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Linnéuniversitetet
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Examensarbete

Mindfulness and working memory

Evaluating short-term meditation effects on working memory related tasks and self-reported health benefits

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Abstract

Effekten av kortsiktig meditation är omdiskuterad. Det finns studier som indikerar att det inte finns någon eller limiterad effekt. Tidigare forskning kring meditation har också visat positiva effekter på arbetsrelaterade uppgifter och bibehållen uppmärksamhet men även på stressreducering och depression. Den här studien utvärderar effekten av guidad meditation vid tre tillfällen på en experimentgrupp av tio personer i jämförelse med en kontrollgrupp. Resultaten visar inte att mindfulness hade signifikant påverkan på arbetsminnet men signifikant positiv påverkan på stressreducering och på mindfulnessdrag som Agera med medvetenhet och Acceptera utan fördomar. Resultaten går i linje med tidigare forskning inom det här området.

Nyckelord

Arbetsminne – Kortidsminne - Mindfulness - Meditation - Stress - Ångest – Agera med edvetenhet – Acceptera utan fördomar

Abstract

The effects of short-term meditation is a debated subject. There is studies that indicates that there is none or limited effect. Research of mindfulness meditation has also shown positive effects on working memory related tasks and sustained attention, but it can also show reduction of stress and depression. This study evaluate the effects of short-term guided meditation in a group of 10 persons in comparison with a control group. Results indicated no difference in memory tasks such as digit-span but the experimental group showed significant improvements in self-reported stress and mindful assets such as Acting with awareness and Acceptance without judgement. The results are consistent with previous research in this area.

Keywords

Working memory - Short-term memory - Mindfulness - Meditation - Stress - Anxiety – Act with awareness - Accept without judgement

Acknowledgments

First of all I want to thank all participants in this study. Thank you for your time and effort. Thanks to my supervisor Bengt Persson who guided me through study. I also want to thank Anna and Martin Wikfalk at MindApps for letting me use their app and recordings for this purpose.

Introduction

This study will evaluate if mindfulness training have a positive effect on working memory and health related subjects such as stress, anxiety and depression. With exercise, the performer will be able to train concentration and attention which in turn provides the means to influence thoughts and behaviour in the present.

Mindfulness

Meditation exercise has been practiced in numerous cultural groups for hundreds of years in different shapes and with different names. There are different styles, eg, concentrative, mindfulness and transcendental meditations. Mindfulness is a key component in search for awareness in both Zen and Vipassana meditations and has its roots in Buddhist philosophy (Chiesa, Calati & Serretti, 2011). Zen buddhist Gunaratana (2011) writes that mindfulness is an activity and that there is no precise answer to what mindfulness is, he means that it can be described in different words but each description could still be correct. Mindfulness is usually defined in terms of paying attention to the present and are also in western editions related with relaxation and concentrative meditation. Marlatt and Kristeller (1999, p. 68) describes it as "bringing one's complete attention to the present experience on a moment-to-moment basis" and Kabat-Zinn (1994, p. 4) states that mindfulness is defined as "paying attention in a particular way, on purpose, in the present moment, and nonjudgmentally".

It can be hard to separate concentrative meditation from mindfulness meditation since when practiced they seem to overlap one another. Mindfulness is used in attentional practice more as a nonjudgmental observer. All feelings, thoughts and sensations are welcome during the attentional stance and concentrative meditations are more about narrowing your focus down to a specific thought, feeling or body sensation (Cahn & Polich, 2006). Overlapping these two exercises in a recorded meditation session could look like e.g.:

> *"focusing on your breath, if your thoughts wander off just notice it nonjudgmentally and bring your focus back to your breath".*

Recently, mindfulness has been more widely accepted in modern medicine and included in medical context as well as school psychology (Jha, Krompinger & Baime, 2007, Terjestam, Bengtsson & Jansson, 2016). There is, for example, a mindfulness stress reduction programme (MBSR) developed by Jon Kabat-Zinn (2003) and a mindfulness

cognitive therapy programme (MBCT) where the participants, with the help from mindfulness practice, learn to develop the capacity to recognize the patterns in the mind. They will allow negative emotions and sensations and look at the objective nonjudgmentally without feeling the urge to fight or run away from them. The treatment is associated with a reduction of depressive relapses compared to usual treatment and antidepressants (Williams & Kuyken, 2012).

In Swedish elementary schools, studies has been conducted with a mindfulness-based program called Compas (Compassion and Attention in the Schools), in which positive results with mindfulness meditation, visualization of compassion, and reflection and mentalization enhanced the pupils' well-being, social relations and self-regulations (Terjestam, et al., 2016).

It is widely known that attention is a key part in meditation, and there is growing research showing that meditation and focused attention can change brain structures and attention processing (Buttle, 2011). Research has also shown that mindfulness meditators score higher on attention measures, compared to non-meditators. Zeidan, Johnson, Diamond, David and Goolkasian (2010) showed that four sessions of twenty-minutes mindfulness sessions had positive effects on memory discriminations, maintaining focus, and retrieving information more accurately from working memory. The meditators had significantly greater number of processing runs under conditions that required faster stimulus processing.

Moore and Malinowski (2009) showed that mindfulness also have a positive effect on task performance and is linked with enhanced cognitive flexibility, focus and sustained attention. This was observed in a comparison between meditators and non-meditators on a Stroop task and a d2-concentration and enduring test. Research also showed that mindfulness and other meditation exercises increased alpha power frontally during the state of practicing, and also as a common trait in normal state. This increase could be monitored for both long-term and short-term meditators (Cahn & Polich, 2006).

Working memory

Working memory has been widely discussed since the first theories were presented. Baddeley (2007) describes working memory as a temporary storage system under attentional control that underpins our capacity for complex thoughts. It is essential in cognitive tasks such as reasoning and learning. In Baddeley and Hitch's theory, working

memory consists of four components: the phonological loop, the visuo spatial sketchpad, the central executive and the episodic buffer. (Henry, 2011). Baddeley and Logie (1999) suggested that the processes and stores used by working memory are considered separate from the long-term memory system but some researchers mean that the temporary retention of information in working memory uses the long-term memory by selective activation (Marklund, 2006). Cowan (1999) suggests that working memory; is part of short-term memory but also extends into long-term memory, and Ericsson and Kintsch (1995) provide a theory with a long-term working memory, in their studies they found clear evidence of storage in long-term memory mediated by retrieval structures. To oppose Baddeleys theories about limited working memory, they mean that interference with the two slave systems, visual-spatial sketchpad and the articulatory loop with a secondary task, only degrade performance on the primary task slightly.

Reading (Baddeley, 1986), typing (Shaffer, 1975) and other highly skilled activities such as piano playing (Allport, Antonis & Reynolds, 1972) seem to have lesser impairment of on-going memory tasks in comparison to activities without any skills. These findings imply that the central executive has sufficient working memory capacity to complete the processing, leaving working memory for skilled activities virtually unexplained, (Ericsson & Kintsch, 1995).

Over the years, researchers have argued over what is shared between short-term memory's reflected memory storage and working memory executive attention (Engle, Tuholski, Laughlin & Conway, 1999). There are no direct answers, and the model and its terminology are not universally accepted, but over the last two decades we have seen a general acceptance for the term working memory to be used in a context postulating a system which combines specialized storage systems with executive control and attention that shows differences between verbal and visual material (Tulvin & Crank, 2000).

Training working memory is also a subject that has been diverted, Melby-Lervåg and Hulme (2013) suggest that it is hard to prove the effect of working memory training among both children and adults. With a Stroop task they measured a small effect directly after training but no measurable effect at a follow-up test for verbal working memory. They also found limited evidence that suggested sustained improvement for visuo-spatial working memory. Lee, Lu and Ko (2007) found that music training is related to performance on working memory tests such as digit span and nonverbal span. They also found that mental abacus calculations enhance children's

ability to store visuospatial information. This result goes in line with Ericsson and Kintsch (1995) ideas that working memory training is possible and that it would enhance the efficiency of storing and assessing task-relevant information.

Recent meta-analytic studies determined that anxiety is related to reduced working memory capacity. Although some studies tended to find that anxiety mostly interfered with demanding tasks such as random generation, the meta-analysis found that poorer performance on simple span test also is associated with anxiety, (Moran, 2016). Studies by Edwards, Moore, Champion and Edwards (2015) pointed out interesting facts; their results showed that anxiety and situational stress were not associated with processing efficiency in participants with higher level of working memory capacity. At lower working memory capacity, though, higher trait anxiety was associated with poorer efficiency but only for those who reported higher situational stress.

Mindfulness and working memory

Most research made on mindfulness and memory includes a population that has been practicing mindfulness everyday for years, and effects of short-term practising is not very well examined except for a few studies (Yates, 2015). Since meditation includes the practice of attention and concentration, researchers have argued that it should lead to improvements in both attentional skills and memory related skills (Lykins, Baer & Gottlob, 2010). The focus of attention in mindfulness should have a rewarding effect on short-term memory as well as working memory.

Buttle (2011) writes that attention and working memory are linked to our ability to function, where working memory selects information from our long-time memory or our environment to be held temporarily in order to be manipulated, to perform decisions and tasks.

Event Related Potentials (ERPs) have shown a correlation between mindfulness training and increased cerebral blood flow and cortical auditory processing changes, associated with learning and memory. This study underlines the hypothesis that mindfulness training enhances short-term memory (Cahn & Polich, 2006)

Chamber, Lo and Allen (2008) showed significant improvement in memory-related tasks such as Forward and Backward Digit-span while comparing a mindfulness group to control groups after a 10-day intensive mindfulness meditation retreat. They

also show improvement in subjective depressive syndrome, focused attention and other working memory related tasks in comparison to groups that didn't undergo the same mindfulness treatment.

The Present Study

While several studies show that mindfulness can improve attention and cognitive flexibility, the present study intends to study the effects of short-term mindfulness practicing on working memory test such as digit span backwards.

- The main hypothesis is that mindfulness has a positive effect on working memory tests, meaning that the meditators show a greater improvement in digit-span test than non-meditators.
- The study will also try to examine whether there is any link between practicing mindfulness and health benefits. More specifically, do participants with higher level of mindfulness also have better results on self-reported measurments of stress, anxiety and depression.

Method

Participants

Twenty-five persons were asked randomly to participate in this study, five persons answered no, due to lack of time. The study persons was recruited voluntarily and consisted of 13 females and 7 males within the age of 20-35 (M = 25.45, SD = 3.35). Most were students (60%) and the remainder were working. All of the working participants had post-secondary educations and none of the participants reported any subjective memory impairments.

Ethical considerations

All procedures performed with the participants followed the suggested ethical standard provided by the American Psychological Association. The study persons were initially informed about the procedure of the study, that the results would be treated anonymously, that no individual results would be published, and that they could withdraw from the study at any moment without any consequences.

Materials

Demographic Questionnaire

Participants were asked questions concerning their gender, age, level of education and occupation at the entrance of the study.

Kentucky Inventory of Mindfulness Skills scale (KIMS)

The Kentucky Inventory of Mindfulness Skills scale, KIMS, was used to measure the participants´ level of mindfulness (Baer, Smith & Allen, 2004). KIMS consists of 39 scale items. The participant is asked to rate their general experience with possible answers like 'Never or very rarely true' to 'Very often or always true' with scores from 1-5. KIMS items are divided to measure four sub-scales, Observing, Describing, Acting with awareness and Accepting without judgment. Cronbach's Alpha for these sub-scales has been reported as .91, .84, .83 and .87 (Baer et al., 2004).

Perceived Stress Scale

To measure the levels of stress with the participants, Perceived Stress Scale, PSS, was used (Cohen, Kamarck & Mermelstein, 1983). The PSS contains of 10 scale items and it consists of 3 sub-scales. PSS measures how unpredictable, uncontrollable, and overloaded the participant finds life within the last month. Respondents answer how often they felt in a certain way with possible answers like 'never' to 'very often' with scores from 0-4 (Cohen & Williamson, 1988).

Hospital Anxiety and Depression Scale

Hospital Anxiety and Depression scale, HADS, was used to assess the levels of depression and anxiety in the participants. HADS contains of 14 scale items and consists for two sub-scales, anxiety and depression. It measures the respondent's emotional disturbances with questions that refer to their lives within the last week. The questions are scored from 0-3 and possible answers are like 'not at all' to 'most of the time (Lisspers, Nygren & Söderman, 1997; Zigmond & Snaith 1983).

Digit Span Backwards

One of the most commonly used tests for working memory is the digit span backwards (Hilbert, Nakagawa, Puci, Zech & Buhner, 2015). The Digit-span backwards task

requires the participants to repeat a series of numbers read to them. The series of numbers varies from three to ten and increases by one number every sequel. Each sequence is read with one-second interval, only once. For each test a different number series was used to eliminate the possibility of remembering the number order of the last test. The participant was stopped when repeating two wrong numbers in a row, but the test score only counts for correct numbers in a row.

Mindfulness Sessions

The meditation consisted of two recorded visualizing guided meditations, a) Loving Kindness (11min) was practised once and b) Lake meditation (11min) was practised twice. Both recordings starts with quick explanations of the session followed by a mindful breath meditation, being mindful of your breath in body, noticing temporary feelings and thoughts in a non-judgmental and accepting way.

a) The Loving kindness meditation is influenced by sessions created by Rosemary and Steve Weissman (2013). The participants are asked to visualize a person towards whom they feel loving kindness (e.g. a friend, family member or someone unknown) and repeat four sentences to that person (may you feel secure/may you be healthy in your body and your mind/may you be happy/may you find inner peace), after this part they are asked to direct this feelings and sentences towards themselves and to all living things. Compassion and acceptance are in focus. The session ends with instructions to be aware of your body and surroundings.

b) In the Lake meditation is influenced by meditations made by Kabat-Zinn (2017). After the introduction the participants are instructed to visualize a lake (“Imagine the waves on top, are there big or small waves?”, “Imagine the silence below the surface...”) followed by instructions to become the lake. While being this lake, the participants are asked to note their feelings and emotions during the session (”does it change the nature of the lake?”). Awareness, acceptance and self-regulation are in focus. The sessions ends with instructions to be aware of your body and surroundings.

Data analysis

IBM SPSS Statistics 23 (23.0.0.2, 2015) was used to examine the data. A mixed-model ANOVA was conducted to process the results for all measurements between the experiment group and control group. A one-sample T test was used to compare the means between my results and norm means. Spearman's correlation was used to

determine the relationship between the digit span results and anxiety. A 95% confidence interval was calculated for each effect size. Levene's test of equality was used to measure the variance between the groups. Q-Q and histogram plots was used to see if there was any outliers in the data and Mauchly's test was used to see if the assumption of sphericity had been violated.

Procedure

The participants were randomly divided into two groups, one experimental group (EG) and one control group (CG). To secure anonymity, each person was given a number from 1-20. Each participant in the EG met with the experimenter three times in their homes within the range of ten days, the control group met the experimenter two times during the same time range. Consent was obtained from each participant before the study started. The participants filled out the surveys and took the digit span test two times, one at the entrance to get the individual´s baseline and one after completing the study to see if any improvements was made. The test was performed directly after the meditation session.

All the participants in the EG meditated with headphones, alone in the room without the experimental leader, the CG made the test without any mindfulness session. The meetings varied between 20-40 minutes, the length depended on whether the participant was included in the EG or CG.

Results

There was no missing data from this study; all participants took the formulae and tests without any questions.

State of mindfulness

The results from the total scores shows that there was a significant difference within the groups F (1, 18) = 5.022, p = .038, η^2 = .218. The experiment group (M = 128.1, SD = 11.19) had significantly higher level of mindfulness after attending to the meditation sessions.

When analysing the subscales, Act of awareness showed a significant difference F (1, 18) = 5.188, p = .035, η^2 = .224. There were also significant differences when

Accept without judgment was examined F (1, 18) = 6.704, p = .019, η^2 = .271. The EG showed higher level of Awareness (M = 32.8, SD = 3.79) and Accept without judgement (M = 34.4, SD = 2.83) after attending the meditation sessions, indicating that mindfulness has a positive effect on both Awareness and Acceptence without judgement. However, results showed no significant difference within the groups when the level Observe was analysed F (1, 18) = .017, p = .898, η^2 = .001. Neither did the level of Describe show any significant difference within the groups F (1, 18) = .519, p = .480, η^2 = .028. The results showed that there was equal variance between the groups in all measurements.

Table I. Means (Standard Deviations) scores of the KIMS test.

	Experiment group (n = 10)		Control group (n = 10)	
	Pre	Post	Pre	Post
Observe	33.2 (5.99)	33.2 (5.39)	35.0 (5.31)	35.1 (4.95)
Describe	28.3 (4.66)	27.7 (4.96)	32.2 (3.70)	32.2 (3.25)
Act of awareness	28.6 (1,71)	32.8 (3.79)*	28.5 (2.32)	29.9 (3.10)
Accept without judgement	30.0 (4.39)	34.4 (2.83)*	28.6 (3.27)	30.1 (3.72)
Total score	120.1 (11.32)	128.1 (11.19)*	124.3 (7.31)	127.3 (5.39)

* p < .05.

In comparison to the Swedish means, the study participants in the experiment group had a significantly higher mean of Act of awareness than swedish average t (9) = 4.083, p = .003. There was no significant difference when Accept without judgement was examined, the results are equal to the findings of Baer et al., (2004), (Hansen, Lundh, Homman & Wångby-Lundh, 2009).

Table II. Comparison between Swedish means (Standard Deviations) and the EG

	Swedish means (n = 51)	EG group means (n = 10)
Act of awareness	27.9 (6.4)	32.8 (3.79)*
Accept without judgement	30.3 (6.4)	34.4 (2.83)

* p < .05.

PSS

The test results revealed a significant difference within the EG, and not within the CG. F (1, 18) = 5.886, p = .026, η^2 = .246. This indicates that mindfulness meditation sessions had a positive effect on reducing stress (M = 9.9, SD = 2.884). There was equal variance between the groups.

Table III. Means (Standard Deviations) scores of the PSS test.

	Pre study	Post study
Experiment group (n = 10)	14,3 (3.465)	9.9 (2.884)*
Control group (n = 10)	14.9 (5.195)	14.3 (6,165)

* p < .05.

The EG PSS results are signficanly lower than the norm t (9) = -4.714, p = .001, (Cohen, 1994).

Table IV. Comparison between norm Means (Standard Deviations) and the EG

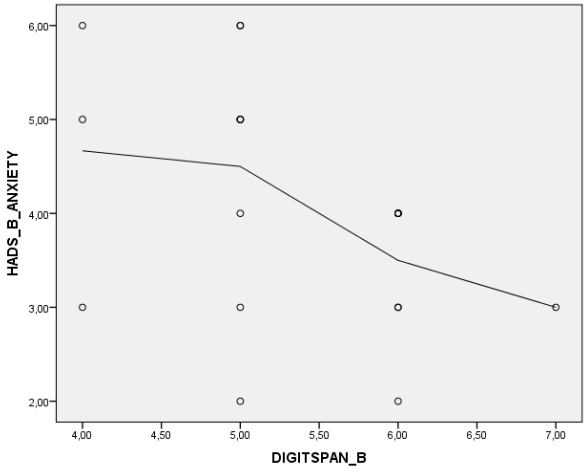
	Norm means (n = 645)	Experiment group (n = 10)
PSS results	14,2 (6.2)	9.9 (2.884)*

* p = .001.

Digit span backwards

There were no significant difference between the experiment group and the control group in digit span results after participating in this study F = (1, 18) = 3.082, p = .096, η^2 = .146. There was equal variance between the groups.

A correlation was found between Anxiety and the digit span results. There was a moderate, negative monotonic correlation between Digit span results and anxiety (= -.452, n = 20, p < .046).



Graph I. The graph shows the correlation between Anxiety and Digit span test results

Table V. Means (Standard Deviations) scores of the Digit span backwards test.

	Pre study	Post study
Experiment group (n = 10)	4.8 (.918)	5.7 (.674)
Control group (n = 10)	4.6 (.699)	5.0 (.816)

HADS

There was no difference in the level of Anxiety F (1, 18) = 1.340, p = .262, , η^2 = .069 or in the level of Depression F (1, 18) = .080, p = .781, , η^2 = .004. The variance was equal between the groups.

Table VI. Means (Standard Deviations) scores of the HADS test.

	Experiment group (n = 10)		Control group (n = 10)	
	Pre	Post	Pre	Post
Anxiety	4.3 (2.35)	3.6 (1.26)	4.4 (1.71)	4.5 (1.08)
Depression	4.2 (1.13)	4.1 (.87)	5.3 (1.25)	5.0 (1.24)

Skewness.

The post study PSS test results showed skewness (statistic = 2.245), besides that, no skewness was reported.

Comparisons between gender, occupation and age.

Differences between gender, occupation and age was tested on all measurements to see if it would make any impact on the results but indicated low or no significant trends on any given test.

Discussion

The results of this study showed that brief mindfulness sessions were effective in increasing mindfulness as measured by scores on KIMS in the experimental group in relative to the control group, with an effect size of .21. Two subscales, Acting with awareness and Accept without judgement was significantly increased after attending to mindfulness sessions, each with a small to medium effect size. Both traits have high positive correlations with quality of life (Hansen et. al., 2009) and might therefore be correlating with psychological well-being. These findings are consistent with previous literature (Baer, 2003; Grossman, Niemann, Schmidt & Walach, 2004).

The findings of this study also show that mindfulness sessions have positive effect on stress. After attending to mindfulness meditation the participants showed a significantly lower mean of stress with an effect size of .25. The findings are consistent with Grossman et al., (2004) meta-analysis, showing that Kabat-Zinn (2003) MSBR program and mindfulness practicing is helpful in coping with distress in everyday life as well as more extraordinary conditions of stress.

It is always wise to be cautious about self-report scales; the engagement and willingness of the participant may as well contribute to the positive outcome.

The finding in the present study was that brief mindfulness sessions did not have a significant effect on the digit-span, and there was no support for the initial hypothesis. Both groups showed increased, but not significant, results at the test. This might be explained by the participants getting used to the test form since both groups showed signs of improvement. Neither did higher level of mindfulness correlate with any improvements at the working memory related tests. This might be explained by numerous different reasons.

First, in most studies where improvements was shown the participants were long-term meditators and had been practicing mindfulness and meditation for several years, except for e.g. the Chambers et al., (2008) study, in which working memory was improved after attending a 10-days mindfulness retreat. In this study the participants only meditated three times, which might be too short to get significant results on working memory test. The results supports Melby-Lervåg and Hulmes (2013) study that points out that working memory training programs give only near-transfer effects, and they didn't find any convincing evidence for durable effects or traits. The results can also be supportive to Miller's law (Miller, 1956), which proclaims the idea that the human brain only can withhold a certain number of digits in the short-term memory. Miller's law recently got major support from Gingac (2015), who examined test results from digit span observed from 1923 to 2008. The results showed no increasing trend in the short-term memory capacity or working memory capacity during this period. The means during this period reaches from 4.80–5.10 and can be used to strengthen validity of the current research, (Cowan, 2001; Gingac, 2015).

Secondly, the sample size was too small and may not represent the general population. The findings might have been different if the sample was increased. To get enough power in this study the recommended sample size should be equivalent to twenty-six or more participants in each group (Cohen, 1992). However, the effect size obtained from my significant results where all over .20. Which, considering the sample size, inditactes the strength of this mindfulness method.

Another factor could be that this study only used digit-span backwards to test working memory. Several researchers use various tests, like the controlled oral word association, symbol digit modalities test and Stroop tests to ensure that working memory is measured accurately (Moore & Malinowski, 2009; Zeidan et. al., 2010).

In similarity to Moran's (2016) study, poorer performance on the digit test correlate with high level of anxiety, although the results indicate that the level of anxiety and depression in this study sample match the Swedish average (Lisspers et al., 1997). The experimental group showed a lower, but not significantly, level of anxiety after attending to the mindfulness sessions, and there was no difference in self-reported depression. Contrary to prior research, mindfulness practicing had a positive effect on depression and negative thoughts which led to reduced levels of anxiety and other powerful emotions like guilt, anger, frustration and shame (Williams & Kuyken, 2012).

Conclusion

After attending to three mindfulness sessions, participants showed significantly positive effects on the overall level of mindfulness, the traits Act with awareness and Accept without judgement were significantly improved. Meditation also significantly reduced the level of stress among the participants. These results have relevance in favour for the support of beneficial mindfulness programs at workplaces, in school environment or as therapy. Since the present study evaluated the benefits from brief mindfulness sessions there is still a lot of ground to cover in this area to find out more about the effects of meditation. In prior research, the positive effect of training increased with the number of times the participants attended to the training (Terjestam et. al., 2016). Research has shown positive results for long-term and short-term meditators, both physically and psychologically (Cahn & Polich, 2006; Kabat-Zinn, 2003; Williams & Kuyken, 2012). This area has just begun to be explored and the literature seems to positively support the findings concerning the effects of mindfulness.

Future research

The results make a strong case for further investigations to short-term mindfulness practicing where the frequency and length of the sessions are manipulated. The mindfulness meditation in this study focused on awareness, acceptance and compassion. It would be interesting to see if different kinds of mindfulness traits and other health benefits are affected by the alignment of mindfulness session. For further research in working memory, expanded measurement with a viariety of tests is recommended. The connection between mindfulness, sustained attention and working memory is also a subject that would increase the knowledge in this area.

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