

# Méditation de pleine conscience et cerveau : 150 résumés d'articles de recherche (1975-juin 2013)

1. Soc Cogn Affect Neurosci. 2013 Jun 3. [Epub ahead of print]

Neural correlates of mindfulness meditation-related anxiety relief.

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Anxiety is the cognitive state related to the inability to control emotional responses to perceived threats. Anxiety is inversely related to brain activity associated with the cognitive regulation of emotions. Mindfulness meditation has been found to regulate anxiety. However, the brain mechanisms involved in meditation-related anxiety relief are largely unknown. We employed pulsed arterial spin labeling MRI to compare the effects of distraction in the form of attending to the breath (ATB; before meditation training) to mindfulness meditation (after meditation training) on state anxiety across the same subjects. Fifteen healthy subjects, with no prior meditation experience, participated in 4 d of mindfulness meditation training. ATB did not reduce state anxiety, but state anxiety was significantly reduced in every session that subjects meditated. Meditation-related anxiety relief was associated with activation of the anterior cingulate cortex, ventromedial prefrontal cortex and anterior insula. Meditation-related activation in these regions exhibited a strong relationship to anxiety relief when compared to ATB. During meditation, those who exhibited greater default-related activity (i.e. posterior cingulate cortex) reported greater anxiety, possibly reflecting an inability to control self-referential thoughts. These findings provide evidence that mindfulness meditation attenuates anxiety through mechanisms involved in the regulation of self-referential thought processes.

PMID: 23615765 [PubMed - as supplied by publisher]

2. Neuroimage. 2013 May 17;81C:110-118. doi: 10.1016/j.neuroimage.2013.05.030. [Epub ahead of print]

Real-time fMRI links subjective experience with brain activity during focused attention.

Garrison KA, Scheinost D, Worhunsky PD, Elwafi HM, Thornhill TA 4th, Thompson E, Saron C, Desbordes G, Kober H, Hampson M, Gray JR, Constable RT, Papademetris X, Brewer JA.

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Recent advances in brain imaging have improved the measure of neural processes related to perceptual, cognitive and affective functions, yet the relation between brain activity and subjective experience remains poorly characterized. In part, it is a challenge to obtain reliable accounts of participant's experience in such studies. Here we addressed this limitation by utilizing experienced meditators who are expert in introspection. We tested a novel method to link objective and subjective data, using real-time fMRI (rt-fMRI) to provide participants with feedback of their own brain activity during an ongoing task. We provided real-time feedback during a focused attention task from the posterior cingulate cortex, a hub of the default mode network shown to be activated during mind-wandering and deactivated during meditation. In a first experiment, both meditators and non-meditators reported significant correspondence between the feedback graph and their subjective experience of focused attention and mind-wandering. When instructed to volitionally decrease the feedback graph, meditators, but not non-meditators, showed significant deactivation of the posterior cingulate cortex. We were able to replicate these results in a separate group of meditators using a novel step-wise rt-fMRI discovery protocol in which participants were not provided with prior knowledge of the expected relationship between their experience and the feedback graph (i.e., focused attention versus mind-wandering). These findings support the feasibility of using rt-fMRI to link objective measures of brain activity with reports of ongoing subjective experience in cognitive neuroscience research, and demonstrate the generalization of expertise in introspective awareness to novel contexts.

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3. Explore (NY). 2013 May-Jun;9(3):136-41. doi: 10.1016/j.explore.2013.02.005.

On mind wandering, attention, brain networks, and meditation.

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Human attention selectively focuses on aspects of experience that are threatening, pleasant, or novel. The physical threats of the ancient times have largely been replaced by chronic psychological worries and hurts. The mind gets drawn to these worries and hurts, mostly in the domain of the past and future, leading to mind wandering. In the brain, a network of neurons called the default mode network has been associated with mind wandering. Abnormal activity in the default mode network may predispose to depression, anxiety, attention deficit, and posttraumatic stress disorder. Several studies show that meditation can reverse some of these abnormalities, producing salutary functional and structural changes in the brain. This narrative review presents a mechanistic understanding of meditation in the context of recent advances in neurosciences about mind wandering, attention, and the brain networks.

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4. PLoS One. 2013 Apr 9;8(4):e61038. doi: 10.1371/journal.pone.0061038. Print 2013.

Can taichi reshape the brain? A brain morphometry study.

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Although research has provided abundant evidence for Taichi-induced improvements in psychological and physiological well-being, little is known about possible

links to brain structure of Taichi practice. Using high-resolution MRI of 22 Tai Chi Chuan (TCC) practitioners and 18 controls matched for age, sex and education, we set out to examine the underlying anatomical correlates of long-term Taichi practice at two different levels of regional specificity. For this purpose, parcel-wise and vertex-wise analyses were employed to quantify the difference between TCC practitioners and the controls based on cortical surface reconstruction. We also adopted the Attention Network Test (ANT) to explore the effect of TCC on executive control. TCC practitioners, compared with controls, showed significantly thicker cortex in precentral gyrus, insula sulcus and middle frontal sulcus in the right hemisphere and superior temporal gyrus and medial occipito-temporal sulcus and lingual sulcus in the left hemisphere. Moreover, we found that thicker cortex in left medial occipito-temporal sulcus and lingual sulcus was associated with greater intensity of TCC practice. These findings indicate that long-term TCC practice could induce regional structural change and also suggest TCC might share similar patterns of neural correlates with meditation and aerobic exercise.

PMCID: PMC3621760

PMID: 23585869 [PubMed - in process]

5. Biol Psychol. 2013 Apr;93(1):105-13. doi: 10.1016/j.biopsych.2013.01.016. Epub 2013 Feb 11.

Approaching dysphoric mood: state-effects of mindfulness meditation on frontal brain asymmetry.

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Meditation-based interventions reduce the relapse risk in recurrently depressed patients. Randomized trials utilizing neurophysiologic outcome measures, however, have yielded inconsistent results with regard to a prophylactic effect. Although frontal brain asymmetry, assessed through electroencephalographic (EEG) alpha activity (8-13 Hz), is indicative of approach vs. withdrawal-related response dispositions and represents a vulnerability marker of depression, clinical trials have provided mixed results as to whether meditation has beneficial effects on alpha asymmetry. Inconsistencies might have arisen since such trials relied on resting-state recordings, instead of active paradigms under challenge, as

suggested by contemporary notions of alpha asymmetry. We examined two groups of remitted, recurrently depressed females. In a "mindfulness support group", EEG was recorded during neutral rest, and rest following a negative mood induction. Subsequently, participants received initial meditation instructions. EEG was then obtained during an active period of guided mindfulness meditation and rest following the active period. In a "rumination challenge group", EEG was obtained during the same resting conditions, whereas in the active period, initial meditation instructions were followed by a rumination challenge. A significant shift in mid-frontal asymmetry, yielding a pattern indicative of approach motivation, was observed in the mindfulness support group, specifically during the meditation period. This indicates that mindfulness meditation may have a transient beneficial effect, which enables patients to take an approach-related motivational stance, particularly under circumstances of risk.

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PMID: 23410762 [PubMed - in process]

6. Neuroimage. 2013 Apr 1;69:35-42. doi: 10.1016/j.neuroimage.2012.12.021. Epub 2012 Dec 22.

Pre-existing brain function predicts subsequent practice of mindfulness and compassion meditation.

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While a variety of meditation techniques are increasingly employed as health interventions, the fact that meditation requires a significant commitment of time and effort may limit its potential widespread utility. In the current study, we ask whether baseline subjective reports or brain activity in response to a "Pain for Self and Others" paradigm predicts subsequent engagement in mindfulness and compassion meditation. The study also investigated whether compassion training would impact neural responses when compared to an active health education control group. Prior to training, activation of the left and right anterior insula, an area thought to be important for empathy, in response to the Other pain task was positively related to engagement with compassion meditation as measured by practice time (n=13). On the other hand, activity in the left amygdala during the

Self pain task was negatively correlated with mindfulness practice time. Following the study intervention, there was no difference between the compassion group (n=13), and the control group (n=8), in brain responses to either the Self or Other task. These results are the first to indicate that baseline neural responses may predict engagement with meditation training and suggest that pre-existing neurobiological profiles differentially predispose individuals to engage with disparate meditation techniques.

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7. Biol Psychol. 2013 Feb;92(2):275-81. doi: 10.1016/j.biopsych.2012.09.007. Epub 2012 Oct 6.

Cortical thickness, mental absorption and meditative practice: possible implications for disorders of attention.

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Mental training techniques rooted in meditation are associated with attention improvement, increased activation and cortical thickening of attention/executive-related brain areas. Interestingly, attention-deficit/hyperactivity disorder (ADHD) is associated with behavioural deficits, hypo-activation and cortical thinning of similar networks. This study assessed the relationship between prior meditative training, attentional absorption, and cortical thickness. Grey matter thickness was measured in 18 meditators and 18 controls. Subjective reports of attentional absorption were modestly higher in meditators and across the entire sample correlated positively with cortical thickness in several regions corresponding to cingulo-fronto-parietal attention networks. Within these regions the meditation group had greater cortical thickness which was positively related to the extent of prior training. Evidence suggesting that meditative practice activates these cortical areas, improves attention and may ameliorate symptoms of ADHD by targeting vulnerable brain regions is discussed.

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8. Clin Psychol Rev. 2013 Feb;33(1):82-96. doi: 10.1016/j.cpr.2012.10.006. Epub 2012 Oct 23.

Mindfulness: top-down or bottom-up emotion regulation strategy?

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The beneficial clinical effects of mindfulness practices are receiving increasing support from empirical studies. However, the functional neural mechanisms underlying these benefits have not been thoroughly investigated. Some authors suggest that mindfulness should be described as a 'top-down' emotion regulation strategy, while others suggest that mindfulness should be described as a 'bottom-up' emotion regulation strategy. Current discrepancies might derive from the many different descriptions and applications of mindfulness. The present review aims to discuss current descriptions of mindfulness and the relationship existing between mindfulness practice and most commonly investigated emotion regulation strategies. Recent results from functional neuro-imaging studies investigating mindfulness training within the context of emotion regulation are presented. We suggest that mindfulness training is associated with 'top-down' emotion regulation in short-term practitioners and with 'bottom-up' emotion regulation in long-term practitioners. Limitations of current evidence and suggestions for future research on this topic are discussed.

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9. Brain Behav Immun. 2013 Jan;27(1):174-84. doi: 10.1016/j.bbi.2012.10.013. Epub 2012 Oct 22.

A comparison of mindfulness-based stress reduction and an active control in modulation of neurogenic inflammation.

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Psychological stress is a major provocative factor of symptoms in chronic inflammatory conditions. In recent years, interest in addressing stress responsivity through meditation training in health-related domains has increased astoundingly, despite a paucity of evidence that reported benefits are specific to meditation practice. We designed the present study to rigorously compare an 8-week Mindfulness-Based Stress Reduction (MBSR) intervention to a well-matched active control intervention, the Health Enhancement Program (HEP) in ability to reduce psychological stress and experimentally-induced inflammation. The Trier Social Stress Test (TSST) was used to induce psychological stress and inflammation was produced using topical application of capsaicin cream to forearm skin. Immune and endocrine measures of inflammation and stress were collected both before and after MBSR training. Results show those randomized to MBSR and HEP training had comparable post-training stress-evoked cortisol responses, as well as equivalent reductions in self-reported psychological distress and physical symptoms. However, MBSR training resulted in a significantly smaller post-stress inflammatory response compared to HEP, despite equivalent levels of stress hormones. These results suggest behavioral interventions designed to reduce emotional reactivity may be of therapeutic benefit in chronic inflammatory conditions. Moreover, mindfulness practice, in particular, may be more efficacious in symptom relief than the well-being promoting activities cultivated in the HEP program.

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PMID: 23092711 [PubMed - indexed for MEDLINE]

10. Brain Behav Immun. 2013 Jan;27(1):145-54. doi: 10.1016/j.bbi.2012.10.009. Epub 2012 Oct 16.

Workplace based mindfulness practice and inflammation: a randomized trial.

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We have developed a low dose Mindfulness-Based Intervention (MBI-ld) that reduces the time committed to meetings and formal mindfulness practice, while conducting the sessions during the workday. This reduced the barriers commonly mentioned for non-participation in mindfulness programs. In a controlled randomized trial we studied university faculty and staff (n=186) who were found to have an elevated CRP level,>3.0 mg/ml, and who either had, or were at risk for cardiovascular disease. This study was designed to evaluate if MBI-ld could produce a greater decrease in CRP, IL-6 and cortisol than an active control group receiving a lifestyle education program when measured at the end of the 2 month interventions. We found that MBI-ld significantly enhanced mindfulness by 2-months and it was maintained for up to a year when compared to the education control. No significant changes were noted between interventions in cortisol, IL-6 levels or self-reported measures of perceived stress, depression and sleep quality at 2-months. Although not statistically significant ( $p=.08$ ), the CRP level at 2-months was one mg/ml lower in the MBI-ld group than in the education control group, a change which may have clinical significance (Ridker et al., 2000; Wassel et al., 2010). A larger MBI-ld effect on CRP (as compared to control) occurred among participants who had a baseline BMI <30 (-2.67 mg/ml) than for those with BMI >30 (-0.18 mg/ml). We conclude that MBI-ld should be more fully investigated as a low-cost self-directed complementary strategy for decreasing inflammation, and it seems most promising for non-obese subjects.

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PMID: 23078984 [PubMed - indexed for MEDLINE]

11. Clin EEG Neurosci. 2013 Jan;44(1):39-43. doi: 10.1177/1550059412451705. Epub 2012 Nov 19.

Conscious attention, meditation, and bilateral information transfer.

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Recent findings indicate that conscious attention is related to large-scale information integration of various brain regions, including both hemispheres, that enables integration of parallel distributed modalities of processed information. There is also evidence that the level of information transference related to integration or splitting among brain regions, and between hemispheres, establishes a certain level of efficiency of the information processing. The level of information transference also may have modulatory influences on attentional capacity that are closely linked to the emotional arousal and autonomic response related to a stimulus. These findings suggest a hypothesis that changes in conscious attention, specifically during meditation could be reflected in the autonomic activity as the left-right information transference calculated from bilateral electrodermal activity (EDA). With the aim to compare conscious attention during meditation with other attentional states (resting state, Stroop task, and memory task), we performed bilateral EDA measurement in 7 healthy persons during resting state, Stroop task, neurofeedback memory test, and meditation. The results indicate that the information transference (ie, transinformation) is able to distinguish those attentional states, and that the highest level of the transinformation has been found during attentional processing related to meditation, indicating higher level of connectivity between left and right sides. Calculations other than pointwise transinformation (PTI) performed on EDA records, such as mean skin conductance level or laterality index, were not able to distinguish attentional states. The results suggest that PTI may present an interesting method useful for the assessment of information flow, related to neural functioning, that in the case of meditation may reflect typical integrative changes in the autonomic nervous system related to brain functions and focused attentional processing.

PMID: 23171535 [PubMed - in process]

12. Front Hum Neurosci. 2013;7:12. doi: 10.3389/fnhum.2013.00012. Epub 2013 Feb 13.

Mindfulness starts with the body: somatosensory attention and top-down modulation of cortical alpha rhythms in mindfulness meditation.

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Using a common set of mindfulness exercises, mindfulness based stress reduction (MBSR) and mindfulness based cognitive therapy (MBCT) have been shown to reduce

distress in chronic pain and decrease risk of depression relapse. These standardized mindfulness (ST-Mindfulness) practices predominantly require attending to breath and body sensations. Here, we offer a novel view of ST-Mindfulness's somatic focus as a form of training for optimizing attentional modulation of 7-14 Hz alpha rhythms that play a key role in filtering inputs to primary sensory neocortex and organizing the flow of sensory information in the brain. In support of the framework, we describe our previous finding that ST-Mindfulness enhanced attentional regulation of alpha in primary somatosensory cortex (SI). The framework allows us to make several predictions. In chronic pain, we predict somatic attention in ST-Mindfulness "de-biases" alpha in SI, freeing up pain-focused attentional resources. In depression relapse, we predict ST-Mindfulness's somatic attention competes with internally focused rumination, as internally focused cognitive processes (including working memory) rely on alpha filtering of sensory input. Our computational model predicts ST-Mindfulness enhances top-down modulation of alpha by facilitating precise alterations in timing and efficacy of SI thalamocortical inputs. We conclude by considering how the framework aligns with Buddhist teachings that mindfulness starts with "mindfulness of the body." Translating this theory into neurophysiology, we hypothesize that with its somatic focus, mindfulness' top-down alpha rhythm modulation in SI enhances gain control which, in turn, sensitizes practitioners to better detect and regulate when the mind wanders from its somatic focus. This enhanced regulation of somatic mind-wandering may be an important early stage of mindfulness training that leads to enhanced cognitive regulation and metacognition.

PMCID: PMC3570934  
PMID: 23408771 [PubMed]

13. Front Neurosci. 2013;7:8. doi: 10.3389/fnins.2013.00008. Epub 2013 Feb 4.

Neural mechanisms of attentional control in mindfulness meditation.

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The scientific interest in meditation and mindfulness practice has recently seen an unprecedented surge. After an initial phase of presenting beneficial effects of mindfulness practice in various domains, research is now seeking to unravel

the underlying psychological and neurophysiological mechanisms. Advances in understanding these processes are required for improving and fine-tuning mindfulness-based interventions that target specific conditions such as eating disorders or attention deficit hyperactivity disorders. This review presents a theoretical framework that emphasizes the central role of attentional control mechanisms in the development of mindfulness skills. It discusses the phenomenological level of experience during meditation, the different attentional functions that are involved, and relates these to the brain networks that subserve these functions. On the basis of currently available empirical evidence specific processes as to how attention exerts its positive influence are considered and it is concluded that meditation practice appears to positively impact attentional functions by improving resource allocation processes. As a result, attentional resources are allocated more fully during early processing phases which subsequently enhance further processing. Neural changes resulting from a pure form of mindfulness practice that is central to most mindfulness programs are considered from the perspective that they constitute a useful reference point for future research. Furthermore, possible interrelations between the improvement of attentional control and emotion regulation skills are discussed.

PMCID: PMC3563089  
PMID: 23382709 [PubMed]

14. Neural Plast. 2013;2013:653572. doi: 10.1155/2013/653572. Epub 2013 May 2.

Case study of ecstatic meditation: fMRI and EEG evidence of self-stimulating a reward system.

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We report the first neural recording during ecstatic meditations called jhanas and test whether a brain reward system plays a role in the joy reported. Jhanas are Altered States of Consciousness (ASC) that imply major brain changes based on subjective reports: (1) external awareness dims, (2) internal verbalizations fade, (3) the sense of personal boundaries is altered, (4) attention is highly focused on the object of meditation, and (5) joy increases to high levels. The fMRI and EEG results from an experienced meditator show changes in brain activity in 11 regions shown to be associated with the subjective reports, and these

changes occur promptly after jhana is entered. In particular, the extreme joy is associated not only with activation of cortical processes but also with activation of the nucleus accumbens (NAc) in the dopamine/opioid reward system. We test three mechanisms by which the subject might stimulate his own reward system by external means and reject all three. Taken together, these results demonstrate an apparently novel method of self-stimulating a brain reward system using only internal mental processes in a highly trained subject.

PMCID: PMC3659471

PMID: 23738149 [PubMed - in process]

15. Neuroimage. 2013 Jan 1;64:538-46. doi: 10.1016/j.neuroimage.2012.09.030. Epub 2012 Sep 19.

Altered anterior insula activation during anticipation and experience of painful stimuli in expert meditators.

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Experientially opening oneself to pain rather than avoiding it is said to reduce the mind's tendency toward avoidance or anxiety which can further exacerbate the experience of pain. This is a central feature of mindfulness-based therapies. Little is known about the neural mechanisms of mindfulness on pain. During a meditation practice similar to mindfulness, functional magnetic resonance imaging was used in expert meditators (>10,000 h of practice) to dissociate neural activation patterns associated with pain, its anticipation, and habituation. Compared to novices, expert meditators reported equal pain intensity, but less unpleasantness. This difference was associated with enhanced activity in the dorsal anterior insula (aI), and the anterior mid-cingulate (aMCC) the so-called 'salience network', for experts during pain. This enhanced activity during pain was associated with reduced baseline activity before pain in these regions and the amygdala for experts only. The reduced baseline activation in left aI correlated with lifetime meditation experience. This pattern of low baseline activity coupled with high response in aIns and aMCC was associated with enhanced neural habituation in amygdala and pain-related regions before painful stimulation and in the pain-related regions during painful stimulation. These findings suggest that cultivating experiential openness down-regulates

anticipatory representation of aversive events, and increases the recruitment of attentional resources during pain, which is associated with faster neural habituation.

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16. PLoS One. 2013;8(3):e58476. doi: 10.1371/journal.pone.0058476. Epub 2013 Mar 25.

Brain changes in long-term zen meditators using proton magnetic resonance spectroscopy and diffusion tensor imaging: a controlled study.

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**INTRODUCTION:** This work aimed to determine whether  $(1)^H$  magnetic resonance imaging (MRI), magnetic resonance spectroscopy (MRS), diffusion-weighted imaging (DWI) and diffusion tensor imaging (DTI) are correlated with years of meditation and psychological variables in long-term Zen meditators compared to healthy non-meditator controls.

**MATERIALS AND METHODS:** Design. Controlled, cross-sectional study. Sample. Meditators were recruited from a Zen Buddhist monastery. The control group was recruited from hospital staff. Meditators were administered questionnaires on anxiety, depression, cognitive impairment and mindfulness.  $(1)^H$ -MRS (1.5 T) of the brain was carried out by exploring four areas: both thalamus, both hippocampi, the posterior superior parietal lobule (PSPL) and posterior cingulate gyrus. Predefined areas of the brain were measured for diffusivity (ADC) and fractional anisotropy (FA) by MR-DTI.

**RESULTS:** Myo-inositol (mI) was increased in the posterior cingulate gyrus and Glutamate (Glu), N-acetyl-aspartate (NAA) and N-acetyl-aspartate/Creatine (NAA/Cr) was reduced in the left thalamus in meditators. We found a significant positive correlation between mI in the posterior cingulate and years of meditation ( $r=0.518$ ;  $p=.019$ ). We also found significant negative correlations between Glu ( $r=-0.452$ ;  $p=.045$ ), NAA ( $r=-0.617$ ;  $p=.003$ ) and NAA/Cr ( $r=-0.448$ ;  $P=.047$ ) in the left thalamus and years of meditation. Meditators showed a lower Apparent Diffusion Coefficient (ADC) in the left posterior parietal white matter than did controls, and the ADC was negatively correlated

with years of meditation ( $r=-0.4850$ ,  $p=.0066$ ).

**CONCLUSIONS:** The results are consistent with the view that mI, Glu and NAA are the most important altered metabolites. This study provides evidence of subtle abnormalities in neuronal function in regions of the white matter in meditators.

PMCID: PMC3607604

PMID: 23536796 [PubMed - in process]

17. Soc Cogn Affect Neurosci. 2013 Jan;8(1):34-9. doi: 10.1093/scan/nss076. Epub 2012 Jul 18.

Increased gray matter volume in the right angular and posterior parahippocampal gyri in loving-kindness meditators.

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Previous voxel-based morphometry (VBM) studies have revealed that meditation is associated with structural brain changes in regions underlying cognitive processes that are required for attention or mindfulness during meditation. This VBM study examined brain changes related to the practice of an emotion-oriented meditation: loving-kindness meditation (LKM). A 3 T magnetic resonance imaging (MRI) scanner captured images of the brain structures of 25 men, 10 of whom had practiced LKM in the Theravada tradition for at least 5 years. Compared with novices, more gray matter volume was detected in the right angular and posterior parahippocampal gyri in LKM experts. The right angular gyrus has not been previously reported to have structural differences associated with meditation, and its specific role in mind and cognitive empathy theory suggests the uniqueness of this finding for LKM practice. These regions are important for affective regulation associated with empathic response, anxiety and mood. At the same time, gray matter volume in the left temporal lobe in the LKM experts appeared to be greater, an observation that has also been reported in previous MRI meditation studies on meditation styles other than LKM. Overall, the findings of our study suggest that experience in LKM may influence brain structures associated with affective regulation.

PMCID: PMC3541494

PMID: 22814662 [PubMed - in process]

18. Soc Cogn Affect Neurosci. 2013 Jan;8(1):15-26. doi: 10.1093/scan/nss066. Epub 2012 Jun 11.

Mindfulness meditation training alters cortical representations of interoceptive attention.

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One component of mindfulness training (MT) is the development of interoceptive attention (IA) to visceral bodily sensations, facilitated through daily practices such as breath monitoring. Using functional magnetic resonance imaging (fMRI), we examined experience-dependent functional plasticity in accessing interoceptive representations by comparing graduates of a Mindfulness-Based Stress Reduction course to a waitlisted control group. IA to respiratory sensations was contrasted against two visual tasks, controlling for attentional requirements non-specific to IA such as maintaining sensation and suppressing distraction. In anatomically partitioned analyses of insula activity, MT predicted greater IA-related activity in anterior dysgranular insula regions, consistent with greater integration of interoceptive sensation with external context. MT also predicted decreased recruitment of the dorsomedial prefrontal cortex (DMPFC) during IA, and altered functional connectivity between the DMPFC and the posterior insula, putative primary interoceptive cortex. Furthermore, meditation practice compliance predicted greater posterior insula and reduced visual pathway recruitment during IA. These findings suggest that interoceptive training modulates task-specific cortical recruitment, analogous to training-related plasticity observed in the external senses. Further, DMPFC modulation of IA networks may be an important mechanism by which MT alters information processing in the brain, increasing the contribution of interoception to perceptual experience.

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PMID: 22689216 [PubMed - in process]

19. Soc Cogn Affect Neurosci. 2013 Jan;8(1):27-33. doi: 10.1093/scan/nss056. Epub 2012 May 7.

The effect of meditation on brain structure: cortical thickness mapping and

diffusion tensor imaging.

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A convergent line of neuroscientific evidence suggests that meditation alters the functional and structural plasticity of distributed neural processes underlying attention and emotion. The purpose of this study was to examine the brain structural differences between a well-matched sample of long-term meditators and controls. We employed whole-brain cortical thickness analysis based on magnetic resonance imaging, and diffusion tensor imaging to quantify white matter integrity in the brains of 46 experienced meditators compared with 46 matched meditation-naïve volunteers. Meditators, compared with controls, showed significantly greater cortical thickness in the anterior regions of the brain, located in frontal and temporal areas, including the medial prefrontal cortex, superior frontal cortex, temporal pole and the middle and inferior temporal cortices. Significantly thinner cortical thickness was found in the posterior regions of the brain, located in the parietal and occipital areas, including the postcentral cortex, inferior parietal cortex, middle occipital cortex and posterior cingulate cortex. Moreover, in the region adjacent to the medial prefrontal cortex, both higher fractional anisotropy values and greater cortical thickness were observed. Our findings suggest that long-term meditators have structural differences in both gray and white matter.

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PMID: 22569185 [PubMed - in process]

20. Soc Cogn Affect Neurosci. 2013 Jan;8(1):85-92. doi: 10.1093/scan/nss045. Epub 2012 Apr 15.

Meditation, mindfulness and executive control: the importance of emotional acceptance and brain-based performance monitoring.

Teper R, Inzlicht M.

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Previous studies have documented the positive effects of mindfulness meditation on executive control. What has been lacking, however, is an understanding of the mechanism underlying this effect. Some theorists have described mindfulness as embodying two facets-present moment awareness and emotional acceptance. Here, we examine how the effect of meditation practice on executive control manifests in the brain, suggesting that emotional acceptance and performance monitoring play important roles. We investigated the effect of meditation practice on executive control and measured the neural correlates of performance monitoring, specifically, the error-related negativity (ERN), a neurophysiological response that occurs within 100 ms of error commission. Meditators and controls completed a Stroop task, during which we recorded ERN amplitudes with electroencephalography. Meditators showed greater executive control (i.e. fewer errors), a higher ERN and more emotional acceptance than controls. Finally, mediation pathway models further revealed that meditation practice relates to greater executive control and that this effect can be accounted for by heightened emotional acceptance, and to a lesser extent, increased brain-based performance monitoring.

PMCID: PMC3541488 [Available on 2014/1/1]

PMID: 22507824 [PubMed - in process]

21. Stress Health. 2012 Dec;28(5):397-407. doi: 10.1002/smj.2470.

Changes in cerebral blood flow and anxiety associated with an 8-week mindfulness programme in women with breast cancer.

Monti DA, Kash KM, Kunkel EJ, Brainard G, Wintering N, Moss AS, Rao H, Zhu S, Newberg AB.

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This study employed functional magnetic resonance imaging to evaluate changes in cerebral blood flow (CBF) associated with the Mindfulness-based Art Therapy (MBAT) programme and correlate such changes to stress and anxiety in women with breast cancer. Eighteen breast cancer patients were randomized to the MBAT or education control group. The patients received the diagnosis of breast cancer between 6 months and 3 years prior to enrollment and were not in active treatment. The age of participants ranged from 52 to 77 years. A voxel-based

analysis was performed to assess differences at rest, during meditation and during a stress task. The anxiety sub-scale of the Symptoms Checklist-90-Revised was compared with changes in resting CBF before and after the programmes. Subjects in the MBAT arm demonstrated significant increases in CBF at rest and during meditation in multiple limbic regions, including the left insula, right amygdala, right hippocampus and bilateral caudate. Patients in the MBAT programme also had a significant correlation between increased CBF in the left caudate and decreased anxiety scores. In the MBAT group, responses to a stressful cue resulted in reduced activation of the posterior cingulate. The results demonstrate that the MBAT programme was associated with significant changes in CBF, which correlated with decreased anxiety over an 8-week period.

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PMID: 23129559 [PubMed - indexed for MEDLINE]

22. J Neurosci. 2012 Oct 31;32(44):15601-10. doi: 10.1523/JNEUROSCI.2957-12.2012.

Cognitive-affective neural plasticity following active-controlled mindfulness intervention.

Allen M, Dietz M, Blair KS, van Beek M, Rees G, Vestergaard-Poulsen P, Lutz A, Roepstorff A.

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Mindfulness meditation is a set of attention-based, regulatory, and self-inquiry training regimes. Although the impact of mindfulness training (MT) on self-regulation is well established, the neural mechanisms supporting such plasticity are poorly understood. MT is thought to act through interoceptive salience and attentional control mechanisms, but until now conflicting evidence from behavioral and neural measures renders difficult distinguishing their respective roles. To resolve this question we conducted a fully randomized 6 week longitudinal trial of MT, explicitly controlling for cognitive and treatment effects with an active-control group. We measured behavioral metacognition and whole-brain blood oxygenation level-dependent (BOLD) signals using functional MRI during an affective Stroop task before and after intervention in healthy human subjects. Although both groups improved significantly on a response-inhibition task, only the MT group showed reduced affective Stroop conflict. Moreover, the

MT group displayed greater dorsolateral prefrontal cortex responses during executive processing, consistent with increased recruitment of top-down mechanisms to resolve conflict. In contrast, we did not observe overall group-by-time interactions on negative affect-related reaction times or BOLD responses. However, only participants with the greatest amount of MT practice showed improvements in response inhibition and increased recruitment of dorsal anterior cingulate cortex, medial prefrontal cortex, and right anterior insula during negative valence processing. Our findings highlight the importance of active control in MT research, indicate unique neural mechanisms for progressive stages of mindfulness training, and suggest that optimal application of MT may differ depending on context, contrary to a one-size-fits-all approach.

PMID: 23115195 [PubMed - indexed for MEDLINE]

23. Cogn Process. 2012 Aug;13(3):255-65. doi: 10.1007/s10339-012-0441-4. Epub 2012 May 5.

EEG source imaging during two Qigong meditations.

Faber PL, Lehmann D, Tei S, Tsujiuchi T, Kumano H, Pascual-Marqui RD, Kochi K.

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Experienced Qigong meditators who regularly perform the exercises "Thinking of Nothing" and "Qigong" were studied with multichannel EEG source imaging during their meditations. The intracerebral localization of brain electric activity during the two meditation conditions was compared using sLORETA functional EEG tomography. Differences between conditions were assessed using t statistics (corrected for multiple testing) on the normalized and log-transformed current density values of the sLORETA images. In the EEG alpha-2 frequency, 125 voxels differed significantly; all were more active during "Qigong" than "Thinking of Nothing," forming a single cluster in parietal Brodmann areas 5, 7, 31, and 40, all in the right hemisphere. In the EEG beta-1 frequency, 37 voxels differed significantly; all were more active during "Thinking of Nothing" than "Qigong," forming a single cluster in prefrontal Brodmann areas 6, 8, and 9, all in the left hemisphere. Compared to combined initial-final no-task resting, "Qigong" showed activation in posterior areas whereas "Thinking of Nothing" showed activation in anterior areas. The stronger activity of posterior (right) parietal

areas during "Qigong" and anterior (left) prefrontal areas during "Thinking of Nothing" may reflect a predominance of self-reference, attention and input-centered processing in the "Qigong" meditation, and of control-centered processing in the "Thinking of Nothing" meditation.

PMID: 22562287 [PubMed - indexed for MEDLINE]

24. Psychol Addict Behav. 2012 Jul 9. [Epub ahead of print]

Retraining the Addicted Brain: A Review of Hypothesized Neurobiological Mechanisms of Mindfulness-Based Relapse Prevention.

Witkiewitz K, Lustyk MK, Bowen S.

Addiction has generally been characterized as a chronic relapsing condition (Leshner, 1999). Several laboratory, preclinical, and clinical studies have provided evidence that craving and negative affect are strong predictors of the relapse process. These states, as well as the desire to avoid them, have been described as primary motives for substance use. A recently developed behavioral treatment, mindfulness-based relapse prevention (MBRP), was designed to target experiences of craving and negative affect and their roles in the relapse process. MBRP offers skills in cognitive-behavioral relapse prevention integrated with mindfulness meditation. The mindfulness practices in MBRP are intended to increase discriminative awareness, with a specific focus on acceptance of uncomfortable states or challenging situations without reacting "automatically." A recent efficacy trial found that those randomized to MBRP, as compared with those in a control group, demonstrated significantly lower rates of substance use and greater decreases in craving following treatment. Furthermore, individuals in MBRP did not report increased craving or substance use in response to negative affect. It is important to note, areas of the brain that have been associated with craving, negative affect, and relapse have also been shown to be affected by mindfulness training. Drawing from the neuroimaging literature, we review several plausible mechanisms by which MBRP might be changing neural responses to the experiences of craving and negative affect, which subsequently may reduce risk for relapse. We hypothesize that MBRP may affect numerous brain systems and may reverse, repair, or compensate for the neuroadaptive changes associated with addiction and addictive-behavior relapse. (PsycINFO Database Record (c) 2012 APA, all rights reserved).

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25. Neurosci Lett. 2012 Jun 29;520(2):165-73. doi: 10.1016/j.neulet.2012.03.082. Epub 2012 Apr 6.

Mindfulness meditation-related pain relief: evidence for unique brain mechanisms in the regulation of pain.

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The cognitive modulation of pain is influenced by a number of factors ranging from attention, beliefs, conditioning, expectations, mood, and the regulation of emotional responses to noxious sensory events. Recently, mindfulness meditation has been found attenuate pain through some of these mechanisms including enhanced cognitive and emotional control, as well as altering the contextual evaluation of sensory events. This review discusses the brain mechanisms involved in mindfulness meditation-related pain relief across different meditative techniques, expertise and training levels, experimental procedures, and neuroimaging methodologies. Converging lines of neuroimaging evidence reveal that mindfulness meditation-related pain relief is associated with unique appraisal cognitive processes depending on expertise level and meditation tradition. Moreover, it is postulated that mindfulness meditation-related pain relief may share a common final pathway with other cognitive techniques in the modulation of pain.

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26. Proc Natl Acad Sci U S A. 2012 Jun 26;109(26):10570-4. doi: 10.1073/pnas.1207817109. Epub 2012 Jun 11.

Mechanisms of white matter changes induced by meditation.

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Using diffusion tensor imaging, several recent studies have shown that training results in changes in white matter efficiency as measured by fractional anisotropy (FA). In our work, we found that a form of mindfulness meditation, integrative body-mind training (IBMT), improved FA in areas surrounding the anterior cingulate cortex after 4-wk training more than controls given relaxation training. Reductions in radial diffusivity (RD) have been interpreted as improved myelin but reductions in axial diffusivity (AD) involve other mechanisms, such as axonal density. We now report that after 4-wk training with IBMT, both RD and AD decrease accompanied by increased FA, indicating improved efficiency of white matter involves increased myelin as well as other axonal changes. However, 2-wk IBMT reduced AD, but not RD or FA, and improved moods. Our results demonstrate the time-course of white matter neuroplasticity in short-term meditation. This dynamic pattern of white matter change involving the anterior cingulate cortex, a part of the brain network related to self-regulation, could provide a means for intervention to improve or prevent mental disorders.

PMCID: PMC3387117

PMID: 22689998 [PubMed - indexed for MEDLINE]

27. J Neurosci. 2012 Apr 11;32(15):5242-9. doi: 10.1523/JNEUROSCI.4135-11.2012.

Dynamical properties of BOLD activity from the ventral posteromedial cortex associated with meditation and attentional skills.

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Neuroimaging data suggest a link between the spontaneous production of thoughts during wakeful rest and slow fluctuations of activity in the default mode network (DMN), a set of brain regions with high basal metabolism and a major neural hub in the ventral posteromedial cortex (vPMC). Meta-awareness and regulation of mind-wandering are core cognitive components of most contemplative practices and to study their impact on DMN activity, we collected functional MRI (fMRI) data from a cohort of experienced Zen meditators and meditation-naïve controls engaging in a basic attention-to-breathing protocol. We observed a significant

group difference in the skewness of the fMRI BOLD signal from the vPMC, suggesting that the relative incidence of states of elevated vPMC activity was lower in meditators; furthermore, the same parameter was significantly correlated with performance on a rapid visual information processing (RVIP) test for sustained attention conducted outside the scanner. Finally, a functional connectivity analysis with the vPMC seed revealed a significant association of RVIP performance with the degree of temporal correlation between vPMC and the right temporoparietal junction (TPJ), a region strongly implicated in stimulus-triggered reorienting of attention. Together, these findings suggest that the vPMC BOLD signal skewness and the temporal relationship of vPMC and TPJ activities reflect the dynamic tension between mind-wandering, meta-awareness, and directed attention, and may represent a useful endophenotype for studying individual differences in attentional abilities and the impairment of the latter in specific clinical conditions.

PMCID: PMC3362741

PMID: 22496570 [PubMed - indexed for MEDLINE]

28. Clin Neurophysiol. 2012 Apr;123(4):700-10. doi: 10.1016/j.clinph.2011.07.048. Epub 2011 Sep 21.

Mindfulness-induced changes in gamma band activity - implications for the default mode network, self-reference and attention.

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Comment in

Clin Neurophysiol. 2012 Apr;123(4):631-2.

**OBJECTIVE:** There is a growing scientific interest in mindfulness meditation (MM), yet its underlying neurophysiological mechanism is still uncertain. We investigated whether MM affects self-referential processing, associated with default mode network (DMN), either as short (state) - or long-term (trait) effects.

**METHODS:** Three levels of MM expertise were compared with controls (n=12 each) by electroencephalography (EEG).

**RESULTS:** DMN deactivation was identified during the transition from resting state

to a time production task, as lower gamma (25–45 Hz) power over frontal and midline regions. MM practitioners exhibited a trait lower frontal gamma activity, related to narrative self-reference and DMN activity, as well as producing longer durations, these being negatively correlated with frontal gamma activity.

Additionally, we found state increases in posterior gamma power, suggesting increased attention and sensory awareness. MM proficiency did not affect the results.

**CONCLUSIONS:** Gamma power over frontal midline areas reflects DMN activity. MM practitioners exhibit lower trait frontal gamma activity, as well as a state and trait increases in posterior gamma power, irrespective of practice proficiency.

**SIGNIFICANCE:** First, the DMN can be studied non-invasively by EEG. Second, MM induces from the early stages of practice neuroplasticity in self-referential and attentional networks.

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PMID: 21940201 [PubMed - indexed for MEDLINE]

29. Conscious Cogn. 2012 Mar;21(1):269–76. doi: 10.1016/j.concog.2011.09.019. Epub 2011 Oct 17.

A neurocognitive model of meditation based on activation likelihood estimation (ALE) meta-analysis.

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Meditation comprises a series of practices mainly developed in eastern cultures aiming at controlling emotions and enhancing attentional processes. Several authors proposed to divide meditation techniques in focused attention (FA) and open monitoring (OM) techniques. Previous studies have reported differences in brain networks underlying FA and OM. On the other hand common activations across different meditative practices have been reported. Despite differences between forms of meditation and their underlying cognitive processes, we propose that all meditative techniques could share a central process that would be supported by a core network for meditation since their general common goal is to induce relaxation, regulating attention and developing an attitude of detachment from

one's own thoughts. To test this hypothesis, we conducted a quantitative meta-analysis based on activation likelihood estimation (ALE) of 10 neuroimaging studies (91 subjects) on different meditative techniques to evidence the core cortical network subserving meditation. We showed activation of basal ganglia (caudate body), limbic system (enthorinal cortex) and medial prefrontal cortex (MPFC). We discuss the functional role of these structures in meditation and we tentatively propose a neurocognitive model of meditation that could guide future research.

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PMID: 22005087 [PubMed - indexed for MEDLINE]

30. BMC Psychiatry. 2012 Feb 29;12:15. doi: 10.1186/1471-244X-12-15.

Mindfulness based cognitive therapy improves frontal control in bipolar disorder: a pilot EEG study.

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**BACKGROUND:** Cognitive processing in Bipolar Disorder is characterized by a number of attentional abnormalities. Mindfulness Based Cognitive Therapy combines mindfulness meditation, a form of attentional training, along with aspects of cognitive therapy, and may improve attentional dysfunction in bipolar disorder patients.

**METHODS:** 12 euthymic BD patients and 9 control participants underwent record of electroencephalography (EEG, band frequency analysis) during resting states (eyes open, eyes closed) and during the completion of a continuous performance task (A-X version, EEG event-related potential (ERP) wave component analysis). The individuals with BD completed an 8-week MBCT intervention and record of EEG was repeated.

**RESULTS:** (1) Brain activity, individuals with BD showed significantly decreased theta band power, increased beta band power, and decreased theta/beta ratios during the resting state, eyes closed, for frontal and cingulate cortices. Post MBCT intervention improvement over the right frontal cortex was seen in the individuals with BD, as beta band power decreased. (2) Brain activation, individuals with BD showed a significant P300-like wave form over the frontal

cortex during the cue. Post MBCT intervention the P300-like waveform was significantly attenuated over the frontal cortex.

**CONCLUSIONS:** Individuals with BD show decreased attentional readiness and activation of non-relevant information processing during attentional processes. These data are the first that show, MBCT in BD improved attentional readiness, and attenuated activation of non-relevant information processing during attentional processes.

PMCID: PMC3305658

PMID: 22375965 [PubMed - indexed for MEDLINE]

31. Can J Psychiatry. 2012 Feb;57(2):70-7.

The mindful brain and emotion regulation in mood disorders.

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Comment in

Can J Psychiatry. 2012 Feb;57(2):61-2.

Mindfulness involves nonjudgmental attention to present-moment experience. In its therapeutic forms, mindfulness interventions promote increased tolerance of negative affect and improved well-being. However, the neural mechanisms underlying mindful mood regulation are poorly understood. Mindfulness training appears to enhance focused attention, supported by the anterior cingulate cortex and the lateral prefrontal cortex (PFC). In emotion regulation, these PFC changes promote the stable recruitment of a nonconceptual sensory pathway, an alternative to conventional attempts to cognitively reappraise negative emotion. In neural terms, the transition to nonconceptual awareness involves reducing evaluative processing, supported by midline structures of the PFC. Instead, attentional resources are directed toward a limbic pathway for present-moment sensory awareness, involving the thalamus, insula, and primary sensory regions. In patients with affective disorders, mindfulness training provides an alternative to cognitive efforts to control negative emotion, instead directing attention toward the transitory nature of momentary experience. Limiting cognitive elaboration in favour of momentary awareness appears to reduce automatic negative self-evaluation, increase tolerance for negative affect and pain, and help to

engender self-compassion and empathy in people with chronic dysphoria.

PMCID: PMC3303604

PMID: 22340146 [PubMed - indexed for MEDLINE]

32. Can J Psychiatry. 2012 Feb;57(2):61-2.

Mindfulness and psychiatry.

Abbey SE.

Comment on

Can J Psychiatry. 2012 Feb;57(2):63-9.

Can J Psychiatry. 2012 Feb;57(2):70-7.

PMID: 22340144 [PubMed - indexed for MEDLINE]

33. Neuroimage. 2012 Jan 2;59(1):750-60. doi: 10.1016/j.neuroimage.2011.07.008. Epub 2011 Jul 14.

Mind wandering and attention during focused meditation: a fine-grained temporal analysis of fluctuating cognitive states.

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Studies have suggested that the default mode network is active during mind wandering, which is often experienced intermittently during sustained attention tasks. Conversely, an anticorrelated task-positive network is thought to subserve various forms of attentional processing. Understanding how these two systems work together is central for understanding many forms of optimal and sub-optimal task performance. Here we present a basic model of naturalistic cognitive fluctuations between mind wandering and attentional states derived from the practice of focused attention meditation. This model proposes four intervals in a cognitive cycle: mind wandering, awareness of mind wandering, shifting of attention, and sustained attention. People who train in this style of meditation cultivate their abilities to monitor cognitive processes related to attention and distraction,

making them well suited to report on these mental events. Fourteen meditation practitioners performed breath-focused meditation while undergoing fMRI scanning. When participants realized their mind had wandered, they pressed a button and returned their focus to the breath. The four intervals above were then constructed around these button presses. We hypothesized that periods of mind wandering would be associated with default mode activity, whereas cognitive processes engaged during awareness of mind wandering, shifting of attention and sustained attention would engage attentional subnetworks. Analyses revealed activity in brain regions associated with the default mode during mind wandering, and in salience network regions during awareness of mind wandering. Elements of the executive network were active during shifting and sustained attention. Furthermore, activations during these cognitive phases were modulated by lifetime meditation experience. These findings support and extend theories about cognitive correlates of distributed brain networks.

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PMID: 21782031 [PubMed - indexed for MEDLINE]

34. Neuroimage. 2012 Jan 2;59(1):745-9. doi: 10.1016/j.neuroimage.2011.06.088. Epub 2011 Jul 7.

Meditation training increases brain efficiency in an attention task.

Kozasa EH, Sato JR, Lacerda SS, Barreiros MA, Radvany J, Russell TA, Sanches LG, Mello LE, Amaro E Jr.

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Meditation is a mental training, which involves attention and the ability to maintain focus on a particular object. In this study we have applied a specific attentional task to simply measure the performance of the participants with different levels of meditation experience, rather than evaluating meditation practice per se or task performance during meditation. Our objective was to evaluate the performance of regular meditators and non-meditators during an fMRI adapted Stroop Word-Colour Task (SWCT), which requires attention and impulse control, using a block design paradigm. We selected 20 right-handed regular meditators and 19 non-meditators matched for age, years of education and gender. Participants had to choose the colour (red, blue or green) of single words

presented visually in three conditions: congruent, neutral and incongruent. Non-meditators showed greater activity than meditators in the right medial frontal, middle temporal, precentral and postcentral gyri and the lentiform nucleus during the incongruent conditions. No regions were more activated in meditators relative to non-meditators in the same comparison. Non-meditators showed an increased pattern of brain activation relative to regular meditators under the same behavioural performance level. This suggests that meditation training improves efficiency, possibly via improved sustained attention and impulse control.

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35. Behav Res Ther. 2012 Jan;50(1):3-12. doi: 10.1016/j.brat.2011.10.011. Epub 2011 Nov 11.

The validation of an active control intervention for Mindfulness Based Stress Reduction (MBSR).

MacCoon DG, Imel ZE, Rosenkranz MA, Sheftel JG, Weng HY, Sullivan JC, Bonus KA, Stoney CM, Salomons TV, Davidson RJ, Lutz A.

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Most of the extant literature investigating the health effects of mindfulness interventions relies on wait-list control comparisons. The current article specifies and validates an active control condition, the Health Enhancement Program (HEP), thus providing the foundation necessary for rigorous investigations of the relative efficacy of Mindfulness Based Stress Reduction (MBSR) and for testing mindfulness as an active ingredient. 63 participants were randomized to either MBSR ( $n = 31$ ) or HEP ( $n = 32$ ). Compared to HEP, MBSR led to reductions in thermal pain ratings in the mindfulness- but not the HEP-related instruction condition ( $\eta^2 = .18$ ). There were significant improvements over time for general distress ( $\eta^2 = .09$ ), anxiety ( $\eta^2 = .08$ ), hostility ( $\eta^2 = .07$ ), and medical symptoms ( $\eta^2 = .14$ ), but no effects of intervention. Practice was not related to change. HEP is an active control condition for MBSR while remaining inert to mindfulness. These claims are supported by results from a pain task. Participant-reported outcomes (PROs) replicate previous improvements to

well-being in MBSR, but indicate that MBSR is no more effective than a rigorous active control in improving these indices. These results emphasize the importance of using an active control condition like HEP in studies evaluating the effectiveness of MBSR.

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PMID: 22137364 [PubMed - indexed for MEDLINE]

36. Brain Inj. 2012;26(13-14):1621-8. doi: 10.3109/02699052.2012.700082. Epub 2012 Jul 13.

Mindfulness-based stress reduction (MBSR) improves long-term mental fatigue after stroke or traumatic brain injury.

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**OBJECTIVE:** Patients who suffer from mental fatigue after a stroke or traumatic brain injury (TBI) have a drastically reduced capacity for work and for participating in social activities. Since no effective therapy exists, the aim was to implement a novel, non-pharmacological strategy aimed at improving the condition of these patients.

**METHODS:** This study tested a treatment with mindfulness-based stress reduction (MBSR). The results of the programme were evaluated using a self-assessment scale for mental fatigue and neuropsychological tests. Eighteen participants with stroke and 11 with TBI were included. All the subjects were well rehabilitated physically with no gross impairment to cognitive functions other than the symptom mental fatigue. Fifteen participants were randomized for inclusion in the MBSR programme for 8 weeks, while the other 14 served as controls and received no active treatment. Those who received no active treatment were offered MBSR during the next 8 weeks.

**RESULTS:** Statistically significant improvements were achieved in the primary end-point--the self-assessment for mental fatigue--and in the secondary end-point--neuropsychological tests; Digit Symbol-Coding and Trail Making Test.

**CONCLUSION:** The results from the present study show that MBSR may be a promising

non-pharmacological treatment for mental fatigue after a stroke or TBI.

PMID: 22794665 [PubMed - indexed for MEDLINE]

37. Evid Based Complement Alternat Med. 2012;2012:821307. doi: 10.1155/2012/821307.  
Epub 2012 Dec 5.

Yoga meditation practitioners exhibit greater gray matter volume and fewer reported cognitive failures: results of a preliminary voxel-based morphometric analysis.

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Hatha yoga techniques, including physical postures (asanas), breathing exercises (pranayama), and meditation, involve the practice of mindfulness. In turn, yoga meditation practices may induce the state of mindfulness, which, when evoked recurrently through repeated practice, may accrue into trait or dispositional mindfulness. Putatively, these changes may be mediated by experience-dependent neuroplastic changes. Though prior studies have identified differences in gray matter volume (GMV) between long-term mindfulness practitioners and controls, no studies to date have reported on whether yoga meditation is associated with GMV differences. The present study investigated GMV differences between yoga meditation practitioners (YMP) and a matched control group (CG). The YMP group exhibited greater GM volume in frontal, limbic, temporal, occipital, and cerebellar regions; whereas the CG had no greater regional greater GMV. In addition, the YMP group reported significantly fewer cognitive failures on the Cognitive Failures Questionnaire (CFQ), the magnitude of which was positively correlated with GMV in numerous regions identified in the primary analysis. Lastly, GMV was positively correlated with the duration of yoga practice. Results from this preliminary study suggest that hatha yoga practice may be associated with the promotion of neuroplastic changes in executive brain systems, which may confer therapeutic benefits that accrue with repeated practice.

PMCID: PMC3525089

PMID: 23304217 [PubMed]

38. Front Hum Neurosci. 2012;6:346. doi: 10.3389/fnhum.2012.00346. Epub 2013 Jan 4.

Meditation-related activations are modulated by the practices needed to obtain it and by the expertise: an ALE meta-analysis study.

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The brain network governing meditation has been studied using a variety of meditation practices and techniques eliciting different cognitive processes (e.g., silence, attention to own body, sense of joy, mantras, etc.). It is very possible that different practices of meditation are subserved by largely, if not entirely, disparate brain networks. This assumption was tested by conducting an activation likelihood estimation (ALE) meta-analysis of meditation neuroimaging studies, which assessed 150 activation foci from 24 experiments. Different ALE meta-analyses were carried out. One involved the subsets of studies involving meditation induced through exercising focused attention (FA). The network included clusters bilaterally in the medial gyrus, the left superior parietal lobe, the left insula and the right supramarginal gyrus (SMG). A second analysis addressed the studies involving meditation states induced by chanting or by repetition of words or phrases, known as "mantra." This type of practice elicited a cluster of activity in the right SMG, the SMA bilaterally and the left postcentral gyrus. Furthermore, the last analyses addressed the effect of meditation experience (i.e., short- vs. long-term meditators). We found that frontal activation was present for short-term, as compared with long-term experience meditators, confirming that experts are better enabled to sustain attentional focus, rather recruiting the right SMG and concentrating on aspects involving disembodyment.

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PMID: 23316154 [PubMed]

39. Front Hum Neurosci. 2012;6:295. doi: 10.3389/fnhum.2012.00295. Epub 2012 Nov 5.

Randomized controlled trial of mindfulness-based stress reduction versus aerobic exercise: effects on the self-referential brain network in social anxiety disorder.

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**Background:** Social anxiety disorder (SAD) is characterized by distorted self-views. The goal of this study was to examine whether mindfulness-based stress reduction (MBSR) alters behavioral and brain measures of negative and positive self-views. **Methods:** Fifty-six adult patients with generalized SAD were randomly assigned to MBSR or a comparison aerobic exercise (AE) program. A self-referential encoding task was administered at baseline and post-intervention to examine changes in behavioral and neural responses in the self-referential brain network during functional magnetic resonance imaging. Patients were cued to decide whether positive and negative social trait adjectives were self-descriptive or in upper case font. **Results:** Behaviorally, compared to AE, MBSR produced greater decreases in negative self-views, and equivalent increases in positive self-views. Neurally, during negative self versus case, compared to AE, MBSR led to increased brain responses in the posterior cingulate cortex (PCC). There were no differential changes for positive self versus case. Secondary analyses showed that changes in endorsement of negative and positive self-views were associated with decreased social anxiety symptom severity for MBSR, but not AE. Additionally, MBSR-related increases in dorsomedial prefrontal cortex (DMPFC) activity during negative self-view versus case were associated with decreased social anxiety related disability and increased mindfulness. Analysis of neural temporal dynamics revealed MBSR-related changes in the timing of neural responses in the DMPFC and PCC for negative self-view versus case. **Conclusion:** These findings suggest that MBSR attenuates maladaptive habitual self-views by facilitating automatic (i.e., uninstructed) recruitment of cognitive and attention regulation neural networks. This highlights potentially important links between self-referential and cognitive-attention regulation systems and suggests that MBSR may enhance more adaptive social self-referential processes in patients with SAD.

PMCID: PMC3488800

PMID: 23133411 [PubMed]

40. Front Hum Neurosci. 2012;6:296. doi: 10.3389/fnhum.2012.00296. Epub 2012 Oct 25.

Self-awareness, self-regulation, and self-transcendence (S-ART): a framework for understanding the neurobiological mechanisms of mindfulness.

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Mindfulness-as a state, trait, process, type of meditation, and intervention has proven to be beneficial across a diverse group of psychological disorders as well as for general stress reduction. Yet, there remains a lack of clarity in the operationalization of this construct, and underlying mechanisms. Here, we provide an integrative theoretical framework and systems-based neurobiological model that explains the mechanisms by which mindfulness reduces biases related to self-processing and creates a sustainable healthy mind. Mindfulness is described through systematic mental training that develops meta-awareness (self-awareness), an ability to effectively modulate one's behavior (self-regulation), and a positive relationship between self and other that transcends self-focused needs and increases prosocial characteristics (self-transcendence). This framework of self-awareness, -regulation, and -transcendence (S-ART) illustrates a method for becoming aware of the conditions that cause (and remove) distortions or biases. The development of S-ART through meditation is proposed to modulate self-specifying and narrative self-networks through an integrative fronto-parietal control network. Relevant perceptual, cognitive, emotional, and behavioral neuropsychological processes are highlighted as supporting mechanisms for S-ART, including intention and motivation, attention regulation, emotion regulation, extinction and reconsolidation, prosociality, non-attachment, and decentering. The S-ART framework and neurobiological model is based on our growing understanding of the mechanisms for neurocognition, empirical literature, and through dismantling the specific meditation practices thought to cultivate mindfulness. The proposed framework will inform future research in the contemplative sciences and target specific areas for development in the treatment of psychological disorders.

PMCID: PMC3480633

PMID: 23112770 [PubMed]

41. Front Hum Neurosci. 2012;6:256. doi: 10.3389/fnhum.2012.00256. Epub 2012 Sep 10.

Intensive training induces longitudinal changes in meditation state-related EEG oscillatory activity.

Saggar M, King BG, Zanesco AP, Maclean KA, Aichele SR, Jacobs TL, Bridwell DA,

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The capacity to focus one's attention for an extended period of time can be increased through training in contemplative practices. However, the cognitive processes engaged during meditation that support trait changes in cognition are not well characterized. We conducted a longitudinal wait-list controlled study of intensive meditation training. Retreat participants practiced focused attention (FA) meditation techniques for three months during an initial retreat. Wait-list participants later undertook formally identical training during a second retreat. Dense-array scalp-recorded electroencephalogram (EEG) data were collected during 6 min of mindfulness of breathing meditation at three assessment points during each retreat. Second-order blind source separation, along with a novel semi-automatic artifact removal tool (SMART), was used for data preprocessing. We observed replicable reductions in meditative state-related beta-band power bilaterally over anteriocentral and posterior scalp regions. In addition, individual alpha frequency (IAF) decreased across both retreats and in direct relation to the amount of meditative practice. These findings provide evidence for replicable longitudinal changes in brain oscillatory activity during meditation and increase our understanding of the cortical processes engaged during meditation that may support long-term improvements in cognition.

PMCID: PMC3437523

PMID: 22973218 [PubMed]

42. Front Hum Neurosci. 2012;6:133. doi: 10.3389/fnhum.2012.00133. Epub 2012 May 15.

Meditation increases the depth of information processing and improves the allocation of attention in space.

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During meditation, practitioners are required to center their attention on a specific object for extended periods of time. When their thoughts get diverted,

they learn to quickly disengage from the distracter. We hypothesized that learning to respond to the dual demand of engaging attention on specific objects and disengaging quickly from distracters enhances the efficiency by which meditation practitioners can allocate attention. We tested this hypothesis in a global-to-local task while measuring electroencephalographic activity from a group of eight highly trained Buddhist monks and nuns and a group of eight age and education matched controls with no previous meditation experience.

Specifically, we investigated the effect of attentional training on the global precedence effect, i.e., faster detection of targets on a global than on a local level. We expected to find a reduced global precedence effect in meditation practitioners but not in controls, reflecting that meditators can more quickly disengage their attention from the dominant global level. Analysis of reaction times confirmed this prediction. To investigate the underlying changes in brain activity and their time course, we analyzed event-related potentials. Meditators showed an enhanced ability to select the respective target level, as reflected by enhanced processing of target level information. In contrast with control group, which showed a local target selection effect only in the P1 and a global target selection effect in the P3 component, meditators showed effects of local information processing in the P1, N2, and P3 and of global processing for the N1, N2, and P3. Thus, meditators seem to display enhanced depth of processing. In addition, meditation altered the uptake of information such that meditators selected target level information earlier in the processing sequence than controls. In a longitudinal experiment, we could replicate the behavioral effects, suggesting that meditation modulates attention already after a 4-day meditation retreat. Together, these results suggest that practicing meditation enhances the speed with which attention can be allocated and relocated, thus increasing the depth of information processing and reducing response latency.

PMCID: PMC3351800

PMID: 22615691 [PubMed]

43. Front Hum Neurosci. 2012;6:38. doi: 10.3389/fnhum.2012.00038. Epub 2012 Mar 1.

Effects of meditation experience on functional connectivity of distributed brain networks.

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This study sought to examine the effect of meditation experience on brain networks underlying cognitive actions employed during contemplative practice. In a previous study, we proposed a basic model of naturalistic cognitive fluctuations that occur during the practice of focused attention meditation. This model specifies four intervals in a cognitive cycle: mind wandering (MW), awareness of MW, shifting of attention, and sustained attention. Using subjective input from experienced practitioners during meditation, we identified activity in salience network regions during awareness of MW and executive network regions during shifting and sustained attention. Brain regions associated with the default mode were active during MW. In the present study, we reasoned that repeated activation of attentional brain networks over years of practice may induce lasting functional connectivity changes within relevant circuits. To investigate this possibility, we created seeds representing the networks that were active during the four phases of the earlier study, and examined functional connectivity during the resting state in the same participants. Connectivity maps were then contrasted between participants with high vs. low meditation experience. Participants with more meditation experience exhibited increased connectivity within attentional networks, as well as between attentional regions and medial frontal regions. These neural relationships may be involved in the development of cognitive skills, such as maintaining attention and disengaging from distraction, that are often reported with meditation practice. Furthermore, because altered connectivity of brain regions in experienced meditators was observed in a non-meditative (resting) state, this may represent a transference of cognitive abilities "off the cushion" into daily life.

PMCID: PMC3290768  
PMID: 22403536 [PubMed]

44. Front Hum Neurosci. 2012;6:34. doi: 10.3389/fnhum.2012.00034. Epub 2012 Feb 29.

The unique brain anatomy of meditation practitioners: alterations in cortical gyration.

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Several cortical regions are reported to vary in meditation practitioners. However, prior analyses have focused primarily on examining gray matter or

cortical thickness. Thus, additional effects with respect to other cortical features might have remained undetected. Gyrification (the pattern and degree of cortical folding) is an important cerebral characteristic related to the geometry of the brain's surface. Thus, exploring cortical gyrification in long-term meditators may provide additional clues with respect to the underlying anatomical correlates of meditation. This study examined cortical gyrification in a large sample ( $n=100$ ) of meditators and controls, carefully matched for sex and age. Cortical gyrification was established by calculating mean curvature across thousands of vertices on individual cortical surface models. Pronounced group differences indicating larger gyrification in meditators were evident within the left precentral gyrus, right fusiform gyrus, right cuneus, as well as left and right anterior dorsal insula (the latter representing the global significance maximum). Positive correlations between gyrification and the number of meditation years were similarly pronounced in the right anterior dorsal insula. Although the exact functional implications of larger cortical gyrification remain to be established, these findings suggest the insula to be a key structure involved in aspects of meditation. For example, variations in insular complexity could affect the regulation of well-known distractions in the process of meditation, such as daydreaming, mind-wandering, and projections into past or future. Moreover, given that meditators are masters in introspection, awareness, and emotional control, increased insular gyrification may reflect an integration of autonomic, affective, and cognitive processes. Due to the cross-sectional nature of this study, further research is necessary to determine the relative contribution of nature and nurture to links between cortical gyrification and meditation.

PMCID: PMC3289949  
PMID: 22393318 [PubMed]

45. Front Psychol. 2012;3:116. doi: 10.3389/fpsyg.2012.00116. Epub 2012 Apr 18.

Meditate to create: the impact of focused-attention and open-monitoring training on convergent and divergent thinking.

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The practice of meditation has seen a tremendous increase in the western world since the 60s. Scientific interest in meditation has also significantly grown in

the past years; however, so far, it has neglected the idea that different type of meditations may drive specific cognitive-control states. In this study we investigate the possible impact of meditation based on focused-attention (FA) and meditation based on open-monitoring (OM) on creativity tasks tapping into convergent and divergent thinking. We show that FA meditation and OM meditation exert specific effect on creativity. First, OM meditation induces a control state that promotes divergent thinking, a style of thinking that allows many new ideas of being generated. Second, FA meditation does not sustain convergent thinking, the process of generating one possible solution to a particular problem. We suggest that the enhancement of positive mood induced by meditating has boosted the effect in the first case and counteracted in the second case.

PMCID: PMC3328799  
PMID: 22529832 [PubMed]

46. PLoS One. 2012;7(9):e46377. doi: 10.1371/journal.pone.0046377. Epub 2012 Sep 28.

The structure of mindful brain.

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Mindfulness is currently attracting a great deal of attention as a psychotherapy technique. It is defined as bringing one's complete attention to the experiences occurring in the present moment in a nonjudgmental or accepting way. The Five Facet Mindfulness Questionnaire (FFMQ) was developed to assess individual differences in mindfulness states. The FFMQ is composed of five facets representing elements of mindfulness: non-reactivity to inner experience, non-judging, acting with awareness, describing, and observing. In the present study, we applied voxel-based morphometry to investigate the relationship between the brain structure and each facet as measured by the FFMQ. The results showed a positive association between the describing facet of mindfulness on the FFMQ and gray matter volume in the right anterior insula and the right amygdala. In conclusion, mindfulness was related with development in parts of the somatic marker circuit of the brain.

PMCID: PMC3460809  
PMID: 23029500 [PubMed - indexed for MEDLINE]

47. PLoS One. 2012;7(8):e40054. doi: 10.1371/journal.pone.0040054. Epub 2012 Aug 15.

Distinct neural activity associated with focused-attention meditation and loving-kindness meditation.

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This study examined the dissociable neural effects of ānāpānasati (focused-attention meditation, FAM) and mettā (loving-kindness meditation, LKM) on BOLD signals during cognitive (continuous performance test, CPT) and affective (emotion-processing task, EPT, in which participants viewed affective pictures) processing. Twenty-two male Chinese expert meditators (11 FAM experts, 11 LKM experts) and 22 male Chinese novice meditators (11 FAM novices, 11 LKM novices) had their brain activity monitored by a 3T MRI scanner while performing the cognitive and affective tasks in both meditation and baseline states. We examined the interaction between state (meditation vs. baseline) and expertise (expert vs. novice) separately during LKM and FAM, using a conjunction approach to reveal common regions sensitive to the expert meditative state. Additionally, exclusive masking techniques revealed distinct interactions between state and group during LKM and FAM. Specifically, we demonstrated that the practice of FAM was associated with expertise-related behavioral improvements and neural activation differences in attention task performance. However, the effect of state LKM meditation did not carry over to attention task performance. On the other hand, both FAM and LKM practice appeared to affect the neural responses to affective pictures. For viewing sad faces, the regions activated for FAM practitioners were consistent with attention-related processing; whereas responses of LKM experts to sad pictures were more in line with differentiating emotional contagion from compassion/emotional regulation processes. Our findings provide the first report of distinct neural activity associated with forms of meditation during sustained attention and emotion processing.

PMCID: PMC3419705

PMID: 22905090 [PubMed - indexed for MEDLINE]

48. Biol Psychol. 2011 Dec;88(2-3):243-52. doi: 10.1016/j.biopsych.2011.08.008. Epub

2011 Aug 30.

Mindfulness-based cognitive therapy (MBCT), cognitive style, and the temporal dynamics of frontal EEG alpha asymmetry in recurrently depressed patients.

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Mindfulness-based cognitive therapy (MBCT), a meditation-based maintenance therapy, reduces the relapse risk in individuals suffering from major depressive disorder (MDD). However, only a few studies investigated the psychophysiological mechanisms underlying this protective effect. We examined effects of MBCT on trait rumination and mindfulness, as indicators of global cognitive style, as well as on residual depressive symptoms in a group of recurrently depressed patients ( $n=78$ ) in remission. Additionally, alpha asymmetry in resting-state electroencephalogram (EEG) was assessed. Alpha asymmetry has been found to be predictive of affective style and a pattern indicative of stronger relative right-hemispheric anterior cortical activity may represent a trait marker for the vulnerability to develop MDD. In line with previous findings, residual depressive symptoms and trait rumination decreased, whereas trait mindfulness increased following MBCT, while no such changes took place in a wait-list control group. Mean values of alpha asymmetry, on the other hand, remained unaffected by training, and shifted systematically toward a pattern indicative of stronger relative right-hemispheric anterior cortical activity in the whole sample. These findings provide further support for the protective effect of MBCT. In the examined patients who were at an extremely high risk for relapse, however, this effect did not manifest itself on a neurophysiological level in terms of alpha asymmetry, where a shift, putatively indicative of increased vulnerability, was observed.

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PMID: 21884751 [PubMed - indexed for MEDLINE]

49. Clin Psychol Rev. 2011 Nov;31(7):1126-32. doi: 10.1016/j.cpr.2011.07.003. Epub 2011 Jul 26.

Loving-kindness and compassion meditation: potential for psychological interventions.

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Mindfulness-based meditation interventions have become increasingly popular in contemporary psychology. Other closely related meditation practices include loving-kindness meditation (LKM) and compassion meditation (CM), exercises oriented toward enhancing unconditional, positive emotional states of kindness and compassion. This article provides a review of the background, the techniques, and the empirical contemporary literature of LKM and CM. The literature suggests that LKM and CM are associated with an increase in positive affect and a decrease in negative affect. Preliminary findings from neuroendocrine studies indicate that CM may reduce stress-induced subjective distress and immune response. Neuroimaging studies suggest that LKM and CM may enhance activation of brain areas that are involved in emotional processing and empathy. Finally, preliminary intervention studies support application of these strategies in clinical populations. It is concluded that, when combined with empirically supported treatments, such as cognitive-behavioral therapy, LKM and CM may provide potentially useful strategies for targeting a variety of different psychological problems that involve interpersonal processes, such as depression, social anxiety, marital conflict, anger, and coping with the strains of long-term caregiving.

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PMCID: PMC3176989

PMID: 21840289 [PubMed - indexed for MEDLINE]

50. Sci China Life Sci. 2011 Oct;54(10):961-5. doi: 10.1007/s11427-011-4233-3. Epub 2011 Oct 29.

Meditation promotes insightful problem-solving by keeping people in a mindful and alert conscious state.

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Although previous studies have shown that sleep can inspire insight, it is still unclear whether meditation can promote insight. Meditation differs from other types of passive rest such as relaxation and sleep because it requires full consciousness and mindfulness of targets such as one's breathing. Forty-eight university students without meditation experience were recruited to learn a simple meditation technique. They were given a list of 10 insight problems to solve (the pre-test session). In this study, we focused on the unsolved problems and examined if they could be successfully solved after a 20 min rest interval with or without meditation. Results showed that relative to the control group that listened to Chinese or English words and made a language judgment, the groups who learned meditation successfully solved significantly more failed problems from the pre-test session, providing direct evidence for the role of meditation in promoting insight. Further analysis showed that maintaining a mindful and alert state during meditation (raising a hand to report every 10 deep breaths compared to every 100 deep breaths) resulted in more insight regarding the failed items from the pre-test session. This implies that it was watchfulness in meditation, rather than relaxation, that actually contributed to insight. Consistently, in the meditation session or control task, the percentage of alpha waves—a brain index of mental relaxation—was negatively correlated with insight. These results suggest a meditation-based insight-promoting mechanism different from that involved in passive rest such as relaxation and sleep.

PMID: 22038009 [PubMed - indexed for MEDLINE]

51. Neuroimage. 2011 Aug 15;57(4):1524-33. doi: 10.1016/j.neuroimage.2011.06.001. Epub 2011 Jun 12.

Impact of mindfulness on the neural responses to emotional pictures in experienced and beginner meditators.

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There is mounting evidence that mindfulness meditation is beneficial for the

treatment of mood and anxiety disorders, yet little is known regarding the neural mechanisms through which mindfulness modulates emotional responses. Thus, a central objective of this functional magnetic resonance imaging study was to investigate the effects of mindfulness on the neural responses to emotionally laden stimuli. Another major goal of this study was to examine the impact of the extent of mindfulness training on the brain mechanisms supporting the processing of emotional stimuli. Twelve experienced (with over 1000 h of practice) and 10 beginner meditators were scanned as they viewed negative, positive, and neutral pictures in a mindful state and a non-mindful state of awareness. Results indicated that the Mindful condition attenuated emotional intensity perceived from pictures, while brain imaging data suggested that this effect was achieved through distinct neural mechanisms for each group of participants. For experienced meditators compared with beginners, mindfulness induced a deactivation of default mode network areas (medial prefrontal and posterior cingulate cortices) across all valence categories and did not influence responses in brain regions involved in emotional reactivity during emotional processing. On the other hand, for beginners relative to experienced meditators, mindfulness induced a down-regulation of the left amygdala during emotional processing. These findings suggest that the long-term practice of mindfulness leads to emotional stability by promoting acceptance of emotional states and enhanced present-moment awareness, rather than by eliciting control over low-level affective cerebral systems from higher-order cortical brain regions. These results have implications for affect-related psychological disorders.

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PMID: 21679770 [PubMed - indexed for MEDLINE]

52. Psychoneuroendocrinology. 2011 Jun;36(5):664-81. doi:  
10.1016/j.psyneuen.2010.09.010. Epub 2010 Oct 29.

Intensive meditation training, immune cell telomerase activity, and psychological mediators.

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**BACKGROUND:** Telomerase activity is a predictor of long-term cellular viability, which decreases with chronic psychological distress (Epel et al., 2004). Buddhist traditions claim that meditation decreases psychological distress and promotes well-being (e.g., Dalai Lama and Cutler, 2009). Therefore, we investigated the effects of a 3-month meditation retreat on telomerase activity and two major contributors to the experience of stress: Perceived Control (associated with decreased stress) and Neuroticism (associated with increased subjective distress). We used mediation models to test whether changes in Perceived Control and Neuroticism explained meditation retreat effects on telomerase activity. In addition, we investigated whether two qualities developed by meditative practice, increased Mindfulness and Purpose in Life, accounted for retreat-related changes in the two stress-related variables and in telomerase activity.

**METHODS:** Retreat participants (n=30) meditated for ~6 h daily for 3 months and were compared with a wait-list control group (n=30) matched for age, sex, body mass index, and prior meditation experience. Retreat participants received instruction in concentrative meditation techniques and complementary practices used to cultivate benevolent states of mind (Wallace, 2006). Psychological measures were assessed pre- and post-retreat. Peripheral blood mononuclear cell samples were collected post-retreat for telomerase activity. Because there were clear, *a priori* hypotheses, 1-tailed significance criteria were used throughout.

**RESULTS:** Telomerase activity was significantly greater in retreat participants than in controls at the end of the retreat ( $p<0.05$ ). Increases in Perceived Control, decreases in Neuroticism, and increases in both Mindfulness and Purpose in Life were greater in the retreat group ( $p<0.01$ ). Mediation analyses indicated that the effect of the retreat on telomerase was mediated by increased Perceived Control and decreased Neuroticism. In turn, changes in Perceived Control and Neuroticism were both partially mediated by increased Mindfulness and Purpose in Life. Additionally, increases in Purpose in Life directly mediated the telomerase group difference, whereas increases in Mindfulness did not.

**CONCLUSIONS:** This is the first study to link meditation and positive psychological change with telomerase activity. Although we did not measure baseline telomerase activity, the data suggest that increases in perceived control and decreases in negative affectivity contributed to an increase in telomerase activity, with implications for telomere length and immune cell longevity. Further, Purpose in Life is influenced by meditative practice and directly affects both perceived control and negative emotionality, affecting telomerase activity directly as well as indirectly.

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PMID: 21035949 [PubMed - indexed for MEDLINE]

53. Brain Res Bull. 2011 May 30;85(3-4):96-103. doi:  
10.1016/j.brainresbull.2011.03.026. Epub 2011 Apr 8.

Effects of mindfulness meditation training on anticipatory alpha modulation in primary somatosensory cortex.

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During selective attention, ~7-14 Hz alpha rhythms are modulated in early sensory cortices, suggesting a mechanistic role for these dynamics in perception. Here, we investigated whether alpha modulation can be enhanced by "mindfulness" meditation (MM), a program training practitioners in sustained attention to body and breath-related sensations. We hypothesized that participants in the MM group would exhibit enhanced alpha power modulation in a localized representation in the primary somatosensory neocortex in response to a cue, as compared to participants in the control group. Healthy subjects were randomized to 8-weeks of MM training or a control group. Using magnetoencephalographic (MEG) recording of the SI finger representation, we found meditators demonstrated enhanced alpha power modulation in response to a cue. This finding is the first to show enhanced local alpha modulation following sustained attentional training, and implicates this form of enhanced dynamic neural regulation in the behavioral effects of meditative practice.

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54. Int J Psychophysiol. 2011 May;80(2):103-11. doi: 10.1016/j.ijpsycho.2011.02.004. Epub 2011 Feb 17.

Activation of the anterior prefrontal cortex and serotonergic system is associated with improvements in mood and EEG changes induced by Zen meditation practice in novices.

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To gain insight into the neurophysiological mechanisms involved in Zen meditation, we evaluated the effects of focused attention (FA) on breathing movements in the lower abdomen (Tanden) in novices. We investigated hemodynamic changes in the prefrontal cortex (PFC), an attention-related brain region, using 24-channel near-infrared spectroscopy during a 20-minute session of FA on Tanden breathing in 15 healthy volunteers. We found that the level of oxygenated hemoglobin in the anterior PFC was significantly increased during FA on Tanden breathing, accompanied by a reduction in feelings of negative mood compared to before the meditation session. Electroencephalography (EEG) revealed increased alpha band activity and decreased theta band activity during and after FA on Tanden breathing. EEG changes were correlated with a significant increase in whole blood serotonin (5-HT) levels. These results suggest that activation of the anterior PFC and 5-HT system may be responsible for the improvement of negative mood and EEG signal changes observed during FA on Tanden breathing.

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55. Neuroimage. 2011 May 1;56(1):290-8. doi: 10.1016/j.neuroimage.2011.02.034. Epub 2011 Feb 18.

Impact of Mindfulness-Based Stress Reduction training on intrinsic brain connectivity.

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The beneficial effects of mindful awareness and mindfulness meditation training on physical and psychological health are thought to be mediated in part through changes in underlying brain processes. Functional connectivity MRI (fcMRI) allows identification of functional networks in the brain. It has been used to examine

state-dependent activity and is well suited for studying states such as meditation. We applied fcMRI to determine if Mindfulness-Based Stress Reduction (MBSR) training is effective in altering intrinsic connectivity networks (ICNs). Healthy women were randomly assigned to participate in an 8-week Mindfulness-Based Stress Reduction (MBSR) training course or an 8-week waiting period. After 8 weeks, fMRI data (1.5T) was acquired while subjects rested with eyes closed, with the instruction to pay attention to the sounds of the scanner environment. Group independent component analysis was performed to investigate training-related changes in functional connectivity. Significant MBSR-related differences in functional connectivity were found mainly in auditory/salience and medial visual networks. Relative to findings in the control group, MBSR subjects showed (1) increased functional connectivity within auditory and visual networks, (2) increased functional connectivity between auditory cortex and areas associated with attentional and self-referential processes, (3) stronger anticorrelation between auditory and visual cortex, and (4) stronger anticorrelation between visual cortex and areas associated with attentional and self-referential processes. These findings suggest that 8 weeks of mindfulness meditation training alters intrinsic functional connectivity in ways that may reflect a more consistent attentional focus, enhanced sensory processing, and reflective awareness of sensory experience.

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PMCID: PMC3072791

PMID: 21334442 [PubMed - indexed for MEDLINE]

56. Front Neurosci. 2011 Apr 18;5:49. doi: 10.3389/fnins.2011.00049.

Interoception drives increased rational decision-making in meditators playing the ultimatum game.

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Human decision-making is often conceptualized as a competition between cognitive and emotional processes in the brain. Deviations from rational processes are believed to derive from inclusion of emotional factors in decision-making. Here, we investigate whether experienced Buddhist meditators are better equipped to

regulate emotional processes compared with controls during economic decision-making in the Ultimatum Game. We show that meditators accept unfair offers on more than half of the trials, whereas controls only accept unfair offers on one-quarter of the trials. By applying fMRI we show that controls recruit the anterior insula during unfair offers. Such responses are powerful predictors of rejecting offers in social interaction. By contrast, meditators display attenuated activity in high-level emotional representations of the anterior insula and increased activity in the low-level interoceptive representations of the posterior insula. In addition we show that a subset of control participants who play rationally (i.e., accepts >85% unfair offers) recruits the dorsolateral prefrontal cortex presumably reflecting increased cognitive demands, whereas rational meditators by contrast display elevated activity in the somatosensory cortex and posterior superior temporal cortex. In summary, when assessing unfairness in the Ultimatum Game, meditators activate a different network of brain areas compared with controls enabling them to uncouple negative emotional reactions from their behavior. These findings highlight the clinically and socially important possibility that sustained training in mindfulness meditation may impact distinct domains of human decision-making.

PMCID: PMC3082218

PMID: 21559066 [PubMed]

57. J Neurosci. 2011 Apr 6;31(14):5540-8. doi: 10.1523/JNEUROSCI.5791-10.2011.

Brain mechanisms supporting the modulation of pain by mindfulness meditation.

Zeidan F, Martucci KT, Kraft RA, Gordon NS, McHaffie JG, Coghill RC.

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Comment in

J Neurosci. 2011 Sep 7;31(36):12705-7.

The subjective experience of one's environment is constructed by interactions among sensory, cognitive, and affective processes. For centuries, meditation has been thought to influence such processes by enabling a nonevaluative representation of sensory events. To better understand how meditation influences

the sensory experience, we used arterial spin labeling functional magnetic resonance imaging to assess the neural mechanisms by which mindfulness meditation influences pain in healthy human participants. After 4 d of mindfulness meditation training, meditating in the presence of noxious stimulation significantly reduced pain unpleasantness by 57% and pain intensity ratings by 40% when compared to rest. A two-factor repeated-measures ANOVA was used to identify interactions between meditation and pain-related brain activation. Meditation reduced pain-related activation of the contralateral primary somatosensory cortex. Multiple regression analysis was used to identify brain regions associated with individual differences in the magnitude of meditation-related pain reductions. Meditation-induced reductions in pain intensity ratings were associated with increased activity in the anterior cingulate cortex and anterior insula, areas involved in the cognitive regulation of nociceptive processing. Reductions in pain unpleasantness ratings were associated with orbitofrontal cortex activation, an area implicated in reframing the contextual evaluation of sensory events. Moreover, reductions in pain unpleasantness also were associated with thalamic deactivation, which may reflect a limbic gating mechanism involved in modifying interactions between afferent input and executive-order brain areas. Together, these data indicate that meditation engages multiple brain mechanisms that alter the construction of the subjectively available pain experience from afferent information.

PMCID: PMC3090218

PMID: 21471390 [PubMed - indexed for MEDLINE]

58. Harv Womens Health Watch. 2011 Apr;18(8):6-7.

Mindfulness meditation practice changes the brain.

[No authors listed]

PMID: 21544974 [PubMed - indexed for MEDLINE]

59. J Neural Eng. 2011 Apr;8(2):025019. doi: 10.1088/1741-2560/8/2/025019. Epub 2011 Mar 24.

Manipulating attention via mindfulness induction improves P300-based brain-computer interface performance.

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In this study, we examined the effects of a short mindfulness meditation induction (MMI) on the performance of a P300-based brain-computer interface (BCI) task. We expected that MMI would harness present-moment attentional resources, resulting in two positive consequences for P300-based BCI use. Specifically, we believed that MMI would facilitate increases in task accuracy and promote the production of robust P300 amplitudes. Sixteen-channel electroencephalographic data were recorded from 18 subjects using a row/column speller task paradigm. Nine subjects participated in a 6 min MMI and an additional nine subjects served as a control group. Subjects were presented with a  $6 \times 6$  matrix of alphanumeric characters on a computer monitor. Stimuli were flashed at a stimulus onset asynchrony (SOA) of 125 ms. Calibration data were collected on 21 items without providing feedback. These data were used to derive a stepwise linear discriminant analysis classifier that was applied to an additional 14 items to evaluate accuracy. Offline performance analyses revealed that MMI subjects were significantly more accurate than control subjects. Likewise, MMI subjects produced significantly larger P300 amplitudes than control subjects at Cz and PO7. The discussion focuses on the potential attentional benefits of MMI for P300-based BCI performance.

PMID: 21436516 [PubMed - indexed for MEDLINE]

60. Psychiatry Res. 2011 Jan 30;191(1):36-43. doi: 10.1016/j.psychresns.2010.08.006. Epub 2010 Nov 10.

Mindfulness practice leads to increases in regional brain gray matter density.

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Therapeutic interventions that incorporate training in mindfulness meditation have become increasingly popular, but to date little is known about neural mechanisms associated with these interventions. Mindfulness-Based Stress Reduction (MBSR), one of the most widely used mindfulness training programs, has been reported to produce positive effects on psychological well-being and to

ameliorate symptoms of a number of disorders. Here, we report a controlled longitudinal study to investigate pre-post changes in brain gray matter concentration attributable to participation in an MBSR program. Anatomical magnetic resonance (MR) images from 16 healthy, meditation-naïve participants were obtained before and after they underwent the 8-week program. Changes in gray matter concentration were investigated using voxel-based morphometry, and compared with a waiting list control group of 17 individuals. Analyses in a priori regions of interest confirmed increases in gray matter concentration within the left hippocampus. Whole brain analyses identified increases in the posterior cingulate cortex, the temporo-parietal junction, and the cerebellum in the MBSR group compared with the controls. The results suggest that participation in MBSR is associated with changes in gray matter concentration in brain regions involved in learning and memory processes, emotion regulation, self-referential processing, and perspective taking.

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PMCID: PMC3004979

PMID: 21071182 [PubMed - indexed for MEDLINE]

61. Neurosci Lett. 2011 Jan 10;487(3):358-62. doi: 10.1016/j.neulet.2010.10.056. Epub 2010 Oct 27.

Increased default mode network connectivity associated with meditation.

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Areas associated with the default mode network (DMN) are substantially similar to those associated with meditation practice. However, no studies on DMN connectivity during resting states have been conducted on meditation practitioners. It was hypothesized that meditators would show heightened functional connectivity in areas of cortical midline activity. Thirty-five meditation practitioners and 33 healthy controls without meditation experience were included in this study. All subjects received 4.68-min resting state functional scanning runs. The posterior cingulate cortex and medial prefrontal cortex were chosen as seed regions for the DMN map. Meditation practitioners demonstrated greater functional connectivity within the DMN in the medial

prefrontal cortex area (xyz=339-21) than did controls. These results suggest that the long-term practice of meditation may be associated with functional changes in regions related to internalized attention even when meditation is not being practiced.

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PMID: 21034792 [PubMed - indexed for MEDLINE]

62. Front Hum Neurosci. 2011;5:183. doi: 10.3389/fnhum.2011.00183. Epub 2012 Jan 3.

Influence of meditation on anti-correlated networks in the brain.

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Human experiences can be broadly divided into those that are external and related to interaction with the environment, and experiences that are internal and self-related. The cerebral cortex appears to be divided into two corresponding systems: an "extrinsic" system composed of brain areas that respond more to external stimuli and tasks and an "intrinsic" system composed of brain areas that respond less to external stimuli and tasks. These two broad brain systems seem to compete with each other, such that their activity levels over time is usually anti-correlated, even when subjects are "at rest" and not performing any task. This study used meditation as an experimental manipulation to test whether this competition (anti-correlation) can be modulated by cognitive strategy.

Participants either fixated without meditation (fixation), or engaged in non-dual awareness (NDA) or focused attention (FA) meditations. We computed inter-area correlations ("functional connectivity") between pairs of brain regions within each system, and between the entire extrinsic and intrinsic systems.

Anti-correlation between extrinsic vs. intrinsic systems was stronger during FA meditation and weaker during NDA meditation in comparison to fixation (without mediation). However, correlation between areas within each system did not change across conditions. These results suggest that the anti-correlation found between extrinsic and intrinsic systems is not an immutable property of brain organization and that practicing different forms of meditation can modulate this gross functional organization in profoundly different ways.

PMCID: PMC3250078  
PMID: 22287947 [PubMed]

63. Front Hum Neurosci. 2011;5:110. doi: 10.3389/fnhum.2011.00110. Epub 2011 Nov 2.

Artists and the mind in the 21st century.

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In 2008, Lesley University Professors Geoffrey Koetsch and Ellen Schön conducted an informal survey of New England artists to ascertain the degree to which recent work in neuroscience had impacted the visual arts. The two curators mounted an exhibition (MINDmatters May-June, 2008) at the Laconia Gallery in Boston in which they showcased the work of artists who had chosen mental processes as their primary subject. These artists were reacting to the new vision of the mind revealed by science; their inquiry was subjective, sensory, and existential, not empirical. They approached consciousness from several vantage points. Some of the artists had had personal experience with pathologies of the brain such as dementia or cancer and were puzzling out the phenomenon consuming the mind of a loved one. They looked to neuroscience for clarity and understanding. Some artists were personally involved with new techniques of cognitive psychotherapy. Others were inspired by the sheer physical beauty of the brain as revealed by new imaging technologies. Two of the artists explored the links between meditation, mindfulness practice and neuroscience. Issues such as the "boundary" and "binding" problems were approached, as well as the challenge of creating visual metaphors for neural processes. One artist visualized the increasing transparency of the body as researchers introduce more and more invasive technologies.

PMCID: PMC3215148  
PMID: 22102837 [PubMed]

64. Mens Sana Monogr. 2011 Jan;9(1):276-83. doi: 10.4103/0973-1229.77444.

Meditation and the brain: attention, control and emotion.

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Meditation has been for long time avoided as a scientific theme because of its complexity and its religious connotations. Fortunately, in the last years, it has increasingly been studied within different neuroscientific experimental protocols. Attention and concentration are surely among the most important topics in these experiments. Notwithstanding this, inhibition of emotions and discursive thoughts are equally important to understand what is at stake during those types of mental processes. I philosophically and technically analyse and compare results from neuroimaging studies, produced by leading authorities on the theme, dealing with two types of meditation: "one-pointed concentration" and "compassion meditation". Analysing "one-pointed concentration", I show the differences between novice and expert meditation practitioners in terms of brain activity and connectivity, considering the relationship among increased attention and concentration and decreased activity in areas related to discursive thought and emotion. Analysing "compassion meditation", I show the importance of the limbic circuitry in emotion sharing. I follow the same strategy of comparing novice and expert meditation practitioners. The conclusion establishes a common structure to those different ways of dealing with emotion during meditation.

PMCID: PMC3115297  
PMID: 21694979 [PubMed]

65. Pain. 2011 Jan;152(1):150-6. doi: 10.1016/j.pain.2010.10.006. Epub 2010 Nov 4.

A non-elaborative mental stance and decoupling of executive and pain-related cortices predicts low pain sensitivity in Zen meditators.

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Concepts originating from ancient Eastern texts are now being explored scientifically, leading to new insights into mind/brain function. Meditative practice, often viewed as an emotion regulation strategy, has been associated with pain reduction, low pain sensitivity, chronic pain improvement, and thickness of pain-related cortices. Zen meditation is unlike previously studied

emotion regulation techniques; more akin to 'no appraisal' than 'reappraisal'. This implies the cognitive evaluation of pain may be involved in the pain-related effects observed in meditators. Using functional magnetic resonance imaging and a thermal pain paradigm we show that practitioners of Zen, compared to controls, reduce activity in executive, evaluative and emotion areas during pain (prefrontal cortex, amygdala, hippocampus). Meditators with the most experience showed the largest activation reductions. Simultaneously, meditators more robustly activated primary pain processing regions (anterior cingulate cortex, thalamus, insula). Importantly, the lower pain sensitivity in meditators was strongly predicted by reductions in functional connectivity between executive and pain-related cortices. Results suggest a functional decoupling of the cognitive-evaluative and sensory-discriminative dimensions of pain, possibly allowing practitioners to view painful stimuli more neutrally. The activation pattern is remarkably consistent with the mindset described in Zen and the notion of mindfulness. Our findings contrast and challenge current concepts of pain and emotion regulation and cognitive control; commonly thought to manifest through increased activation of frontal executive areas. We suggest it is possible to self-regulate in a more 'passive' manner, by reducing higher-order evaluative processes, as demonstrated here by the disengagement of anterior brain systems in meditators.

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PMID: 21055874 [PubMed - indexed for MEDLINE]

66. Soc Neurosci. 2011;6(3):231-42. doi: 10.1080/17470919.2010.513495. Epub 2010 Sep 9.

The neural substrates of mindfulness: an fMRI investigation.

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"Mindfulness" is a capacity for heightened present-moment awareness that we all possess to a greater or lesser extent. Enhancing this capacity through training has been shown to alleviate stress and promote physical and mental well-being. As a consequence, interest in mindfulness is growing and so is the need to better understand it. This study employed functional magnetic resonance imaging (fMRI)

to identify the brain regions involved in state mindfulness and to shed light on its mechanisms of action. Significant signal decreases were observed during mindfulness meditation in midline cortical structures associated with interoception, including bilateral anterior insula, left ventral anterior cingulate cortex, right medial prefrontal cortex, and bilateral precuneus. Significant signal increase was noted in the right posterior cingulate cortex. These findings lend support to the theory that mindfulness achieves its positive outcomes through a process of disidentification.

PMID: 20835972 [PubMed - indexed for MEDLINE]

67. Conscious Cogn. 2010 Dec;19(4):899-905. doi: 10.1016/j.concog.2010.05.003. Epub 2010 Jun 8.

Cerebral blood flow differences between long-term meditators and non-meditators.

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We have studied a number of long-term meditators in previous studies. The purpose of this study was to determine if there are differences in baseline brain function of experienced meditators compared to non-meditators. All subjects were recruited as part of an ongoing study of different meditation practices. We evaluated 12 advanced meditators and 14 non-meditators with cerebral blood flow (CBF) SPECT imaging at rest. Images were analyzed with both region of interest and statistical parametric mapping. The CBF of long-term meditators was significantly higher ( $p < .05$ ) compared to non-meditators in the prefrontal cortex, parietal cortex, thalamus, putamen, caudate, and midbrain. There was also a significant difference in the thalamic laterality with long-term meditators having greater asymmetry. The observed changes associated with long-term meditation appear in structures that underlie the attention network and also those that relate to emotion and autonomic function.

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PMID: 20570534 [PubMed - indexed for MEDLINE]

68. Conscious Cogn. 2010 Dec;19(4):1119-21; discussion 1122-3. doi: 10.1016/j.concog.2010.03.016. Epub 2010 Apr 10.

Duality and nonduality in meditation research.

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Comment on

Conscious Cogn. 2010 Dec;19(4):1110-8.

The great variety of meditation techniques found in different contemplative traditions presents a challenge when attempting to create taxonomies based on the constructs of contemporary cognitive sciences. In the current issue of Consciousness and Cognition, Travis and Shear add 'automatic self-transcending' to the previously proposed categories of 'focused attention' and 'open monitoring', and suggest characteristic EEG bands as the defining criteria for each of the three categories. Accuracy of current taxonomies and potential limitations of EEG measurements as classifying criteria are discussed.

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PMID: 20385506 [PubMed - indexed for MEDLINE]

69. Conscious Cogn. 2010 Dec;19(4):1110-8. doi: 10.1016/j.concog.2010.01.007. Epub 2010 Feb 18.

Focused attention, open monitoring and automatic self-transcending: Categories to organize meditations from Vedic, Buddhist and Chinese traditions.

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Comment in

Conscious Cogn. 2010 Dec;19(4):1119-21; discussion 1122-3.

This paper proposes a third meditation-category--automatic self-transcending--to extend the dichotomy of focused attention and open monitoring proposed by Lutz. Automatic self-transcending includes techniques designed to transcend their own activity. This contrasts with focused attention, which keeps attention focused on an object; and open monitoring, which keeps attention involved in the monitoring process. Each category was assigned EEG bands, based on reported brain patterns during mental tasks, and meditations were categorized based on their reported EEG. Focused attention, characterized by beta/gamma activity, included meditations from Tibetan Buddhist, Buddhist, and Chinese traditions. Open monitoring, characterized by theta activity, included meditations from Buddhist, Chinese, and Vedic traditions. Automatic self-transcending, characterized by alpha1 activity, included meditations from Vedic and Chinese traditions. Between categories, the included meditations differed in focus, subject/object relation, and procedures. These findings shed light on the common mistake of averaging meditations together to determine mechanisms or clinical effects.

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PMID: 20167507 [PubMed - indexed for MEDLINE]

70. Clin Psychol Rev. 2010 Nov;30(7):849-64. doi: 10.1016/j.cpr.2010.03.002. Epub 2010 Mar 12.

Upward spirals of positive emotions counter downward spirals of negativity: insights from the broaden-and-build theory and affective neuroscience on the treatment of emotion dysfunctions and deficits in psychopathology.

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This review integrates Fredrickson's broaden-and-build theory of positive emotions with advances in affective neuroscience regarding plasticity in the neural circuitry of emotions to inform the treatment of emotion deficits within psychopathology. We first present a body of research showing that positive emotions broaden cognition and behavioral repertoires, and in so doing, build durable biopsychosocial resources that support coping and flourishing mental health. Next, by explicating the processes through which momentary experiences of

emotions may accrue into self-perpetuating emotional systems, the current review proposes an underlying architecture of state-trait interactions that engenders lasting affective dispositions. This theoretical framework is then used to elucidate the cognitive-emotional mechanisms underpinning three disorders of affect regulation: depression, anxiety, and schizophrenia. In turn, two mind training interventions, mindfulness and loving-kindness meditation, are highlighted as means of generating positive emotions that may counter the negative affective processes implicated in these disorders. We conclude with the proposition that positive emotions may exert a countervailing force on the dysphoric, fearful, or anhedonic states characteristic of psychopathologies typified by emotional dysfunctions.

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PMCID: PMC2908186

PMID: 20363063 [PubMed - indexed for MEDLINE]

71. Addiction. 2010 Oct;105(10):1698-706. doi: 10.1111/j.1360-0443.2009.02890.x.

Mindfulness-based treatments for co-occurring depression and substance use disorders: what can we learn from the brain?

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Comment in

Addiction. 2010 Oct;105(10):1707-8; discussion 1709-10.

Addiction. 2010 Oct;105(10):1708-9; discussion 1709-10.

Both depression and substance use disorders represent major global public health concerns and are often co-occurring. Although there are ongoing discoveries regarding the pathophysiology and treatment of each condition, common mechanisms and effective treatments for co-occurring depression and substance abuse remain elusive. Mindfulness training has been shown recently to benefit both depression and substance use disorders, suggesting that this approach may target common behavioral and neurobiological processes. However, it remains unclear whether these pathways constitute specific shared neurobiological mechanisms or more extensive components universal to the broader human experience of psychological

distress or suffering. We offer a theoretical, clinical and neurobiological perspective of the overlaps between these disorders, highlight common neural pathways that play a role in depression and substance use disorders and discuss how these commonalities may frame our conceptualization and treatment of co-occurring disorders. Finally, we discuss how advances in our understanding of potential mechanisms of mindfulness training may offer not only unique effects on depression and substance use, but also offer promise for treatment of co-occurring disorders.

PMCID: PMC2905496

PMID: 20331548 [PubMed - indexed for MEDLINE]

72. J Neurol Neurosurg Psychiatry. 2010 Oct;81(10):1128-34. doi:  
10.1136/jnnp.2008.170092. Epub 2010 Aug 27.

Psychological approaches to treatment of postconcussion syndrome: a systematic review.

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**BACKGROUND AND AIM:** Postconcussion syndrome (PCS) is a term used to describe the complex, and controversial, constellation of physical, cognitive and emotional symptoms associated with mild brain injury. At the current time, there is a lack of clear, evidence-based treatment strategies. In this systematic review, the authors aimed to evaluate the potential efficacy of cognitive behavioural therapy (CBT) and other psychological treatments in postconcussion symptoms.

**METHODS:** Four electronic databases were searched up to November 2008 for studies of psychological approaches to treatment or prevention of postconcussion syndrome or symptoms.

**RESULTS:** The search identified 7763 citations, and 42 studies were included. This paper reports the results of 17 randomised controlled trials for psychological interventions which fell into four categories: CBT for PCS or specific PCS symptoms; information, reassurance and education; rehabilitation with a psychotherapeutic element and mindfulness/relaxation. Due to heterogeneity of methodology and outcome measures, a meta-analysis was not possible. The largest limitation to our findings was the lack of high-quality studies.

**CONCLUSION:** There was evidence that CBT may be effective in the treatment of PCS.

Information, education and reassurance alone may not be as beneficial as previously thought. There was limited evidence that multifaceted rehabilitation programmes that include a psychotherapeutic element or mindfulness/relaxation benefit those with persisting symptoms. Further, more rigorous trials of CBT for postconcussion symptoms are required.

PMID: 20802219 [PubMed - indexed for MEDLINE]

73. Pain. 2010 Sep;150(3):428-38. doi: 10.1016/j.pain.2010.04.017. Epub 2010 May 21.

Meditation experience predicts less negative appraisal of pain: electrophysiological evidence for the involvement of anticipatory neural responses.

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Comment in

Pain. 2010 Sep;150(3):382-3.

The aim of mindfulness meditation is to develop present-focused, non-judgmental, attention. Therefore, experience in meditation should be associated with less anticipation and negative appraisal of pain. In this study we compared a group of individuals with meditation experience to a control group to test whether any differences in the affective appraisal of pain could be explained by lower anticipatory neural processing. Anticipatory and pain-evoked ERPs and reported pain unpleasantness were recorded in response to laser stimuli of matched subjective intensity between the two groups. ERP data were analysed after source estimation with LORETA. No group effects were found on the laser energies used to induce pain. More experienced meditators perceived the pain as less unpleasant relative to controls, with meditation experience correlating inversely with unpleasantness ratings. ERP source data for anticipation showed that in meditators, lower activity in midcingulate cortex relative to controls was related to the lower unpleasantness ratings, and was predicted by lifetime meditation experience. Meditators also reversed the normal positive correlation between medial prefrontal cortical activity and pain unpleasantness during anticipation. Meditation was also associated with lower activity in S2 and insula

during the pain-evoked response, although the experiment could not disambiguate this activity from the preceding anticipation response. Our data is consistent with the hypothesis that meditation reduces the anticipation and negative appraisal of pain, but effects on pain-evoked activity are less clear and may originate from preceding anticipatory activity. Further work is required to directly test the causal relationship between meditation, pain anticipation, and pain experience.

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PMID: 20494517 [PubMed - indexed for MEDLINE]

74. Percept Mot Skills. 2010 Aug;111(1):291-306.

Meditation-specific prefrontal cortical activation during acem meditation: an fMRI study.

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Some of the most popular meditation practices emphasize a relaxed focus of attention in which thoughts, images, sensations, and emotions may emerge and pass freely without actively controlling or pursuing them. Several recent studies show that meditation activates frontal brain areas associated with attention focusing and physical relaxation. The objective of the present study was to assess whether brain activation during relaxed focusing on a meditation sound could be distinguished from similar, concentrative control tasks. Brain activation was measured with functional magnetic resonance imaging (fMRI) in experienced practitioners of Acem meditation. Bilateral areas of the inferior frontal gyrus (BA47) were significantly more activated during repetition of a meditation sound than during concentrative meditation-like cognitive tasks. Meditation-specific brain activation did not habituate over time, but increased in strength with continuous meditation bouts. These observations suggest that meditation with a relaxed focus of attention may activate distinct areas of the prefrontal cortex, with implications for the understanding of neurobiological correlates of meditation.

PMID: 21058608 [PubMed - indexed for MEDLINE]

75. Psychol Med. 2010 Aug;40(8):1239-52. doi: 10.1017/S0033291709991747. Epub 2009 Nov 27.

A systematic review of neurobiological and clinical features of mindfulness meditations.

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Comment in

Psychol Med. 2011 Mar;41(3):666-7; author reply 7-8.

**BACKGROUND:** Mindfulness meditation (MM) practices constitute an important group of meditative practices that have received growing attention. The aim of the present paper was to systematically review current evidence on the neurobiological changes and clinical benefits related to MM practice in psychiatric disorders, in physical illnesses and in healthy subjects.

**METHOD:** A literature search was undertaken using Medline, ISI Web of Knowledge, the Cochrane collaboration database and references of retrieved articles.

Controlled and cross-sectional studies with controls published in English up to November 2008 were included.

**RESULTS:** Electroencephalographic (EEG) studies have revealed a significant increase in alpha and theta activity during meditation. Neuroimaging studies showed that MM practice activates the prefrontal cortex (PFC) and the anterior cingulate cortex (ACC) and that long-term meditation practice is associated with an enhancement of cerebral areas related to attention. From a clinical viewpoint, Mindfulness-Based Stress Reduction (MBSR) has shown efficacy for many psychiatric and physical conditions and also for healthy subjects. Mindfulness-Based Cognitive Therapy (MBCT) is mainly efficacious in reducing relapses of depression in patients with three or more episodes. Zen meditation significantly reduces blood pressure and Vipassana meditation shows efficacy in reducing alcohol and substance abuse in prisoners. However, given the low-quality designs of current studies it is difficult to establish whether clinical outcomes are due to specific or non-specific effects of MM.

**DISCUSSION:** Despite encouraging findings, several limitations affect current studies. Suggestions are given for future research based on better designed

methodology and for future directions of investigation.

PMID: 19941676 [PubMed - indexed for MEDLINE]

76. Q J Exp Psychol (Hove). 2010 Jun;63(6):1168-80.

Greater efficiency in attentional processing related to mindfulness meditation.

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In this study, attentional processing in relation to mindfulness meditation was investigated. Since recent studies have suggested that mindfulness meditation may induce improvements in attentional processing, we have tested 20 expert mindfulness meditators in the attention network test. Their performance was compared to that of 20 age- and gender-matched controls. In addition to attentional network analyses, overall attentional processing was analysed by means of efficiency scores (i.e., accuracy controlled for reaction time). Better orienting and executive attention (reflected by smaller differences in either reaction time or error score, respectively) were observed in the mindfulness meditation group. Furthermore, extensive mindfulness meditation appeared to be related to a reduction of the fraction of errors for responses with the same reaction time. These results provide new insights into differences in attentional processing related to mindfulness meditation and suggest the possibility of increasing the efficiency in attentional processing by extensive mental training.

PMID: 20509209 [PubMed - indexed for MEDLINE]

77. Brain Res Bull. 2010 Apr 29;82(1-2):46-56. doi: 10.1016/j.brainresbull.2010.03.001. Epub 2010 Mar 16.

Neural correlates of focused attention and cognitive monitoring in meditation.

Manna A, Raffone A, Perrucci MG, Nardo D, Ferretti A, Tartaro A, Londei A, Del Gratta C, Belardinelli MO, Romani GL.

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Meditation refers to a family of complex emotional and attentional regulatory practices, which can be classified into two main styles - focused attention (FA) and open monitoring (OM) - involving different attentional, cognitive monitoring and awareness processes. In a functional magnetic resonance study we originally characterized and contrasted FA and OM meditation forms within the same experiment, by an integrated FA-OM design. Theravada Buddhist monks, expert in both FA and OM meditation forms, and lay novices with 10 days of meditation practice, participated in the experiment. Our evidence suggests that expert meditators control cognitive engagement in conscious processing of sensory-related, thought and emotion contents, by massive self-regulation of fronto-parietal and insular areas in the left hemisphere, in a meditation state-dependent fashion. We also found that anterior cingulate and dorsolateral prefrontal cortices play antagonist roles in the executive control of the attention setting in meditation tasks. Our findings resolve the controversy between the hypothesis that meditative states are associated to transient hypofrontality or deactivation of executive brain areas, and evidence about the activation of executive brain areas in meditation. Finally, our study suggests that a functional reorganization of brain activity patterns for focused attention and cognitive monitoring takes place with mental practice, and that meditation-related neuroplasticity is crucially associated to a functional reorganization of activity patterns in prefrontal cortex and in the insula.

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PMID: 20223285 [PubMed - indexed for MEDLINE]

78. Evid Based Complement Alternat Med. 2010 Mar;7(1):121-7. doi: 10.1093/ecam/nem163. Epub 2007 Dec 27.

Regional brain activation during meditation shows time and practice effects: an exploratory fMRI study.

Baron Short E, Kose S, Mu Q, Borckardt J, Newberg A, George MS, Kozel FA.

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Meditation involves attentional regulation and may lead to increased activity in brain regions associated with attention such as dorsal lateral prefrontal cortex (DLPFC) and anterior cingulate cortex (ACC). Using functional magnetic resonance imaging, we examined whether DLPFC and ACC were activated during meditation. Subjects who meditate were recruited and scanned on a 3.0 Tesla scanner. Subjects meditated for four sessions of 12 min and performed four sessions of a 6 min control task. Individual and group t-maps were generated of overall meditation response versus control response and late meditation response versus early meditation response for each subject and time courses were plotted. For the overall group ( $n = 13$ ), and using an overall brain analysis, there were no statistically significant regional activations of interest using conservative thresholds. A region of interest analysis of the entire group time courses of DLPFC and ACC were statistically more active throughout meditation in comparison to the control task. Moreover, dividing the cohort into short ( $n = 8$ ) and long-term ( $n = 5$ ) practitioners ( $>10$  years) revealed that the time courses of long-term practitioners had significantly more consistent and sustained activation in the DLPFC and the ACC during meditation versus control in comparison to short-term practitioners. The regional brain activations in the more practised subjects may correlate with better sustained attention and attentional error monitoring. In summary, brain regions associated with attention vary over the time of a meditation session and may differ between long- and short-term meditation practitioners.

PMCID: PMC2816391  
PMID: 18955268 [PubMed]

79. Soc Cogn Affect Neurosci. 2010 Mar;5(1):11-7. doi: 10.1093/scan/nsp034. Epub 2009 Sep 23.

Stress reduction correlates with structural changes in the amygdala.

Hölzel BK, Carmody J, Evans KC, Hoge EA, Dusek JA, Morgan L, Pitman RK, Lazar SW.

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Stress has significant adverse effects on health and is a risk factor for many illnesses. Neurobiological studies have implicated the amygdala as a brain structure crucial in stress responses. Whereas hyperactive amygdala function is often observed during stress conditions, cross-sectional reports of differences in gray matter structure have been less consistent. We conducted a longitudinal MRI study to investigate the relationship between changes in perceived stress with changes in amygdala gray matter density following a stress-reduction intervention. Stressed but otherwise healthy individuals ( $N = 26$ ) participated in an 8-week mindfulness-based stress reduction intervention. Perceived stress was rated on the perceived stress scale (PSS) and anatomical MR images were acquired pre- and post-intervention. PSS change was used as the predictive regressor for changes in gray matter density within the bilateral amygdalae. Following the intervention, participants reported significantly reduced perceived stress. Reductions in perceived stress correlated positively with decreases in right basolateral amygdala gray matter density. Whereas prior studies found gray matter modifications resulting from acquisition of abstract information, motor and language skills, this study demonstrates that neuroplastic changes are associated with improvements in a psychological state variable.

PMCID: PMC2840837

PMID: 19776221 [PubMed - indexed for MEDLINE]

80. Cogn Process. 2010 Feb;11(1):31-8. doi: 10.1007/s10339-009-0272-0. Epub 2009 Jul 22.

Theta activity and meditative states: spectral changes during concentrative meditation.

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Brain oscillatory activity is associated with different cognitive processes and plays a critical role in meditation. In this study, we investigated the temporal dynamics of oscillatory changes during Sahaj Samadhi meditation (a concentrative form of meditation that is part of Sudarshan Kriya yoga). EEG was recorded during Sudarshan Kriya yoga meditation for meditators and relaxation for controls. Spectral and coherence analysis was performed for the whole duration as well as specific blocks extracted from the initial, middle, and end portions of Sahaj

Samadhi meditation or relaxation. The generation of distinct meditative states of consciousness was marked by distinct changes in spectral powers especially enhanced theta band activity during deep meditation in the frontal areas.

Meditators also exhibited increased theta coherence compared to controls. The emergence of the slow frequency waves in the attention-related frontal regions provides strong support to the existing claims of frontal theta in producing meditative states along with trait effects in attentional processing.

Interestingly, increased frontal theta activity was accompanied reduced activity (deactivation) in parietal-occipital areas signifying reduction in processing associated with self, space and, time.

PMID: 19626355 [PubMed - indexed for MEDLINE]

81. Emotion. 2010 Feb;10(1):83-91. doi: 10.1037/a0018441.

Effects of mindfulness-based stress reduction (MBSR) on emotion regulation in social anxiety disorder.

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Mindfulness-based stress reduction (MBSR) is an established program shown to reduce symptoms of stress, anxiety, and depression. MBSR is believed to alter emotional responding by modifying cognitive-affective processes. Given that social anxiety disorder (SAD) is characterized by emotional and attentional biases as well as distorted negative self-beliefs, we examined MBSR-related changes in the brain-behavior indices of emotional reactivity and regulation of negative self-beliefs in patients with SAD. Sixteen patients underwent functional MRI while reacting to negative self-beliefs and while regulating negative emotions using 2 types of attention deployment emotion regulation-breath-focused attention and distraction-focused attention. Post-MBSR, 14 patients completed neuroimaging assessments. Compared with baseline, MBSR completers showed improvement in anxiety and depression symptoms and self-esteem. During the breath-focused attention task (but not the distraction-focused attention task), they also showed (a) decreased negative emotion experience, (b) reduced amygdala activity, and (c) increased activity in brain regions implicated in attentional deployment. MBSR training in patients with SAD may reduce emotional reactivity while enhancing emotion regulation. These changes might facilitate reduction in

SAD-related avoidance behaviors, clinical symptoms, and automatic emotional reactivity to negative self-beliefs in adults with SAD.

PMID: 20141305 [PubMed - indexed for MEDLINE]

82. Emotion. 2010 Feb;10(1):25-33. doi: 10.1037/a0017151.

Minding one's emotions: mindfulness training alters the neural expression of sadness.

Farb NA, Anderson AK, Mayberg H, Bean J, McKeon D, Segal ZV.

Department of Psychology, University of Toronto, Toronto, Ontario, Canada.

Erratum in

Emotion. 2010 Apr;10(2):215.

Recovery from emotional challenge and increased tolerance of negative affect are both hallmarks of mental health. Mindfulness training (MT) has been shown to facilitate these outcomes, yet little is known about its mechanisms of action. The present study employed functional MRI (fMRI) to compare neural reactivity to sadness provocation in participants completing 8 weeks of MT and waitlisted controls. Sadness resulted in widespread recruitment of regions associated with self-referential processes along the cortical midline. Despite equivalent self-reported sadness, MT participants demonstrated a distinct neural response, with greater right-lateralized recruitment, including visceral and somatosensory areas associated with body sensation. The greater somatic recruitment observed in the MT group during evoked sadness was associated with decreased depression scores. Restoring balance between affective and sensory neural networks-supporting conceptual and body based representations of emotion-could be one path through which mindfulness reduces vulnerability to dysphoric reactivity.

PMID: 20141299 [PubMed - indexed for MEDLINE]

83. Emotion. 2010 Feb;10(1):1-7. doi: 10.1037/a0018360.

Mindfulness and psychological process.

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The author reviews the articles in the Special Section on Mindfulness, starting from the assumption that emotions evolved as signaling systems that need to be sensitive to environmental contingencies. Failure to switch off emotion is due to the activation of mental representations of present, past, and future that are created independently of external contingencies. Mindfulness training can be seen as one way to teach people to discriminate such "simulations" from objects and contingencies as they actually are. The articles in this Special Section show how even brief laboratory training can have effects on processing affective stimuli; that long-term meditation practitioners show distinct reactions to pain; that longer meditation training is associated with differences in brain structure; that 8 weeks' mindfulness practice brings about changes in the way emotion is processed showing that participants can learn to uncouple the sensory, directly experienced self from the "narrative" self; that mindfulness training can affect working memory capacity, and enhance the ability of participants to talk about past crises in a way that enables them to remain specific and yet not be overwhelmed. The implications of these findings for understanding emotion and for further research is discussed.

PMID: 20141295 [PubMed - indexed for MEDLINE]

84. J Altern Complement Med. 2010 Jan;16(1):37-46. doi: 10.1089/acm.2009.0362.

Vipassana meditation: systematic review of current evidence.

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**OBJECTIVES:** Vipassana meditation (VM) is one of the most ancient and diffused types of meditative practices belonging to the pole of mindfulness. Despite the growing interest toward the neurobiological and clinical correlates of many meditative practices, no review has specifically focused on current evidence on neuro-imaging and clinical evidence about VM.

**METHODS:** A literature search was undertaken using MEDLINE, ((R)) ISI web of knowledge, the Cochrane database, and references of retrieved articles. Controlled and cross-sectional studies with controls published in English up to

March 2009 were included.

**RESULTS:** Seven (7) mainly poor-quality studies were identified. Three (3) neuro-imaging studies suggested that VM practice could be associated with the activation of the prefrontal and the anterior cingulate cortex during meditative periods, and with increased thickness in cortical areas related to attention as well as increased subcortical gray matter in right insula and hippocampus in long-term meditators. Three (3) clinical studies in incarcerated populations suggested that VM could reduce alcohol and substance abuse but not post-traumatic stress disorder symptoms in prisoners. One (1) clinical study in healthy subjects suggested that VM could enhance more mature defenses and copying styles.

**DISCUSSION:** Current studies provided preliminary results about neurobiological and clinical changes related to VM practice. Nonetheless, few and mainly low-quality data are available especially for clinical studies and current results have to be considered with caution. Further research is needed to answer critical questions about replications, self-selection, placebo, and long-term effects of VM.

PMID: 20055558 [PubMed - indexed for MEDLINE]

85. Brain Topogr. 2009 Nov;22(3):158-65. doi: 10.1007/s10548-009-0107-4. Epub 2009 Aug 4.

Meditators and non-meditators: EEG source imaging during resting.

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Many meditation exercises aim at increased awareness of ongoing experiences through sustained attention and at detachment, i.e., non-engaging observation of these ongoing experiences by the intent not to analyze, judge or expect anything. Long-term meditation practice is believed to generalize the ability of increased awareness and greater detachment into everyday life. We hypothesized that neuroplasticity effects of meditation (correlates of increased awareness and detachment) would be detectable in a no-task resting state. EEG recorded during resting was compared between Qigong meditators and controls. Using LORETA (low resolution electromagnetic tomography) to compute the intracerebral source locations, differences in brain activations between groups were found in the

inhibitory delta EEG frequency band. In the meditators, appraisal systems were inhibited, while brain areas involved in the detection and integration of internal and external sensory information showed increased activation. This suggests that neuroplasticity effects of long-term meditation practice, subjectively described as increased awareness and greater detachment, are carried over into non-meditating states.

PMID: 19653090 [PubMed - indexed for MEDLINE]

86. J Altern Complement Med. 2009 Nov;15(11):1187-92. doi: 10.1089/acm.2009.0113.

Increased theta and alpha EEG activity during nondirective meditation.

Lagopoulos J, Xu J, Rasmussen I, Vik A, Malhi GS, Eliassen CF, Arntsen IE, Saether JG, Hollup S, Holen A, Davanger S, Ellingsen Ø.

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**OBJECTIVES:** In recent years, there has been significant uptake of meditation and related relaxation techniques, as a means of alleviating stress and maintaining good health. Despite its popularity, little is known about the neural mechanisms by which meditation works, and there is a need for more rigorous investigations of the underlying neurobiology. Several electroencephalogram (EEG) studies have reported changes in spectral band frequencies during meditation inspired by techniques that focus on concentration, and in comparison much less has been reported on mindfulness and nondirective techniques that are proving to be just as popular.

**DESIGN:** The present study examined EEG changes during nondirective meditation. The investigational paradigm involved 20 minutes of acem meditation, where the subjects were asked to close their eyes and adopt their normal meditation technique, as well as a separate 20-minute quiet rest condition where the subjects were asked to close their eyes and sit quietly in a state of rest. Both conditions were completed in the same experimental session with a 15-minute break in between.

**RESULTS:** Significantly increased theta power was found for the meditation condition when averaged across all brain regions. On closer examination, it was found that theta was significantly greater in the frontal and temporal-central regions as compared to the posterior region. There was also a significant increase in alpha power in the meditation condition compared to the rest

condition, when averaged across all brain regions, and it was found that alpha was significantly greater in the posterior region as compared to the frontal region.

**CONCLUSIONS:** These findings from this study suggest that nondirective meditation techniques alter theta and alpha EEG patterns significantly more than regular relaxation, in a manner that is perhaps similar to methods based on mindfulness or concentration.

PMID: 19922249 [PubMed - indexed for MEDLINE]

87. J Neurosci. 2009 Oct 21;29(42):13418-27. doi: 10.1523/JNEUROSCI.1614-09.2009.

Mental training enhances attentional stability: neural and behavioral evidence.

Lutz A, Slagter HA, Rawlings NB, Francis AD, Greischar LL, Davidson RJ.

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The capacity to stabilize the content of attention over time varies among individuals, and its impairment is a hallmark of several mental illnesses. Impairments in sustained attention in patients with attention disorders have been associated with increased trial-to-trial variability in reaction time and event-related potential deficits during attention tasks. At present, it is unclear whether the ability to sustain attention and its underlying brain circuitry are transformable through training. Here, we show, with dichotic listening task performance and electroencephalography, that training attention, as cultivated by meditation, can improve the ability to sustain attention. Three months of intensive meditation training reduced variability in attentional processing of target tones, as indicated by both enhanced theta-band phase consistency of oscillatory neural responses over anterior brain areas and reduced reaction time variability. Furthermore, those individuals who showed the greatest increase in neural response consistency showed the largest decrease in behavioral response variability. Notably, we also observed reduced variability in neural processing, in particular in low-frequency bands, regardless of whether the deviant tone was attended or unattended. Focused attention meditation may thus affect both distracter and target processing, perhaps by enhancing entrainment of neuronal oscillations to sensory input rhythms, a mechanism important for controlling the content of attention. These novel findings highlight the mechanisms underlying focused attention meditation and support the notion that

mental training can significantly affect attention and brain function.

PMCID: PMC2789281

PMID: 19846729 [PubMed - indexed for MEDLINE]

88. Mayo Clin Health Lett. 2009 Oct;27(10):1-3.

Meditation. Calming a restless mind.

[No authors listed]

PMID: 19911456 [PubMed - indexed for MEDLINE]

89. Biol Psychol. 2009 Sep;82(1):1-11. doi: 10.1016/j.biopsych.2009.04.003. Epub 2009 Apr 23.

The neurobiology of Meditation and its clinical effectiveness in psychiatric disorders.

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This paper reviews the evidence for changes of Meditation on body and brain physiology and for clinical effectiveness in disorders of psychiatry. The aim of Meditation is to reduce or eliminate irrelevant thought processes through training of internalised attention, thought to lead to physical and mental relaxation, stress reduction, psycho-emotional stability and enhanced concentration. Physiological evidence shows a reduction with Meditation of stress-related autonomic and endocrine measures, while neuroimaging studies demonstrate the functional up-regulation of brain regions of affect regulation and attention control. Clinical studies show some evidence for the effectiveness of Meditation in disorders of affect, anxiety and attention. The combined evidence from neurobiological and clinical studies seems promising. However, a more thorough understanding of the neurobiological mechanisms of action and clinical effectiveness of the different Meditative practices is needed before Meditative practices can be leveraged in the prevention and intervention of mental illness.

PMID: 19393712 [PubMed - indexed for MEDLINE]

90. Conscious Cogn. 2009 Sep;18(3):593-9. doi: 10.1016/j.concog.2009.05.001. Epub 2009 Jun 9.

Age effects on attentional blink performance in meditation.

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Here we explore whether mental training in the form of meditation can help to overcome age-related attentional decline. We compared performance on the attentional blink task between three populations: A group of long-term meditation practitioners within an older population, a control group of age-matched participants and a control group of young participants. Members of both control groups had never practiced meditation. Our results show that long-term meditation practice leads to a reduction of the attentional blink. Meditation practitioners taken from an older population showed a reduction in blink as compared to a control group taken from a younger population, whereas, the control group age-matched to the meditators' group revealed a blink that was comparatively larger and broader. Our results support the hypothesis that meditation practice can: (i) alter the efficiency with which attentional resources are distributed and (ii) help to overcome age-related attentional deficits in the temporal domain.

PMID: 19515578 [PubMed - indexed for MEDLINE]

91. Resuscitation. 2009 Sep;80(9):1006-10. doi: 10.1016/j.resuscitation.2009.05.006. Epub 2009 Jul 1.

Brain activity in near-death experiencers during a meditative state.

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AIM: To measure brain activity in near-death experiencers during a meditative state.

METHODS: In two separate experiments, brain activity was measured with functional magnetic resonance imaging (fMRI) and electroencephalography (EEG) during a Meditation condition and a Control condition. In the Meditation condition, participants were asked to mentally visualize and emotionally connect with the "being of light" allegedly encountered during their "near-death experience". In the Control condition, participants were instructed to mentally visualize the light emitted by a lamp.

RESULTS: In the fMRI experiment, significant loci of activation were found during the Meditation condition (compared to the Control condition) in the right brainstem, right lateral orbitofrontal cortex, right medial prefrontal cortex, right superior parietal lobule, left superior occipital gyrus, left anterior temporal pole, left inferior temporal gyrus, left anterior insula, left parahippocampal gyrus and left substantia nigra. In the EEG experiment, electrode sites showed greater theta power in the Meditation condition relative to the Control condition at FP1, F7, F3, T5, P3, O1, FP2, F4, F8, P4, Fz, Cz and Pz. In addition, higher alpha power was detected at FP1, F7, T3 and FP2, whereas higher gamma power was found at FP2, F7, T4 and T5.

CONCLUSIONS: The results indicate that the meditative state was associated with marked hemodynamic and neuroelectric changes in brain regions known to be involved either in positive emotions, visual mental imagery, attention or spiritual experiences.

PMID: 19573975 [PubMed - indexed for MEDLINE]

92. Proc Natl Acad Sci U S A. 2009 Jun 2;106(22):8865-70. doi:  
10.1073/pnas.0904031106. Epub 2009 May 18.

Central and autonomic nervous system interaction is altered by short-term meditation.

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Five days of integrative body-mind training (IBMT) improves attention and self-regulation in comparison with the same amount of relaxation training. This paper explores the underlying mechanisms of this finding. We measured the physiological and brain changes at rest before, during, and after 5 days of IBMT and relaxation training. During and after training, the IBMT group showed significantly better physiological reactions in heart rate, respiratory amplitude and rate, and skin conductance response (SCR) than the relaxation control. Differences in heart rate variability (HRV) and EEG power suggested greater involvement of the autonomic nervous system (ANS) in the IBMT group during and after training. Imaging data demonstrated stronger subgenual and adjacent ventral anterior cingulate cortex (ACC) activity in the IBMT group. Frontal midline ACC theta was correlated with high-frequency HRV, suggesting control by the ACC over parasympathetic activity. These results indicate that after 5 days of training, the IBMT group shows better regulation of the ANS by a ventral midfrontal brain system than does the relaxation group. This changed state probably reflects training in the coordination of body and mind given in the IBMT but not in the control group. These results could be useful in the design of further specific interventions.

PMCID: PMC2690030

PMID: 19451642 [PubMed - indexed for MEDLINE]

93. J Clin Psychol Med Settings. 2009 Jun;16(2):200-7. doi: 10.1007/s10880-009-9153-z. Epub 2009 Mar 10.

Mindfulness meditation for symptom reduction in fibromyalgia: psychophysiological correlates.

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**OBJECTIVES:** Fibromyalgia, a chronic pain syndrome, is often accompanied by psychological distress and increased basal sympathetic tone. In a previous report it was shown that mindfulness-based stress-reduction (MBSR) reduced depressive symptoms in patients with fibromyalgia with gains maintained at two months follow-up (Sephton et al., Arthr Rheum 57:77-85, 2007). This second study explores the effects of MBSR on basal sympathetic (SNS) activation among women

with fibromyalgia.

METHODS: Participants (n = 24) responded to a television news appearance, newspaper, and radio advertisements. Effects on anxiety, depressive symptoms, and SNS activation measures were tested before and after MBSR using a within-subjects design.

RESULTS: The MBSR treatment significantly reduced basal electrodermal (skin conductance level; SCL) activity ( $t = 3.298$ ,  $p = .005$ ) and SCL activity during meditation ( $t = 4.389$ ,  $p = .001$ ), consistent with reduced SNS activation.

CONCLUSIONS: In this small sample, basal SNS activity was reduced following MBSR treatment. Future studies should assess how MBSR may help reduce negative psychological symptoms and attenuate SNS activation in fibromyalgia. Further clarification of psychological and physiological responses associated with fibromyalgia may lead to more beneficial treatment.

PMID: 19277851 [PubMed - indexed for MEDLINE]

94. J Altern Complement Med. 2009 May;15(5):585-92. doi: 10.1089/acm.2008.0416.

Zen meditation: an integration of current evidence.

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OBJECTIVE: Despite the growing interest in the neurobiological and clinical correlates of many meditative practices, in particular mindfulness meditations, no review has specifically focused on current evidence on electroencephalographic, neuroimaging, biological, and clinical evidence about an important traditional practice, Zen meditation.

METHODS: A literature search was conducted using MEDLINE, the ISI Web of Knowledge, the Cochrane collaboration database, and references of selected articles. Randomized controlled and cross-sectional studies with controls published in English prior to May 2008 were included.

RESULTS: Electroencephalographic studies on Zen meditation found increased alpha and theta activity, generally related to relaxation, in many brain regions, including the frontal cortex. Theta activity in particular seemed to be related to the degree of experience, being greater in expert practitioners and advanced masters. Moreover, Zen meditation practice could protect from cognitive decline usually associated with age and enhance antioxidant activity. From a clinical

point of view, Zen meditation was found to reduce stress and blood pressure, and be efficacious for a variety of conditions, as suggested by positive findings in therapists and musicians.

CONCLUSION: To date, actual evidence about Zen meditation is scarce and highlights the necessity of further investigations. Comparison with further active treatments, explanation of possible mechanisms of action, and the limitations of current evidence are discussed.

PMID: 19422285 [PubMed - indexed for MEDLINE]

95. Int J Psychophysiol. 2009 Apr;72(1):51-60. doi: 10.1016/j.ijpsycho.2008.03.013. Epub 2008 Sep 23.

Meditation (Vipassana) and the P3a event-related brain potential.

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A three-stimulus auditory oddball series was presented to experienced Vipassana meditators during meditation and a control thought period to elicit event-related brain potentials (ERPs) in the two different mental states. The stimuli consisted of a frequent standard tone (500 Hz), an infrequent oddball tone (1000 Hz), and an infrequent distracter (white noise), with all stimuli passively presented through headphones and no task imposed. The strongest meditation compared to control state effects occurred for the distracter stimuli: N1 amplitude from the distracter was reduced frontally during meditation; P2 amplitude from both the distracter and oddball stimuli were somewhat reduced during meditation; P3a amplitude from the distracter was reduced during meditation. The meditation-induced reduction in P3a amplitude was strongest in participants reporting more hours of daily meditation practice and was not evident in participants reporting drowsiness during their experimental meditative session. The findings suggest that meditation state can decrease the amplitude of neurophysiologic processes that subserve attentional engagement elicited by unexpected and distracting stimuli. Consistent with the aim of Vipassana meditation to reduce cognitive and emotional reactivity, the state effect of reduced P3a amplitude to distracting stimuli reflects decreased automated reactivity and evaluative processing of task irrelevant attention-demanding stimuli.

PMCID: PMC2715145

PMID: 18845193 [PubMed - indexed for MEDLINE]

96. Brain Behav Immun. 2009 Feb;23(2):184-8. doi: 10.1016/j.bbi.2008.07.004. Epub 2008 Jul 19.

Mindfulness meditation training effects on CD4+ T lymphocytes in HIV-1 infected adults: a small randomized controlled trial.

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Mindfulness meditation training has stress reduction benefits in various patient populations, but its effects on biological markers of HIV-1 progression are unknown. The present study tested the efficacy of an 8-week Mindfulness-based stress reduction (MBSR) meditation program compared to a 1-day control seminar on CD4+ T lymphocyte counts in stressed HIV infected adults. A single-blind randomized controlled trial was conducted with enrollment and follow-up occurring between November 2005 and December 2007. A diverse community sample of 48 HIV-1 infected adults was randomized and entered treatment in either an 8-week MBSR or a 1-day control stress reduction education seminar. The primary outcome was circulating counts of CD4+ T lymphocytes. Participants in the 1-day control seminar showed declines in CD4+ T lymphocyte counts whereas counts among participants in the 8-week MBSR program were unchanged from baseline to post-intervention (time x treatment condition interaction,  $p=.02$ ). This effect was independent of antiretroviral (ARV) medication use. Additional analyses indicated that treatment adherence to the mindfulness meditation program, as measured by class attendance, mediated the effects of mindfulness meditation training on buffering CD4+ T lymphocyte declines. These findings provide an initial indication that mindfulness meditation training can buffer CD4+ T lymphocyte declines in HIV-1 infected adults. Clinical Trials Registration: clinicaltrials.gov, Identifier: NCT00600561.

PMCID: PMC2725018

PMID: 18678242 [PubMed - indexed for MEDLINE]

97. Neuroreport. 2009 Jan 28;20(2):170-4. doi: 10.1097/WNR.0b013e328320012a.

Long-term meditation is associated with increased gray matter density in the brain stem.

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Extensive practice involving sustained attention can lead to changes in brain structure. Here, we report evidence of structural differences in the lower brainstem of participants engaged in the long-term practice of meditation. Using magnetic resonance imaging, we observed higher gray matter density in lower brain stem regions of experienced meditators compared with age-matched nonmeditators. Our findings show that long-term practitioners of meditation have structural differences in brainstem regions concerned with cardiorespiratory control. This could account for some of the cardiorespiratory parasympathetic effects and traits, as well as the cognitive, emotional, and immunoreactive impact reported in several studies of different meditation practices.

PMID: 19104459 [PubMed - indexed for MEDLINE]

98. Complement Health Pract Rev. 2009 Jan 1;14(1):10-18.

Mindfulness Research Update: 2008.

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OBJECTIVE: To briefly review the effects of mindfulness on the mind, the brain, the body, and behavior. METHODS: Selective review of MEDLINE, PsycINFO, and Google Scholar databases (2003-2008) using the terms "mindfulness", "meditation", "mental health", "physical health", "quality of life", and "stress reduction." A total of 52 exemplars of empirical and theoretical work were selected for review. RESULTS: Both basic and clinical research indicate that cultivating a more mindful way of being is associated with less emotional distress, more positive

states of mind, and better quality of life. In addition, mindfulness practice can influence the brain, the autonomic nervous system, stress hormones, the immune system, and health behaviors, including eating, sleeping and substance use, in salutary ways. CONCLUSION: The application of cutting-edge technology toward understanding mindfulness - an "inner technology" - is elucidating new ways in which attention, awareness, acceptance, and compassion may promote optimal health - in mind, body, relationships, and spirit.

PMCID: PMC2679512  
PMID: 20047019 [PubMed]

99. J Health Care Chaplain. 2009;16(1-2):53-7. doi: 10.1080/08854720903451055.

Support from neurobiology for spiritual techniques for anxiety: a brief review.

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Research in neurobiology supports use of spiritual techniques as a beneficial treatment for anxiety. Psychotherapy, including mindfulness CBT and meditation, has been shown to change brain structure. The amygdala—the brain structure responsible for processing emotion and anxiety—demonstrates plasticity, and the purpose of therapy may be to allow the cortex to establish more effective and efficient synaptic links with the amygdala. A main feature of spiritual approaches is changing one's focus of attention. Instead of worry, one focuses on peaceful thoughts, thoughts of helping others, etc. Research demonstrates that thought, meditation, and other manifestations of mind can alter the brain, sometimes in an enduring way. Few studies have addressed the neurobiological underpinnings of meditation. Limited evidence, however, suggests that brain changes occur during prolonged meditation and that meditation activates neural structures involved in attention and control of the autonomic nervous system.

PMID: 20183113 [PubMed - indexed for MEDLINE]

100. Prog Brain Res. 2009;176:161-80. doi: 10.1016/S0079-6123(09)17620-3.

An adaptive workspace hypothesis about the neural correlates of consciousness:

insights from neuroscience and meditation studies.

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While enormous progress has been made to identify neural correlates of consciousness (NCC), crucial NCC aspects are still very controversial. A major hurdle is the lack of an adequate definition and characterization of different aspects of conscious experience and also its relationship to attention and metacognitive processes like monitoring. In this paper, we therefore attempt to develop a unitary theoretical framework for NCC, with an interdependent characterization of endogenous attention, access consciousness, phenomenal awareness, metacognitive consciousness, and a non-referential form of unified consciousness. We advance an adaptive workspace hypothesis about the NCC based on the global workspace model emphasizing transient resonant neurodynamics and prefrontal cortex function, as well as meditation-related characterizations of conscious experiences. In this hypothesis, transient dynamic links within an adaptive coding net in prefrontal cortex, especially in anterior prefrontal cortex, and between it and the rest of the brain, in terms of ongoing intrinsic and long-range signal exchanges, flexibly regulate the interplay between endogenous attention, access consciousness, phenomenal awareness, and metacognitive consciousness processes. Such processes are established in terms of complementary aspects of an ongoing transition between context-sensitive global workspace assemblies, modulated moment-to-moment by body and environment states. Brain regions associated to momentary interoceptive and exteroceptive self-awareness, or first-person experiential perspective as emphasized in open monitoring meditation, play an important modulatory role in adaptive workspace transitions.

PMID: 19733756 [PubMed - indexed for MEDLINE]

101. Prog Neurobiol. 2008 Nov;86(3):156-85. doi: 10.1016/j.pneurobio.2008.09.005. Epub 2008 Sep 7.

Frontal-midline theta from the perspective of hippocampal "theta".

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Electrical recordings from the surface of the skull have a wide range of rhythmic components. A major task of analysis of this EEG is to determine their source and functional significance. The hippocampal "theta rhythm" has been extensively studied in rats and its rhythmicity has recently been shown to be functionally significant, *per se*. Here, we use relevant aspects of the hippocampal literature to provide perspective on one of the most studied human EEG rhythms: frontal-midline theta. We review its electrographic features, localization, prevalence, age distribution, behavioural modulation (particularly in relation to working memory, spatial navigation, episodic memory, internalised attention and meditation), relationship to personality, drug interactions, neurochemical relationships, and coherence with rhythmic activity at other sites. We conclude that FM-theta, like hippocampal theta, appears to play a role in (or at least occur during) processing of memory and emotion. It is correlated with working memory and/or sustained attention; but this does not entail a role in function since clear behavioural correlates of hippocampal theta have been demonstrated that are not sensitive to hippocampal damage. FM-theta is increased by anxiolytic drug action and personality-related reductions in anxiety, whereas hippocampal theta is decreased by anxiolytic drugs. In animals, frontal theta and hippocampal theta can be phase-locked or independent, depending on behavioural state. So, the cognitive functions of FM-theta, and their relationship to hippocampal theta, are unclear and definitive evidence for functional involvement in cognitive or emotional processing is lacking. One possible solution to this problem is analysis of FM-theta in animals-provided homology can be determined. The issues of sporadicity and low incidence of FM-theta also need to be addressed in the future. Changes in functional connectivity, indicated by changes in coherence, are also a largely untapped resource. We suggest that the most hopeful path to assessing the functions of FM-theta will be through the use of drugs, and the variation of their effects depending on baseline levels of FM-theta. Finally, we review some theories of theta function. Despite the apparent richness of the current data, we conclude that it is difficult (and may ultimately be impossible) to formulate a theory that attributes a specific cognitive function to FM-theta. However, the theories share some general computational assumptions and these should be a useful guide to future work and, ultimately, a definite theory of the function or functions of FM-theta.

PMID: 18824212 [PubMed - indexed for MEDLINE]

102. PLoS One. 2008 Sep 3;3(9):e3083. doi: 10.1371/journal.pone.0003083.

"Thinking about not-thinking": neural correlates of conceptual processing during Zen meditation.

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Recent neuroimaging studies have identified a set of brain regions that are metabolically active during wakeful rest and consistently deactivate in a variety of the performance of demanding tasks. This "default network" has been functionally linked to the stream of thoughts occurring automatically in the absence of goal-directed activity and which constitutes an aspect of mental behavior specifically addressed by many meditative practices. Zen meditation, in particular, is traditionally associated with a mental state of full awareness but reduced conceptual content, to be attained via a disciplined regulation of attention and bodily posture. Using fMRI and a simplified meditative condition interspersed with a lexical decision task, we investigated the neural correlates of conceptual processing during meditation in regular Zen practitioners and matched control subjects. While behavioral performance did not differ between groups, Zen practitioners displayed a reduced duration of the neural response linked to conceptual processing in regions of the default network, suggesting that meditative training may foster the ability to control the automatic cascade of semantic associations triggered by a stimulus and, by extension, to voluntarily regulate the flow of spontaneous mentation.

PMCID: PMC2518618

PMID: 18769538 [PubMed - indexed for MEDLINE]

103. Brain Behav Immun. 2008 Aug;22(6):969-81. doi: 10.1016/j.bbi.2008.01.012. Epub 2008 Mar 21.

Effect of mindfulness based stress reduction on immune function, quality of life and coping in women newly diagnosed with early stage breast cancer.

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Comment in

Int J Group Psychother. 2011 Jul;61(3):463-8.

This investigation used a non-randomized controlled design to evaluate the effect and feasibility of a mindfulness based stress reduction (MBSR) program on immune function, quality of life (QOL), and coping in women recently diagnosed with breast cancer. Early stage breast cancer patients, who did not receive chemotherapy, self-selected into an 8-week MBSR program or into an assessment only, control group. Outcomes were evaluated over time. The first assessment was at least 10 days after surgery and prior to adjuvant therapy, as well as before the MBSR start-up. Further assessments were mid-MBSR, at completion of MBSR, and at 4-week post-MBSR completion. Women with breast cancer enrolled in the control group (Non-MBSR) were assessed at similar times. At the first assessment (i.e., before MBSR start), reductions in peripheral blood mononuclear cell NK cell activity (NKCA) and IFN-gamma production with increases in IL-4, IL-6, and IL-10 production and plasma cortisol levels were observed for both the MBSR and Non-MBSR groups of breast cancer patients. Over time women in the MBSR group re-established their NKCA and cytokine production levels. In contrast, breast cancer patients in the Non-MBSR group exhibited continued reductions in NKCA and IFN-gamma production with increased IL-4, IL-6, and IL-10 production. Moreover, women enrolled in the MBSR program had reduced cortisol levels, improved QOL, and increased coping effectiveness compared to the Non-MBSR group. In summary, MBSR is a program that is feasible for women recently diagnosed with early stage breast cancer and the results provide preliminary evidence for beneficial effects of MBSR; on immune function, QOL, and coping.

PMCID: PMC2586059

PMID: 18359186 [PubMed - indexed for MEDLINE]

104. Br J Anaesth. 2008 Jul;101(1):111-20. doi: 10.1093/bja/aen090. Epub 2008 May 16.

Advances in understanding the mechanisms and management of persistent pain in older adults.

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Older adults with persistent pain are not simply a chronologically older version of younger pain patients. Pain-related disability in older adults may be driven by pain 'homeostenosis', that is, diminished ability to effectively respond to the stress of persistent pain. Some of the comorbidities of ageing that can contribute to pain homeostenosis include cognitive and physical impairments, increased sensitivity to suprathreshold pain stimuli, medical and psychological comorbidities, altered pharmacokinetics and pharmacodynamics, and social isolation. A key distinction between older and younger individuals with persistent pain is the normal and pathological ageing-associated brain changes. These may alter the expression and experience of pain with impaired descending inhibition and dysfunction of pain gating mechanisms. Cognizance of these brain changes is needed to guide appropriate evaluation and treatment approaches. This paper reviews data that support these ageing-associated phenomena. Specifically, we discuss age-related changes in the brain (both normal and pathological) and in pain physiology; changes in experience and expression of pain that occur with dementia and contribute to pain homeostenosis; and unique aspects of age and pain-associated psychological function and their contribution to disability. We also present data demonstrating changes in brain morphology and neuropsychological performance that accompany persistent non-malignant pain in older adults and the treatment implications of these brain changes. Finally, preliminary data are presented on the efficacy of mindfulness meditation, a treatment that has been examined explicitly in older adults and targets optimizing brain function and descending inhibition.

PMCID: PMC2841779

PMID: 18487247 [PubMed - indexed for MEDLINE]

105. Exp Brain Res. 2008 Jun;188(2):317-22. doi: 10.1007/s00221-008-1409-6. Epub 2008 May 30.

Tactile acuity in experienced Tai Chi practitioners: evidence for use dependent plasticity as an effect of sensory-attentional training.

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The scientific discovery of novel training paradigms has yielded better understanding of basic mechanisms underlying cortical plasticity, learning and development. This study is a first step in evaluating Tai Chi (TC), the Chinese slow-motion meditative exercise, as a training paradigm that, while not engaging in direct tactile stimulus training, elicits enhanced tactile acuity in long-term practitioners. The rationale for this study comes from the fact that, unlike previously studied direct-touch tactile training paradigms, TC practitioners focus specific mental attention on the body's extremities including the fingertips and hands as they perform their slow routine. To determine whether TC is associated with enhanced tactile acuity, experienced adult TC practitioners were recruited and compared to age-gender matched controls. A blinded assessor used a validated method (Van Boven et al. in Neurology 54(12): 2230-2236, 2000) to compare TC practitioners' and controls' ability to discriminate between two different orientations (parallel and horizontal) across different grating widths at the fingertip. Study results showed that TC practitioners' tactile spatial acuity was superior to that of the matched controls ( $P < 0.04$ ). There was a trend showing TC may have an enhanced effect on older practitioners ( $P < 0.066$ ), suggesting that TC may slow age related decline in this measure. To the best of our knowledge, this is the first study to evaluate a long-term attentional practice's effects on a perceptual measure. Longitudinal studies are needed to examine whether TC initiates or is merely correlated with perceptual changes and whether it elicits long-term plasticity in primary sensory cortical maps. Further studies should also assess whether related somatosensory attentional practices (such as Yoga, mindfulness meditation and Qigong) achieve similar effects.

PMCID: PMC2795804

PMID: 18512052 [PubMed - indexed for MEDLINE]

106. Psychiatry Clin Neurosci. 2008 Jun;62(3):366. doi:  
10.1111/j.1440-1819.2008.01809.x.

Preliminary functional magnetic resonance imaging Stroop task results before and after a Zen meditation retreat.

Kozasa EH, Radvany J, Barreiros MA, Leite JR, Amaro E Jr.

PMID: 18588603 [PubMed - indexed for MEDLINE]

107. Psychiatry (Edgmont). 2008 Apr;5(4):48-55.

Meditation-based training: a possible intervention for attention deficit hyperactivity disorder.

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Recent studies suggest that training-based measures are effective in improving cognitive skills. Meditation-based training has produced lasting changes in brain and cognitive functions. This technique of mental training exhibits neuroplasticity in the attentional networks, exhibiting superior performance, especially in the domain of attention and executive control processing, which is impaired in attention deficit hyperactivity disorder (ADHD). Although intervention techniques for ADHD are well researched, many individuals continue to experience significant functional impairment despite the symptom improvement. This emphasizes a need for a comprehensive approach that requires an effective behavioral intervention. The present paper provides a converging review of meditation-based effects on the brain, dysfunctions of ADHD, and suggestions for enhancement of cognitive abilities in patients with ADHD using meditational training combined with existing measures of intervention. The idea proposed herein should be considered a step for initiation of empirical studies on meditation-based training intervention and outcome effects.

PMCID: PMC2719552

PMID: 19727310 [PubMed]

108. Trends Cogn Sci. 2008 Apr;12(4):163-9. doi: 10.1016/j.tics.2008.01.005. Epub 2008 Mar 10.

Attention regulation and monitoring in meditation.

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Meditation can be conceptualized as a family of complex emotional and attentional regulatory training regimes developed for various ends, including the cultivation

of well-being and emotional balance. Among these various practices, there are two styles that are commonly studied. One style, focused attention meditation, entails the voluntary focusing of attention on a chosen object. The other style, open monitoring meditation, involves nonreactive monitoring of the content of experience from moment to moment. The potential regulatory functions of these practices on attention and emotion processes could have a long-term impact on the brain and behavior.

PMCID: PMC2693206

PMID: 18329323 [PubMed - indexed for MEDLINE]

109. Turk Neurosurg. 2008 Apr;18(2):134-41.

Functional brain mapping during recitation of Buddhist scriptures and repetition of the Namu Amida Butsu: a study in experienced Japanese monks.

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**BACKGROUND:** The invocation Namu Amida Butsu (Nembutsu), voices the hope of rebirth into Amida's Pure Land. In the Nembutsu, Buddhists imagine that they are absorbed into Amida's Pure Land. Shiritori, a Japanese word chain game, is a common task used to activate language related regions in Japanese. The purpose of this study was to identify the regions activated during praying of the Namo Amida Butsu (Nembutsu), and the reciting of Buddhist scriptures (Sutra).

**MATERIAL AND METHOD:** Functional MRI (fMRI) was used to identify the regions activated by the Nenbutsu, the Sutra and the Shiritori in eight highlytrained Japanese monks.

**RESULTS:** The task of repeating the Nenbutsu activates the medial frontal gyrus, which is mainly related to mental concentration and visuospatial attention, similar to the areas activated by meditation. The task of reciting the Sutra activates the left lateral middle frontal gyrus, the right angular gyrus, and the right supramarginal gyrus, which are related to visuospatial attention also involved in the area activated by meditation.

**CONCLUSION:** These results suggest that different types of meditation in Japanese Buddhism showed different brain regional activation. The Nenbutsu activated the prefrontal cortex, and the Sutra activated the left dorsolateral prefrontal cortex and right parietal cortex.

PMID: 18597227 [PubMed - indexed for MEDLINE]

110. Appl Psychophysiol Biofeedback. 2008 Mar;33(1):39-47. doi:  
10.1007/s10484-008-9050-5. Epub 2008 Jan 24.

Electroencephalographic (EEG) measurements of mindfulness-based Triarchic body-pathway relaxation technique: a pilot study.

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**OBJECTIVE:** The "Triarchic body-pathway relaxation technique" (TBRT) is a form of ancient Chinese mindfulness-based meditation professed to give rise to positive emotions and a specific state of consciousness in which deep relaxation and internalized attention coexist. The purpose of this study was to examine the EEG pattern generated during the practice of this mindfulness exercise, and compare it to music listening which has been shown to induce positive emotions.

**METHODS:** Nineteen college students (aged 19-22 years) participated in the study. Each participant listened to both the TBRT and music audiotapes while EEG was recorded. The order of presentation was counterbalanced to avoid order effect. Two EEG indicators were used: (1) alpha asymmetry index, an indicator for left-sided anterior activation, as measure of positive emotions, and (2) frontal midline theta activity, as a measure for internalized attention.

**RESULTS:** Increased left-sided activation, a pattern associated with positive emotions, was found during both TBRT exercise and music conditions. However, only TBRT exercise was shown to exhibit greater frontal midline theta power, a pattern associated with internalized attention.

**CONCLUSIONS:** These results provided evidence to support that the TBRT gives rise to positive emotional experience, accompanied by focused internalized attention.

PMID: 18214668 [PubMed - indexed for MEDLINE]

111. Soc Cogn Affect Neurosci. 2008 Mar;3(1):55-61. doi: 10.1093/scan/nsm038. Epub 2007 Dec 3.

Investigation of mindfulness meditation practitioners with voxel-based

morphometry.

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Mindfulness meditators practice the non-judgmental observation of the ongoing stream of internal experiences as they arise. Using voxel-based morphometry, this study investigated MRI brain images of 20 mindfulness (Vipassana) meditators (mean practice 8.6 years; 2 h daily) and compared the regional gray matter concentration to that of non-meditators matched for sex, age, education and handedness. Meditators were predicted to show greater gray matter concentration in regions that are typically activated during meditation. Results confirmed greater gray matter concentration for meditators in the right anterior insula, which is involved in interoceptive awareness. This group difference presumably reflects the training of bodily awareness during mindfulness meditation. Furthermore, meditators had greater gray matter concentration in the left inferior temporal gyrus and right hippocampus. Both regions have previously been found to be involved in meditation. The mean value of gray matter concentration in the left inferior temporal gyrus was predictable by the amount of meditation training, corroborating the assumption of a causal impact of meditation training on gray matter concentration in this region. Results suggest that meditation practice is associated with structural differences in regions that are typically activated during meditation and in regions that are relevant for the task of meditation.

PMCID: PMC2569815

PMID: 19015095 [PubMed - indexed for MEDLINE]

112. Conf Proc IEEE Eng Med Biol Soc. 2008;2008:662-5. doi:  
10.1109/IEMBS.2008.4649239.

Improving the performance of brain-computer interface through meditation practicing.

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Cognitive tasks using motor imagery have been used for generating and controlling EEG activity in most brain-computer interface (BCI). Nevertheless, during the performance of a particular mental task, different factors such as concentration, attention, level of consciousness and the difficulty of the task, may be affecting the changes in the EEG activity. Accordingly, training the subject to consistently and reliably produce and control the changes in the EEG signals is a critical issue in developing a BCI system. In this work, we used meditation practice to enhance the mind controllability during the performance of a mental task in a BCI system. The mental states to be discriminated are the imaginative hand movement and the idle state. The experiments were conducted on two groups of subject, meditation group and control group. The time-frequency analysis of EEG signals for meditation practitioners showed an event-related desynchronization (ERD) of beta rhythm before imagination during resting state. In addition, a strong event-related synchronization (ERS) of beta rhythm was induced in frequency around 25 Hz during hand motor imagery. The results demonstrated that the meditation practice can improve the classification accuracy of EEG patterns. The average classification accuracy was 88.73% in the meditation group, while it was 70.28% in the control group. An accuracy as high as 98.0% was achieved in the meditation group.

PMID: 19162742 [PubMed - indexed for MEDLINE]

113. Soc Cogn Affect Neurosci. 2007 Dec;2(4):313-22. doi: 10.1093/scan/nsm030.

Attending to the present: mindfulness meditation reveals distinct neural modes of self-reference.

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It has long been theorised that there are two temporally distinct forms of self-reference: extended self-reference linking experiences across time, and momentary self-reference centred on the present. To characterise these two aspects of awareness, we used functional magnetic resonance imaging (fMRI) to examine monitoring of enduring traits ('narrative' focus, NF) or momentary experience ('experiential' focus, EF) in both novice participants and those having attended an 8 week course in mindfulness meditation, a program that trains individuals to develop focused attention on the present. In novices, EF yielded

focal reductions in self-referential cortical midline regions (medial prefrontal cortex, mPFC) associated with NF. In trained participants, EF resulted in more marked and pervasive reductions in the mPFC, and increased engagement of a right lateralised network, comprising the lateral PFC and viscerosomatic areas such as the insula, secondary somatosensory cortex and inferior parietal lobule. Functional connectivity analyses further demonstrated a strong coupling between the right insula and the mPFC in novices that was uncoupled in the mindfulness group. These results suggest a fundamental neural dissociation between two distinct forms of self-awareness that are habitually integrated but can be dissociated through attentional training: the self across time and in the present moment.

PMCID: PMC2566754

PMID: 18985137 [PubMed - indexed for MEDLINE]

114. Brain Behav Immun. 2007 Nov;21(8):1038-49. Epub 2007 May 22.

One year pre-post intervention follow-up of psychological, immune, endocrine and blood pressure outcomes of mindfulness-based stress reduction (MBSR) in breast and prostate cancer outpatients.

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**OBJECTIVES:** This study investigated the ongoing effects of participation in a mindfulness-based stress reduction (MBSR) program on quality of life (QL), symptoms of stress, mood and endocrine, immune and autonomic parameters in early stage breast and prostate cancer patients.

**METHODS:** Forty-nine patients with breast cancer and 10 with prostate cancer enrolled in an eight-week MBSR program that incorporated relaxation, meditation, gentle yoga and daily home practice. Demographic and health behaviors, QL, mood, stress symptoms, salivary cortisol levels, immune cell counts, intracellular cytokine production, blood pressure (BP) and heart rate (HR) were assessed pre- and post-intervention, and at 6- and 12-month follow-up.

**RESULTS:** Fifty-nine, 51, 47 and 41 patients were assessed pre- and post-intervention and at 6- and 12-month follow-up, respectively, although not all participants provided data on all outcomes at each time point. Linear mixed

modeling showed significant improvements in overall symptoms of stress which were maintained over the follow-up period. Cortisol levels decreased systematically over the course of the follow-up. Immune patterns over the year supported a continued reduction in Th1 (pro-inflammatory) cytokines. Systolic blood pressure (SBP) decreased from pre- to post-intervention and HR was positively associated with self-reported symptoms of stress.

**CONCLUSIONS:** MBSR program participation was associated with enhanced quality of life and decreased stress symptoms, altered cortisol and immune patterns consistent with less stress and mood disturbance, and decreased blood pressure. These pilot data represent a preliminary investigation of the longer-term relationships between MBSR program participation and a range of potentially important biomarkers.

PMID: 17521871 [PubMed - indexed for MEDLINE]

115. Neuroreport. 2007 Oct 29;18(16):1709-12.

Concentrative meditation enhances preattentive processing: a mismatch negativity study.

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The mismatch negativity (MMN) paradigm that is an indicator of preattentive processing was used to study the effects of concentrative meditation. Sudarshan Kriya Yoga meditation is a yogic exercise practiced in an ordered sequence beginning with breathing exercises, and ending with concentrative (Sahaj Samadhi) meditation. Auditory MMN waveforms were recorded at the beginning and after each of these practices for meditators, and equivalently after relaxation sessions for the nonmeditators. Overall meditators were found to have larger MMN amplitudes than nonmeditators. The meditators also exhibited significantly increased MMN amplitudes immediately after meditation suggesting transient state changes owing to meditation. The results indicate that concentrative meditation practice enhances preattentive perceptual processes, enabling better change detection in auditory sensory memory.

PMID: 17921873 [PubMed - indexed for MEDLINE]

116. Neurobiol Aging. 2007 Oct;28(10):1623-7. Epub 2007 Jul 25.

Age effects on gray matter volume and attentional performance in Zen meditation.

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Zen meditation, a Buddhist practice centered on attentional and postural self-regulation, has been speculated to bring about beneficial long-term effects for the individual, ranging from stress reduction to improvement of cognitive function. In this study, we examined how the regular practice of meditation may affect the normal age-related decline of cerebral gray matter volume and attentional performance observed in healthy individuals. Voxel-based morphometry for MRI anatomical brain images and a computerized sustained attention task were employed in 13 regular practitioners of Zen meditation and 13 matched controls. While control subjects displayed the expected negative correlation of both gray matter volume and attentional performance with age, meditators did not show a significant correlation of either measure with age. The effect of meditation on gray matter volume was most prominent in the putamen, a structure strongly implicated in attentional processing. These findings suggest that the regular practice of meditation may have neuroprotective effects and reduce the cognitive decline associated with normal aging.

PMID: 17655980 [PubMed - indexed for MEDLINE]

117. Explore (NY). 2007 Sep-Oct;3(5):449-52.

New studies support the therapeutic value of meditation.

Horrigan BJ.

PMID: 17905353 [PubMed - indexed for MEDLINE]

118. Proc Natl Acad Sci U S A. 2007 Jul 3;104(27):11483-8. Epub 2007 Jun 27.

Neural correlates of attentional expertise in long-term meditation practitioners.

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Meditation refers to a family of mental training practices that are designed to familiarize the practitioner with specific types of mental processes. One of the most basic forms of meditation is concentration meditation, in which sustained attention is focused on an object such as a small visual stimulus or the breath. In age-matched participants, using functional MRI, we found that activation in a network of brain regions typically involved in sustained attention showed an inverted u-shaped curve in which expert meditators (EMs) with an average of 19,000 h of practice had more activation than novices, but EMs with an average of 44,000 h had less activation. In response to distracter sounds used to probe the meditation, EMs vs. novices had less brain activation in regions related to discursive thoughts and emotions and more activation in regions related to response inhibition and attention. Correlation with hours of practice suggests possible plasticity in these mechanisms.

PMCID: PMC1903340

PMID: 17596341 [PubMed - indexed for MEDLINE]

119. Psychosom Med. 2007 Jul-Aug;69(6):560-5. Epub 2007 Jul 18.

Neural correlates of dispositional mindfulness during affect labeling.

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**OBJECTIVE:** Mindfulness is a process whereby one is aware and receptive to present moment experiences. Although mindfulness-enhancing interventions reduce pathological mental and physical health symptoms across a wide variety of conditions and diseases, the mechanisms underlying these effects remain unknown. Converging evidence from the mindfulness and neuroscience literature suggests that labeling affect may be one mechanism for these effects.

**METHODS:** Participants ( $n = 27$ ) indicated trait levels of mindfulness and then completed an affect labeling task while undergoing functional magnetic resonance

imaging. The labeling task consisted of matching facial expressions to appropriate affect words (affect labeling) or to gender-appropriate names (gender labeling control task).

RESULTS: After controlling for multiple individual difference measures, dispositional mindfulness was associated with greater widespread prefrontal cortical activation, and reduced bilateral amygdala activity during affect labeling, compared with the gender labeling control task. Further, strong negative associations were found between areas of prefrontal cortex and right amygdala responses in participants high in mindfulness but not in participants low in mindfulness.

CONCLUSIONS: The present findings with a dispositional measure of mindfulness suggest one potential neurocognitive mechanism for understanding how mindfulness meditation interventions reduce negative affect and improve health outcomes, showing that mindfulness is associated with enhanced prefrontal cortical regulation of affect through labeling of negative affective stimuli.

PMID: 17634566 [PubMed - indexed for MEDLINE]

120. Neurosci Lett. 2007 Jun 21;421(1):16-21. Epub 2007 May 25.

Differential engagement of anterior cingulate and adjacent medial frontal cortex in adept meditators and non-meditators.

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This study investigated differences in brain activation during meditation between meditators and non-meditators. Fifteen Vipassana meditators (mean practice: 7.9 years, 2h daily) and fifteen non-meditators, matched for sex, age, education, and handedness, participated in a block-design fMRI study that included mindfulness of breathing and mental arithmetic conditions. For the meditation condition (contrasted to arithmetic), meditators showed stronger activations in the rostral anterior cingulate cortex and the dorsal medial prefrontal cortex bilaterally, compared to controls. Greater rostral anterior cingulate cortex activation in meditators may reflect stronger processing of distracting events. The increased activation in the medial prefrontal cortex may reflect that meditators are stronger engaged in emotional processing.

PMID: 17548160 [PubMed - indexed for MEDLINE]

121. Neuroreport. 2007 May 7;18(7):709-12.

Effects of meditation on frontal alpha-asymmetry in previously suicidal individuals.

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This study investigated the effects of a meditation-based treatment for preventing relapse to depression, mindfulness-based cognitive therapy (MBCT), on prefrontal alpha-asymmetry in resting electroencephalogram (EEG), a biological indicator of affective style. Twenty-two individuals with a previous history of suicidal depression were randomly assigned to either MBCT (N=10) or treatment-as-usual (TAU, N=12). Resting electroencephalogram was measured before and after an 8-week course of treatment. The TAU group showed a significant deterioration toward decreased relative left-frontal activation, indexing decreases in positive affective style, while there was no significant change in the MBCT group. The findings suggest that MBCT can help individuals at high risk for suicidal depression to retain a balanced pattern of baseline emotion-related brain activation.

PMID: 17426604 [PubMed - indexed for MEDLINE]

122. J Altern Complement Med. 2007 Jan-Feb;13(1):59-66.

Cortical dynamics as a therapeutic mechanism for touch healing.

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Erratum in  
J Altern Complement Med. 2007 Mar;13(2):301.

Touch Healing (TH) therapies, defined here as treatments whose primary route of administration is tactile contact and/or active guiding of somatic attention, are ubiquitous across cultures. Despite increasing integration of TH into mainstream medicine through therapies such as Reiki, Therapeutic Touch, (TM) and somatically focused meditation practices such as Mindfulness-Based Stress Reduction, relatively little is known about potential underlying mechanisms. Here, we present a neuroscientific explanation for the prevalence and effectiveness of TH therapies for relieving chronic pain. We begin with a cross-cultural review of several different types of TH treatments and identify common characteristics, including: light tactile contact and/or a somatosensory attention directed toward the body, a behaviorally relevant context, a relaxed context and repeated treatment sessions. These cardinal features are also key elements of established mechanisms of neural plasticity in somatosensory cortical maps, suggesting that sensory reorganization is a mechanism for the healing observed. Consideration of the potential health benefits of meditation practice specifically suggests that these practices provide training in the regulation of neural and perceptual dynamics that provide ongoing resistance to the development of maladaptive somatic representations. This model provides several direct predictions for investigating ways that TH may induce cortical plasticity and dynamics in pain remediation.

PMID: 17309379 [PubMed - indexed for MEDLINE]

123. ScientificWorldJournal. 2006 Nov 16;6:2239-53.

Neuroscience of meditation.

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Dhyana-Yoga is a Sanskrit word for the ancient discipline of meditation, as a means to Samadhi or enlightenment. Samadhi is a self-absorptive, adaptive state with realization of one's being in harmony with reality. It is unitive, undifferentiated, reality-consciousness, an essential being, which can only be experienced by spontaneous intuition and self-understanding. Modern neuroscience can help us to better understand Dhyana-Yoga. This article discusses topics including brain-mind-reality, consciousness, attention, emotional intelligence, sense of self, meditative mind, and meditative brain. A new hypothesis is

proposed for a better understanding of the meditative mind. Meditation is an art of being serene and alert in the present moment, instead of constantly struggling to change or to become. It is an art of efficient management of attentional energy with total engagement (poornata, presence, mindfulness) or disengagement (shunyata, silence, emptiness). In both states, there is an experience of spontaneous unity with no sense of situational interactive self or personal time. It is a simultaneous, participatory consciousness rather than a dualistic, sequential attentiveness. There is a natural sense of well being with self-understanding, spontaneous joy, serenity, freedom, and self-fulfillment. It is where the ultimate pursuit of happiness and the search for meaning of life resolve. One realizes the truth of one's harmonious being in nature and nature in oneself. It is being alive at its fullest, when each conscious moment becomes a dynamic process of discovery and continuous learning of the ever-new unfolding reality.

PMID: 17370019 [PubMed - indexed for MEDLINE]

124. CNS Spectr. 2006 Nov;11(11):829-51.

The application of mindfulness-based cognitive interventions in the treatment of co-occurring addictive and mood disorders.

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This article reviews the theory, clinical application, and empirical findings on mindfulness-based cognitive therapy (MBCT) for mental health and addictive disorders. Expanding upon the research demonstrating the efficacy of cognitive-behavioral therapy (CBT) for addiction, this article develops and explores the rationale for combining mindfulness-based interventions with evidence-based CBTs in treating addictive disorders, with an emphasis on substance use disorders with co-occurring mood disorders. This article proposes that deficits in affect--regulation related to the behavioral and emotional effects of neurobiological changes that occur with long-term substance abuse--pose a unique set of challenges in early recovery. Prolonged use of addictive substances impairs the brain pathways that mediate certain affect regulation functions. These functions involve attention and inhibitory control, the saliency of and response to addictive versus natural reward stimuli, and the

ability to detach or maintain perspective in response to strong emotional states. In treating this affective dysregulation, which can contribute to the vulnerability to relapse in the early stages of recovery, the affect-regulation-specific focus of MBCT adds a valuable element to augment CBT for addiction. Summarizing magnetic resonance imaging and positron emission tomography findings on the effects of MBCT and the neurobiology of drug addiction, this article outlines directions for further research on potential benefits of MBCT for the recovering individual. Finally, this article describes a structured protocol, developed at the Mount Sinai School of Medicine in New York City, which combines CBT with mindfulness-based intervention, for the treatment of affect-regulation issues specific to co-occurring addictive and mood disorders.

PMID: 17075556 [PubMed - indexed for MEDLINE]

125. Lakartidningen. 2006 Oct 18-24;103(42):3174-7.

[Mindfulness meditation--an old fashion method for stress relief].

[Article in Swedish]

Asberg M, Sköld C, Wahlberg K, Nygren A.

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PMID: 17111986 [PubMed - indexed for MEDLINE]

126. Bull Cancer. 2006 Jul;93(7):699-708.

[Psychological stress in oncology: the role of glucocorticoids].

[Article in French]

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During the last years, the correlations between biological processes,

psychological adjustment and stress disorders have received increasing attention and a growing body of research results has been published in the general literature. In the realm of psycho-oncology, however, conceptual models on this topic and studies aimed at their validation have remained relatively scanty. On the basis of our observations and available literature in the field of post-traumatic and depressive stress disorders in oncology, we have proposed to apply the concept of allostatic load to the study and understanding of the psychological experience of cancer. This strategy has led us to the formulation of a novel classification of adjustment disorders in oncology and the creation of the clinical entity named "cancer-specific stress syndrome". Depending on clinical presentation of the syndrome, one distinguishes three subtypes, namely the depressive, post-traumatic and "dysallostatic" (mixed) forms. In the present paper, we examine the role of glucocorticoids and their relationships with one of the basic components of allostatic load--a failure to counter-regulate the immune system by the hypothalamic-pituitary-adrenal axis--in the physiopathology of stress disorders in oncology. Conflicting theories are presented--glucocorticoid cascade versus insufficient glucocorticoid signal transmission--and studies measuring potential correlations between stress and cortisol in oncology are critically reviewed. The results of this process provide substantial support for the application of the allostatic load model and post-traumatic phenomenology, but important advances have yet to be achieved before definitive conclusions can be established in this field. Such advances could lead to profound changes in the way we understand and treat psychological distress in patients with cancer, both pharmacologically and psychotherapeutically.

PMID: 16873079 [PubMed - indexed for MEDLINE]

127. Neuroreport. 2005 Nov 28;16(17):1893-7.

Meditation experience is associated with increased cortical thickness.

Lazar SW, Kerr CE, Wasserman RH, Gray JR, Greve DN, Treadway MT, McGarvey M, Quinn BT, Dusek JA, Benson H, Rauch SL, Moore CI, Fischl B.

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Previous research indicates that long-term meditation practice is associated with altered resting electroencephalogram patterns, suggestive of long lasting changes in brain activity. We hypothesized that meditation practice might also be

associated with changes in the brain's physical structure. Magnetic resonance imaging was used to assess cortical thickness in 20 participants with extensive Insight meditation experience, which involves focused attention to internal experiences. Brain regions associated with attention, interoception and sensory processing were thicker in meditation participants than matched controls, including the prefrontal cortex and right anterior insula. Between-group differences in prefrontal cortical thickness were most pronounced in older participants, suggesting that meditation might offset age-related cortical thinning. Finally, the thickness of two regions correlated with meditation experience. These data provide the first structural evidence for experience-dependent cortical plasticity associated with meditation practice.

PMCID: PMC1361002

PMID: 16272874 [PubMed - indexed for MEDLINE]

128. Harv Bus Rev. 2005 Nov;83(11):53-8, 165.

Are you working too hard? A conversation with mind/body researcher Herbert Benson.

Benson H.

Stress is an essential response in highly competitive environments. Before a race, before an exam, before an important meeting, your heart rate and blood pressure rise, your focus tightens, you become more alert and more efficient. But beyond a certain level, stress overloads your system, compromising your performance and, eventually, your health. So the question is: When does stress help and when does it hurt? To find out, HBR talked with Harvard Medical School professor Herbert Benson, M.D., founder of the Mind/Body Medical Institute. Having spent more than 35 years conducting worldwide research in the fields of neuroscience and stress, Benson is best known for his 1975 best seller *The Relaxation Response*, in which he describes how the mind can influence stress levels through such tools as meditation. His most recent research centers on what he calls "the breakout principle," a method by which stress is not simply reduced but carefully controlled so that you reap its benefits while avoiding its dangers. He describes a four-step process in which you first push yourself to the most productive stress level by grappling intently with a problem. Next, just as you feel yourself flagging, you disengage entirely by doing something utterly unrelated-going for a walk, petting a dog, taking a shower. In the third step, as the brain quiets down, activity paradoxically increases in areas associated with

attention, space-time concepts, and decision making, leading to a sudden, creative insight—the breakout. Step four is achievement of a "new-normal state," in which you find that the improved performance is sustained, sometimes indefinitely. As counterintuitive as this research may seem, managers can doubtless recall times when they've had an "aha" moment at the gym, on the golf course, or in the shower. What Benson describes here is a way to tap into this invaluable biological tool whenever we want.

PMID: 16299960 [PubMed - indexed for MEDLINE]

129. *Explore (NY)*. 2005 Sep;1(5):380-8.

Meditation and neuroplasticity: training your brain. Interview by Bonnie J. Horrigan.

Davidson R.

PMID: 16781570 [PubMed - indexed for MEDLINE]

130. *Adv Mind Body Med*. 2004 Spring;20(1):6-16.

The power of the human heart: a story of trauma and recovery and its implications for rehabilitation and healing.

Meili T, Kabat-Zinn J.

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Ms Trisha Meili revealed her identity as the Central Park Jogger in a presentation at Spaulding Rehabilitation Hospital in Boston in May 2003. Her co-presenter was Dr Jon Kabat-Zinn, whose teachings on mindfulness and meditation had been important in Ms Meili's rehabilitation process. This transcript of that conversation describes the various phases she underwent in her recovery, and documents the role of her self-discovered practice of mindfulness in restoring her emotional and physical functioning. Dr Kabat-Zinn reflects on the deeper meaning of the term "rehabilitation," and demonstrates its natural connections to the practice of meditation. A final question and answer section with audience members (clinicians, brain injury survivors and their families) documents the role of emotional support and inspiration in recovery from devastating injury.

PMID: 15068105 [PubMed - indexed for MEDLINE]

131. Psychosom Med. 2004 Jan-Feb;66(1):148-52; author reply 148-52.

Alterations in brain and immune function produced by mindfulness meditation:  
three caveats.

Smith JC.

Comment on  
Psychosom Med. 2003 Jul-Aug;65(4):564-70.

PMID: 14747650 [PubMed - indexed for MEDLINE]

132. Psychosom Med. 2004 Jan-Feb;66(1):147-8; author reply 147-8.

EEG asymmetry and mindfulness meditation.

Travis F, Arenander A.

Comment on  
Psychosom Med. 2003 Jul-Aug;65(4):564-70.

PMID: 14747649 [PubMed - indexed for MEDLINE]

133. Science. 2003 Oct 3;302(5642):44-6.

Buddhism and neuroscience. Studying the well-trained mind.

Barinaga M.

PMID: 14526055 [PubMed - indexed for MEDLINE]

134. Disabil Rehabil. 2003 Jul 8;25(13):722-31.

Pilot evaluation of a mindfulness-based intervention to improve quality of life

among individuals who sustained traumatic brain injuries.

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**PRIMARY OBJECTIVE:** To examine the potential efficacy of a mindfulness-based stress reduction approach to improve quality of life in individuals who have suffered traumatic brain injuries.

**RESEARCH DESIGN:** Pre-post design with drop-outs as controls.

**METHODS AND PROCEDURES:** We recruited individuals with mild to moderate brain injuries, at least 1 year post-injury. We measured their quality of life, psychological status, and function. Results of 10 participants who completed the programme were compared to three drop-outs with complete data.

**EXPERIMENTAL INTERVENTION:** The intervention was delivered in 12-weekly group sessions. The intervention relied on insight meditation, breathing exercises, guided visualization, and group discussion. We aimed to encourage a new way of thinking about disability and life to bring a sense of acceptance, allowing participants to move beyond limiting beliefs.

**MAIN OUTCOMES AND RESULTS:** The treatment group mean quality of life (SF-36) improved by 15.40 (SD = 9.08) compared to - 1.67 (SD = 16.65; p = 0.036) for controls. Improvements on the cognitive-affective domain of the Beck Depression Inventory II (BDI-II) were reported (p = 0.029), while changes in the overall BDI-II (p = 0.059) and the Positive Symptom Distress Inventory of the SCL-90R (p = 0.054) approached statistical significance.

**CONCLUSIONS:** The intervention was simple, and improved quality of life after other treatment avenues for these participants were exhausted.

PMID: 12791557 [PubMed - indexed for MEDLINE]

135. *Psychosom Med.* 2003 Jul-Aug;65(4):564-70.

Alterations in brain and immune function produced by mindfulness meditation.

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Comment in

Psychosom Med. 2004 Jan-Feb;66(1):147-8; author reply 147-8.

Psychosom Med. 2004 Jan-Feb;66(1):148-52; author reply 148-52.

**OBJECTIVE:** The underlying changes in biological processes that are associated with reported changes in mental and physical health in response to meditation have not been systematically explored. We performed a randomized, controlled study on the effects on brain and immune function of a well-known and widely used 8-week clinical training program in mindfulness meditation applied in a work environment with healthy employees.

**METHODS:** We measured brain electrical activity before and immediately after, and then 4 months after an 8-week training program in mindfulness meditation.

Twenty-five subjects were tested in the meditation group. A wait-list control group (N = 16) was tested at the same points in time as the meditators. At the end of the 8-week period, subjects in both groups were vaccinated with influenza vaccine.

**RESULTS:** We report for the first time significant increases in left-sided anterior activation, a pattern previously associated with positive affect, in the meditators compared with the nonmeditators. We also found significant increases in antibody titers to influenza vaccine among subjects in the meditation compared with those in the wait-list control group. Finally, the magnitude of increase in left-sided activation predicted the magnitude of antibody titer rise to the vaccine.

**CONCLUSIONS:** These findings demonstrate that a short program in mindfulness meditation produces demonstrable effects on brain and immune function. These findings suggest that meditation may change brain and immune function in positive ways and underscore the need for additional research.

PMID: 12883106 [PubMed - indexed for MEDLINE]

136. Neurosci Lett. 2002 Sep 20;330(2):143-6.

Non-linear dynamic complexity of the human EEG during meditation.

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We used non-linear analysis to investigate the dynamical properties underlying the EEG in the model of Sahaja Yoga meditation. Non-linear dimensional complexity (DCx) estimates, indicating complexity of neuronal computations, were analyzed in 20 experienced meditators during rest and meditation using 62-channel EEG. When compared to rest, the meditation was accompanied by a focused decrease of DCx estimates over midline frontal and central regions. By contrast, additionally computed linear measures exhibited the opposite direction of changes: power in the theta-1 (4-6 Hz), theta-2 (6-8 Hz) and alpha-1 (8-10 Hz) frequency bands was increased over these regions. The DCx estimates negatively correlated with theta-2 and alpha-1 and positively with beta-3 (22-30 Hz) band power. It is suggested that meditative experience, characterized by less complex dynamics of the EEG, involves 'switching off' irrelevant networks for the maintenance of focused internalized attention and inhibition of inappropriate information. Overall, the results point to the idea that dynamically changing inner experience during meditation is better indexed by a combination of non-linear and linear EEG variables.

PMID: 12231432 [PubMed - indexed for MEDLINE]

137. Brain Res Cogn Brain Res. 2002 Apr;13(2):255-9.

Increased dopamine tone during meditation-induced change of consciousness.

Kjaer TW, Bertelsen C, Piccini P, Brooks D, Alving J, Lou HC.

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This is the first *in vivo* demonstration of an association between endogenous neurotransmitter release and conscious experience. Using <sup>11</sup>C-raclopride PET we demonstrated increased endogenous dopamine release in the ventral striatum during Yoga Nidra meditation. Yoga Nidra is characterized by a depressed level of desire for action, associated with decreased blood flow in prefrontal, cerebellar and subcortical regions, structures thought to be organized in open loops subserving executive control. In the striatum, dopamine modulates excitatory glutamatergic synapses of the projections from the frontal cortex to striatal neurons, which in turn project back to the frontal cortex via the pallidum and ventral thalamus. The present study was designed to investigate whether endogenous dopamine release

increases during loss of executive control in meditation. Participants underwent two <sup>11</sup>C-raclopride PET scans: one while attending to speech with eyes closed, and one during active meditation. The tracer competes with endogenous dopamine for access to dopamine D<sub>2</sub> receptors predominantly found in the basal ganglia. During meditation, <sup>11</sup>C-raclopride binding in ventral striatum decreased by 7.9%. This corresponds to a 65% increase in endogenous dopamine release. The reduced raclopride binding correlated significantly with a concomitant increase in EEG theta activity, a characteristic feature of meditation. All participants reported a decreased desire for action during meditation, along with heightened sensory imagery. The level of gratification and the depth of relaxation did not differ between the attention and meditation conditions. Here we show increased striatal dopamine release during meditation associated with the experience of reduced readiness for action. It is suggested that being in the conscious state of meditation causes a suppression of cortico-striatal glutamatergic transmission. To our knowledge this is the first time *in vivo* evidence has been provided for regulation of conscious states at a synaptic level.

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PMID: 11958969 [PubMed - indexed for MEDLINE]

138. Indian J Physiol Pharmacol. 2002 Apr;46(2):136-58.

Neurophysiological mechanisms of induction of meditation: a hypothetico-deductive approach.

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A detailed analysis of methods of induction of meditation and meditative experience encountered therein implicates involvement of several mechanisms in inducing 'meditative effect'. 'Efferent attenuation', 'sensory attenuation' and 'cognitive restructuring' appear three possible mechanisms employed in varying degree of combinations to produce the 'meditative effect' during different types of meditations. Using hypothetico-deductive approach, it is possible to generate a neural model for explaining the 'meditative effect'. Primarily, the meditation is produced by disengaged association cortices driven by thalamus or other older group of reticular nuclei. Secondarily, there may be involvement of some more

phylogenetically older structures depending upon depth and types of meditation. This model explains induction, maintenance and long-term effects of meditation.

PMID: 12500489 [PubMed - indexed for MEDLINE]

139. Neurosci Lett. 2001 Sep 7;310(1):57-60.

Human anterior and frontal midline theta and lower alpha reflect emotionally positive state and internalized attention: high-resolution EEG investigation of meditation.

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EEG spectral power and coherence estimates in the individually defined delta, theta, alpha-1, alpha-2, and alpha-3 bands were used to identify and characterize brain regions involved in meditative states, in which focused internalized attention gives rise to emotionally positive "blissful" experience. Blissful state was accompanied by increased anterior frontal and midline theta synchronization as well as enhanced theta long-distant connectivity between prefrontal and posterior association cortex with distinct "center of gravity" in the left prefrontal region (AF3 site). Subjective scores of emotional experience significantly correlated with theta, whereas scores of internalized attention with both theta and alpha lower synchronization. Our results propose selective associations of theta and alpha oscillating networks activity with states of internalized attention and positive emotional experience.

PMID: 11524157 [PubMed - indexed for MEDLINE]

140. Brain Res Cogn Brain Res. 2001 Apr;11(2):281-7.

Frontal midline theta rhythm is correlated with cardiac autonomic activities during the performance of an attention demanding meditation procedure.

Kubota Y, Sato W, Toichi M, Murai T, Okada T, Hayashi A, Sengoku A.

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Frontal midline theta rhythm (Fm theta), recognized as distinct theta activity on EEG in the frontal midline area, reflects mental concentration as well as meditative state or relief from anxiety. Attentional network in anterior frontal lobes including anterior cingulate cortex is suspected to be the generator of this activity, and the regulative function of the frontal neural network over autonomic nervous system (ANS) during cognitive process is suggested. However no studies have examined peripheral autonomic activities during Fm theta induction, and interaction of central and peripheral mechanism associated with Fm theta remains unclear. In the present study, a standard procedure of Zen meditation requiring sustained attention and breath control was employed as the task to provoke Fm theta, and simultaneous EEG and ECG recordings were performed. For the subjects in which Fm theta activities were provoked (six men, six women, 48% of the total subjects), peripheral autonomic activities were evaluated during the appearance of Fm theta as well as during control periods. Successive inter-beat intervals were measured from the ECG, and a recently developed method of analysis by Toichi et al. (J. Auton. Nerv. Syst. 62 (1997) 79-84) based on heart rate variability was used to assess cardiac sympathetic and parasympathetic functions separately. Both sympathetic and parasympathetic indices were increased during the appearance of Fm theta compared with control periods. Theta band activities in the frontal area were correlated negatively with sympathetic activation. The results suggest a close relationship between cardiac autonomic function and activity of medial frontal neural circuitry.

PMID: 11275489 [PubMed - indexed for MEDLINE]

141. Biol Psychol. 2000 Nov;55(1):41-55.

Cortical plasticity, contingent negative variation, and transcendent experiences during practice of the Transcendental Meditation technique.

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This study investigated effects of transcendent experiences on contingent negative variation (CNV) amplitude, CNV rebound, and distraction effects. Three

groups of age-matched subjects with few (<1 per year), more frequent (10-20 per year), or daily self-reported transcendent experiences received 31 simple RT trials (flash (S(1))/tone (S(2))/button press) followed by 31 divided-attention trials - randomly intermixed trials with or without a three-letter memory task in the S(1)-S(2) interval). Late CNV amplitudes in the simple trials were smallest in the group with fewest, and largest in the group with most frequent transcendent experiences. Conversely, CNV distraction effects were largest in the group with fewest and smallest in the group with most frequent transcendent experiences (the second group's values were in the middle in each case). These data suggest cumulative effects of transcendent experiences on cortical preparatory response (heightened late CNV amplitude in simple trials) and executive functioning (diminished distraction effects in letter trials).

PMID: 11099807 [PubMed - indexed for MEDLINE]

142. Neuroreport. 2000 May 15;11(7):1581-5.

Functional brain mapping of the relaxation response and meditation.

Lazar SW, Bush G, Gollub RL, Fricchione GL, Khalsa G, Benson H.

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Meditation is a conscious mental process that induces a set of integrated physiologic changes termed the relaxation response. Functional magnetic resonance imaging (fMRI) was used to identify and characterize the brain regions that are active during a simple form of meditation. Significant ( $p<10(-7)$ ) signal increases were observed in the group-averaged data in the dorsolateral prefrontal and parietal cortices, hippocampus/parahippocampus, temporal lobe, pregenual anterior cingulate cortex, striatum, and pre- and post-central gyri during meditation. Global fMRI signal decreases were also noted, although these were probably secondary to cardiorespiratory changes that often accompany meditation. The results indicate that the practice of meditation activates neural structures involved in attention and control of the autonomic nervous system.

PMID: 10841380 [PubMed - indexed for MEDLINE]

143. Clin Electroencephalogr. 2000 Jan;31(1):13-22.

The treatment of addictive disorders by brain wave biofeedback: a review and suggestions for future research.

Trudeau DL.

University of Minnesota, Academic Health Center, Department of Family Practice and Community Health and Minneapolis Veterans Affairs Medical Center, USA.

PMID: 10638348 [PubMed - indexed for MEDLINE]

144. Semin Gastrointest Dis. 1999 Jan;10(1):14-9.

Stress and mind-body impact on the course of inflammatory bowel diseases.

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At present, the medical management of inflammatory bowel diseases (IBD) including Crohn's disease and ulcerative colitis, are focused on topical, locally active antiinflammatories and systemic immunosuppressives, which are thought to exert their targeted effects in the gastrointestinal mucosa. There is a paucity of controlled trials assessing the impact of mind, central nervous system (CNS), and neuromodulation on the overly active immune response in the intestinal mucosa. Patients and their physicians have long been aware of a strong association between attitude, stress, and flares of their IBD. Although reports to date remain mostly anecdotal, the degree to which mind-body influences and stress impact levels of local inflammation deserves closer attention with the aim of identifying contributing mechanisms, which may highlight new therapeutic interventions, as well as assist in identifying particular subsets of patients that may respond to novel forms of adjunctive treatments for IBD, including hypnosis, meditation, neuropeptide receptor modulation, and cortisol-releasing factor (CRF) modulation.

PMID: 10065768 [PubMed - indexed for MEDLINE]

145. Altern Ther Health Med. 1998 Sep;4(5):44-52, 54-60, 62.

Heart-focused attention and heart-brain synchronization: energetic and physiological mechanisms.

Song LZ, Schwartz GE, Russek LG.

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CONTEXT: Many relaxation, meditation, and imagery techniques that implicitly or explicitly involve focused attention on the body, including qigong, massage, and noncontact therapeutic touch, purportedly employ energetic and physiological mechanisms.

OBJECTIVE: To show that, from a perspective of dynamical energy systems, relaxed self-attention enhances connectivity between the brain and body. This enhanced connectivity may be achieved by at least 2 mechanisms: (1) physiological mechanisms employing peripheral negative feedback loops, and (2) bioelectromagnetic mechanisms involving direct energetic resonance between the peripheral organ and the brain.

DESIGN: 19 channels of electroencephalogram, 1 electrocardiogram, and 2 channels of electro-oculogram were recorded from 22 subjects who focused their attention on their heartbeats or eye movements, with and without kinesthetic (touch) biofeedback to increase somatic awareness.

RESULTS: Analyses of the electroencephalogram synchronized with the electrocardiogram revealed significant effects for heart-focused attention, primarily with touch biofeedback, following the contraction of the ventricles (possibly reflecting increased baroreceptor and somatosensory feedback); and significant effects for heart-focused attention, with and without touch biofeedback, preceding the contraction of the ventricles (possibly reflecting direct electromagnetic interactions between the heart and the brain).

CONCLUSIONS: These findings suggest that energetic and physiological mechanisms may be involved in techniques in which the goal is to promote mind-body integration and health.

PMID: 9737031 [PubMed - indexed for MEDLINE]

146. Int J Neurosci. 1984 Nov;24(3-4):217-31.

Electrocortical activity and related phenomena associated with meditation practice: a literature review.

Delmonte MM.

The state effects of meditation appear to include decreased electrocortical arousal. There is also evidence that meditators more readily demonstrate alpha and theta activity than nonmeditators, even when not meditating. It is not clear whether prospective meditators as a group already possessed this characteristic, or whether the state effects of meditation practice eventually generalize to become traits. However, certain individuals, namely the psychologically "healthy" and those with a capacity for relaxed absorbed attention, appear to be more favourably disposed to meditation. Meditators appear to show both stronger orienting and recovery responses to stressors while meditating than controls. Meditation practice may begin with left hemisphere type activity, which gives way to functioning more characteristic of the right hemisphere. However, it appears that during advanced meditation ("no thought") both left and right hemisphere activity are largely inhibited or suspended. Depending on the individual, inexperienced meditators may report sleep, hypnagogic reverie, trance or abreaction during practice. The evidence to date does not support the notion of unique state effects associated with the practice of meditation.

PMID: 6392127 [PubMed - indexed for MEDLINE]

147. Ann Neurol. 1982 Nov;12(5):475-8.

Voluntary alteration of visual evoked potentials.

Bumgartner J, Epstein CM.

Fifteen normal adults had pattern-shift visual evoked potentials (PSVEPs) using monocular checkerboard pattern reversal. Subjects were instructed to concentrate on the pattern in the first set of trials and then to avoid perceiving it in the second set. Direct, continuous visual observation ensured that the eye remained open and fixed on the pattern. Nonetheless, a third of the subjects could spontaneously alter or obliterate the PSVEP using several maneuvers, including meditation, daydreaming, and convergence. Several could produce shifts in apparent PSVEP latency. With explicit instruction, most subjects could learn to alter their PSVEP by maneuvers that are inapparent even to an observant technician.

PMID: 7181452 [PubMed - indexed for MEDLINE]

148. Rev Electroencephalogr Neurophysiol Clin. 1979 Jul-Sep;9(3):221-7.

[Evoked potentials and vigilance states induced during the course of choice reaction time tests].

[Article in French]

Banquet JP, Bourzeix JC, Lesèvre N.

Characteristics of Visual Evoked Potentials (N120, P200, P300) were investigated during choice reaction time situations in a group of 10 subjects practising meditation (E.S.) versus a matched control group (C.S.). During a series of visual stimuli occurring at fixed intervals, with 10% random omissions, the subjects were asked : 1) to respond by a finger displacement to each visual stimulus; 2) to hold on the response to the stimulus and to respond to omission. Both tasks were recorded before and after the practice of meditation or rest for the controls. The intergroup comparison showed that the experimental subjects had faster RT's with less mistakes, and N120 and P200 of larger amplitude and shorter latency. These differences were significant before and after meditation. The transient effects of meditation or rest, were opposite for the two groups : whereas after meditation the RT's became longer with less mistakes, and the amplitude of P300 larger, after rest there was a decrease of the P300 amplitude and no change in the RT's of the controls. These results are interpreted in terms of selective attention capacity and information processing strategies, A.S.C. being used as a model for the study of these processes.

PMID: 392646 [PubMed - indexed for MEDLINE]

149. Electroencephalogr Clin Neurophysiol. 1978 Nov;45(5):671-3.

Auditory evoked potentials and transcendental meditation.

Barwood TJ, Empson JA, Lister SG, Tilley AJ.

Auditory evoked potentials to tone stimuli were recorded from 8 practised meditators before, during, and after meditation, and also during light sleep. No consistent changes were noted between baseline and meditating AEPs, or between meditating and sleep AEPs.

PMID: 81770 [PubMed - indexed for MEDLINE]

150. Acta Psiquiatr Psicol Am Lat. 1975 Mar;21(1):56-63.

[Recent medical research on yoga and states of concentration].

[Article in Spanish]

Lerner M.

Traditional oriental thinking attracts the growing scientific interest of occidental practitioners. Dr. Pierre Etévenon, head of the Department of Neuro-Psycho-Pharmacology at the French Institute for Health and Medical Research (INSERM), held several conversations and scientific exchanges with the author, and kindly provided copies of some of his works. They are at the basis of the present paper. M. A. Descamps (Paris) found that asanas--yoga postures-- are generators of dynamic action when there is an extension of the spinal column, whilst they lead to quiet states when there is a flexion of it. Claeys and Gones (Belgium) proved that overall global relaxation, as well as differential relaxation were far more effective and deep when obtained by yogis than those attempted by University students majoring in Physical Education. Lonsdorfer and Nussbaum (France) studied several parameters concerning hatha-yoga and concluded that it provides a regular functioning of the main bodily functions fostering thus a psycho-physical balance. Wallace and Benson (U.S.A.) proved that transcendental meditation increases aerobic metabolism, counteracting anaerobic metabolism which is related to mental distress. Etévenon (Paris) investigated neurophysiological effects of yoga in connection to ancient Indian concepts (Upanishads) on sleeping, meditation and degree of consciousness. Dr. Etévenon has studied the phylogenetic evolution of waking-sleeping cycles, focusing on phylogenetic and ontogenetic appearances of REM cycles (activated sleep). A correlation has been made with EEG studies during states of concentration (yoga, transcendental meditation, Zen). These states have been found to be specific brain activities, and different from deep sleep, in spite of certain similarities in the EEG. Several hypothesis are set forth to explain brain activities underlying sites of concentration. The possibilities of developing a conscious mastering of dreams are also under research, and special attention is paid to the works of Saint Denys (1867), and hindu tradition. This paper discusses also the psychological, therapeutic and anthropological implications of recent discoveries in the field.

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