliberately aims at reducing stress and therefore, most of the participants chose the program because they hoped to reduce their subjective stress level and they expected the program to have that effect. This means the obtained effect sizes might be partly inflated by some effects that are not attributable to meditation.

Mindfulness We expected mindfulness meditation to elicit the greatest changes in self-attributed mindfulness, and this was indeed found for the meditation studies ($\bar{r} = 0.37$, $d = 0.73$), but not for the MBSR studies. Self-attributed mindfulness is the only variable that is more strongly influenced by meditation alone than by participating in an MBSR course. This indicates that the effects of MBSR on psychological well-being, which are found to a remarkably lower extent with meditation alone, may not be caused by the increasing mindfulness but by other elements of the program. On the other hand, authentic meditators might be better able to bias their mindfulness ratings since they might have dealt more intensively with the Buddhist literature and therefore be more familiar with the concept of mindfulness. A particular problem with mindfulness is the difficulty to observe and therefore to operationalize it. Even subjective information is challengeable since people who are not mindful do not recognize that they are not mindful—especially at the beginning of their mindfulness training. In addition, the understanding of what is "really mindful" might change with increasing meditation experience. And there are further difficulties: according to the western (scientific) point of view, mindfulness might be conceptualized as a trainable ability or as a specific mental state. In the countries of origin (and therefore also for some authentic meditators but not for participants of MBSR courses), mindfulness constitutes an attitude toward life and is closely linked to phenomena such as morality and wisdom (Christopher et al. 2009). The valid measurement of mindfulness seems to remain a challenging task for further research.

Enhancement of Well-Being and Reduction of Negative Emotions Clinical studies on mindfulness-based interventions did not investigate well-being but rather depression, which can be seen as the opposite of mental well-being. Hofmann et al. (2010) found a medium effect of mindfulness-based therapy on depression (g=0.59)[1]. Bohlmeijer et al. (2010) found a rather small effect (d=0.26) when considering only randomized controlled trials with chronic patients. According to our analysis, MBSR (but not so much mindfulness meditation, with its rather low effect of d=0.23), leads to enhanced well-being (d=0.80) in nonpatient samples. The difference between the effects of MBSR and pure meditation indicates that the meditation component may not be the main mediating factor in the effect MBSR exerts on well-being.

The two meta-analyses on MBSR mentioned above also examined anxiety as a dependent measure. Hofmann et al. (2010) reported a mean reduction of anxiety of g=0.63, which is comparable to our result in nonclinical samples (d=0.64 for MBSR and d=0.53 for meditation alone). Bohlmeijer et al. (2010) found a small effect with chronic patients (d=0.47 with all studies included and d=0.24 with "high-quality studies"). It seems that mindfulness meditation is able to reduce trait anxiety of nonclinical persons, probably to an even greater extent than it can reduce the anxiety of patients suffering chronic diseases.

Meditation Experience A quite puzzling result of our meta-analysis is the missing influence of meditation experience on the obtained effect size. We expected something like a training

[1] The effect sizes g and d can be interpreted in the same way, although g is generally slightly smaller than d, especially with small sample sizes, because it uses estimated population variances instead of sample variances.

effect but found no such relationship—neither between the effect size and the duration of the training applied within the study nor between the effect size and the accumulated lifetime meditation experience. Similar phenomena have been mentioned in the literature on MBSR. In a review of 24 empirical MBSR studies in clinical and nonclinical contexts, Vettese et al. (2009) found that almost half of those investigations could not find an association between the participants' actual amount of meditation practice and outcomes. Likewise, in a meta-analysis of 30 MBSR evaluation studies, Carmody and Baer (2009) reported that there was no association between class contact hours and the effect obtained regarding stress reduction. It seems that meditation has an observable effect right after starting to practice, but this effect does not increase with continuing practice time. What could be the reason for this finding?

First, it might be a methodological artifact we introduced by having unduly and unintentionally combined different kinds of studies. But it is not inevitable that this would be the predominant reason for the finding, as we will show in the following. Particularly, there might be a strong initial effect of meditation that leads to a jump in the scores of different variables right after starting to meditate. This initial effect might be, for example, new attitudes and perspectives, a new way of thinking, or a new world view the participants get to know. Examples of this could be that novices learn about "no-self" or the concept of "auto-pilot." Such new (admittedly cognitive) insights could change the scores on different variables in an immediate and enduring fashion.

Second, there might be methodological problems in the primary studies that account for the findings. Studies investigating highly experienced practitioners may have gathered variables just loosely connected to theoretical expectations about alterations that come about on higher levels of experience. This is of particular importance for the studies on mindfulness meditation as (some of) the authentic meditators practice for reasons other than losing fear or attaining greater well-being. As noted above, within such variables ceiling effects are eventually to be expected. According to religious writings, it is, for example, in wisdom or clarity where we could expect changes. But these variables are scarcely captured, perhaps in part due to severe difficulties in operationalizing these very subjective and fuzzy concepts. We hope that in the coming years, there will be more research on the mind-widening effects of meditation that might reveal associations between meditation experience and the magnitude of respective effect sizes.

Alternative Explanations The results of a meta-analysis are at best only as good as the included primary studies. For this reason, we have to point out that there are several alternative explanations for the positive effects found in studies on mindfulness meditation. First, we did not include unpublished material other than unpublished dissertations, for which the results were not different from the published studies. The inclusion of unpublished projects, studies, or pilots might have led to lower estimates of the population effects reported here, and indeed, the funnel plot shown in Fig. 1 might be interpreted as indicating some publication bias. However, the distribution in Fig. 1 also indicates that the size of such a bias, if it exists, is probably quite small and does not invalidate our general findings.

Secondly, placebo and other expectancy effects should be taken into consideration. These expectations might be the motivation to begin meditation practice but they can also be evoked by course leaders, meditation instructions, or pretest measurement. Additionally, the expectations of meditation teachers and course instructors may have a strong impact on the outcomes (Rosenthal & Jacobson 1966). As mentioned above, self-selection effects might have biased the results in some direction. And in particular, with courses that are offered for payment, cognitive dissonance effects can occur (Festinger & Carlsmith 1959). All these effects can be controlled for when active control groups are used. Unfortunately, to date, for published material, this was not often the case. We found six studies that compared mindfulness meditation to a relaxation treatment, cognitive therapy, or a different meditation technique. Because these were not enough studies to conduct a separate analysis, we had to exclude the studies with the best methodology to extract the specific effects of mindfulness meditation. However, extracting specific effects was not the central aim of our work. We wanted to give an overview of the effects of mindfulness meditation, regardless of why these effects occur. Nevertheless, it will be a most interesting question for future research to figure out if there are meditation-specific effects or if the effects can be fully explained by known processes.

Conclusion

In our meta-analysis of controlled studies investigating the effect of mindfulness meditation on psychological variables, we found small- to medium-sized effects on a variety of variables. It seems that MBSR programs, which include a meditation component, have their strongest effects on psychological well-being, whereas pure mindfulness meditation affects mindfulness-related variables the most. To date, many studies have been published that examined the effect of mindfulness meditation on conventional psychological variables. Future theorizing should lead to more precise predictions about what to expect from meditation and therefore also to more precise dependent measures, including those that attempt to measure mindfulness.

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