

By: Matthew Evrard, Rushing to Yoga Foundation

References for Research on Meditation with Abstracts**By Matthew Evrard, M.A. Candidate****San Diego State University****And****Research Associate, Rushing to Yoga Foundation*****Assessing Regulation Skills***

Baer, R. A., Smith, G. T., Lykins, E., Button, D., Krietemeyer, J., Sauer, S., Williams, J. M. G. (2008). Construct validity of the five facet mindfulness questionnaire in meditating and nonmeditating samples. *Assessment*, 15(3), 329-342.

Previous research on assessment of mindfulness by self-report suggests that it may include five component skills: observing, describing, acting with awareness, nonjudging of inner experience, and nonreactivity to inner experience. These elements of mindfulness can be measured with the Five Facet Mindfulness Questionnaire (FFMQ). The authors investigated several aspects of the construct validity of the FFMQ in experienced meditators and nonmeditating comparison groups. Consistent with predictions, most mindfulness facets were significantly related to meditation experience and to psychological symptoms and well-being. As expected, relationships between the observing facet and psychological adjustment varied with meditation experience. Regression and mediation analyses showed that several of the facets contributed independently to the prediction of well-being and significantly mediated the relationship between meditation experience and well-being. Findings support the construct validity of the FFMQ in a combination of samples not previously investigated.

Sauer, S., Walach, H., Schmidt, S., Hinterberger, T., Lynch, S., Büssing, A., & Kohls, N. (2013). Assessment of mindfulness: Review on state of the art. *Mindfulness*, 4(1), 3-17. doi: 10.1007/s12671-012-0122-5

Although alternative methods have been proposed, mindfulness is predominantly measured by means of self-assessment instruments. Until now, several scales have been published and to some degree also psychometrically validated. The number of scales reflects the widespread research interest. While some authors have started to compare the underlying concepts and operationalizations of these scales, up to now no overview has been presented describing, contrasting, and evaluating the different methodological approaches towards measuring mindfulness including questionnaires and alternative approaches. In light of this, the present article summarizes the state of mindfulness measurement. Recommendations on how current measurement practice may be improved are provided, as well as recommendations as to what measurement instruments are deemed to be most appropriate for a particular research context.

Regulation Skills in relation to Neuroscience

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Alvarez, J., & Emory, E. (2006). Executive function and the frontal lobes: A meta-analytic review. *Neuropsychology Review*, 16(1), 17-42. doi: 10.1007/s11065-006-9002-x

Currently, there is debate among scholars regarding how to operationalize and measure executive functions. These functions generally are referred to as “supervisory” cognitive processes because they involve higher level organization and execution of complex thoughts and behavior. Although conceptualizations vary regarding what mental processes actually constitute the “executive function” construct, there has been a historical linkage of these “higher-level” processes with the frontal lobes. In fact, many investigators have used the term “frontal functions” synonymously with “executive functions” despite evidence that contradicts this synonymous usage. The current review provides a critical analysis of lesion and neuroimaging studies using three popular executive function measures (Wisconsin Card Sorting Test, Phonemic Verbal Fluency, and Stroop Color Word Interference Test) in order to examine the validity of the executive function construct in terms of its relation to activation and damage to the frontal lobes. Empirical lesion data are examined via meta-analysis procedures along with formula derivatives. Results reveal mixed evidence that does not support a one-to-one relationship between executive functions and frontal lobe activity. The paper concludes with a discussion of the implications of construing the validity of these neuropsychological tests in anatomical, rather than cognitive and behavioral, terms.

Brefczynski-Lewis, J. A., Lutz, A., Schaefer, H. S., Levinson, D. B., & Davidson, R. J. (2007). Neural correlates of attentional expertise in long-term meditation practitioners. *Proceedings of the National Academy of Sciences*, 104(27), 11483-11488.

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.

Brewer, J., Davis, J., & Goldstein, J. (2013). Why is it so hard to pay attention, or is it? mindfulness, the factors of awakening and reward-based learning. *Mindfulness*, 4(1), 75-80. doi: 10.1007/s12671-012-0164-8



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Though relatively new to Western psychological and spiritual cultures, mindfulness training is becoming more widespread in the general public and is beginning to show promise therapeutically for maladies ranging from generalized stress to specific addictions. However, difficulties remain both with individuals being able to learn core concepts and techniques, such as concentration meditation, and more broadly, with treatment interventions not being optimized to helping individuals learn these. In this manuscript, we examine possible contributing factors to these difficulties. We bring together what is known scientifically about basic learning processes such as operant conditioning with some inspirational suggestions drawn from the early Buddhist dialogues collected in the Theravada Buddhist canon, in particular the description of seven psychological factors known as “the factors of awakening”. Bringing together scientific and textual suggestions, we give an overview of how primary operant conditioning processes lead to stress, and importantly, how a minor shift in emphasis in providing mindfulness training may indeed co-opt these very processes for the reduction and cessation of stress and suffering. Finally, we provide suggestions as to how these can be tracked individually and clinically over time.

Bush, G., Luu, P., & Posner, M. I. (2000). Cognitive and emotional influences in anterior cingulate cortex. *Trends in Cognitive Sciences*, 4(6), 215-222.

Anterior cingulate cortex (ACC) is a part of the brain’s limbic system. Classically, this region has been related to affect, on the basis of lesion studies in humans and in animals. In the late 1980s, neuroimaging research indicated that ACC was active in many studies of cognition. The findings from EEG studies of a focal area of negativity in scalp electrodes following an error response led to the idea that ACC might be the brain’s error detection and correction device. In this article, these various findings are reviewed in relation to the idea that ACC is a part of a circuit involved in a form of attention that serves to regulate both cognitive and emotional processing. Neuroimaging studies showing that separate areas of ACC are involved in cognition and emotion are discussed and related to results showing that the error negativity is influenced by affect and motivation. In addition, the development of the emotional and cognitive roles of ACC are discussed, and how the success of this regulation in controlling responses might be correlated with cingulate size. Finally, some theories are considered about how the different subdivisions of ACC might interact with other cortical structures as a part of the circuits involved in the regulation of mental and emotional activity.

Carlin, E., & Ahrens, A. (2012). The effects of mindfulness and fear-inducing stimuli on avoidance behavior. *Mindfulness*, 1-6. doi: 10.1007/s12671-012-0177-3

Previous research has shown that those with anxiety disorders may avoid distressing emotions, which in turn may increase avoidance behavior and help to maintain anxiety symptoms. The current study used an analogue laboratory design to investigate whether engaging in a brief mindfulness induction may result in decreased avoidance behavior following a fear-inducing stimulus. Undergraduate students were randomly assigned to listen to a brief mindfulness induction or to a control audio designed to induce unfocused



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attention. They were then shown a fear-inducing or neutral film clip. Avoidance behavior was measured by the likelihood of quitting a frustrating math task. Of those participants watching the fear-inducing film clip, those in the mindfulness group were less likely to quit the frustrating task than those in the control audio group. There was no difference in persistence between the mindfulness and control groups after the neutral film. Perhaps mindfulness training can boost persistence after the experience of fear.

Chan, R. C. K., Shum, D., Touloupoulou, T., & Chen, E. Y. H. (2008). Assessment of executive functions: Review of instruments and identification of critical issues. *Archives of Clinical Neuropsychology*, 23(2), 201-216. doi: 10.1016/j.acn.2007.08.010

“Executive functions” is an umbrella term for functions such as planning, working memory, inhibition, mental flexibility, as well as the initiation and monitoring of action. The impairment of executive functions in various clinical groups is a topic of much debate, as are recent attempts to formulate the corresponding intervention and rehabilitation regimes of these dysfunctions. This article reviewed current theories of executive functions and their associated assessment instruments. In addition, it identified issues that are imperative for more accurate, sensitive, and specific assessment of various components of this construct. It is concluded that more research is needed to fractionate the executive system by assessing a wide range of functions and to verify their neuroanatomical correlates. Recently developed measurement models and technology may also facilitate a more ecologically and ethologically valid assessment for the specific needs of different individuals.

Chiesa, A., Calati, R., & Serretti, A. (2011). Does mindfulness training improve cognitive abilities? A systematic review of neuropsychological findings. *Clinical psychology review*, 31(3), 449-464.

Mindfulness meditation practices (MMPs) are a subgroup of meditation practices which are receiving growing attention. The present paper reviews current evidence about the effects of MMPs on objective measures of cognitive functions. Five databases were searched. Twenty three studies providing measures of attention, memory, executive functions and further miscellaneous measures of cognition were included. Fifteen were controlled or randomized controlled studies and 8 were case-control studies. Overall, reviewed studies suggested that early phases of mindfulness training, which are more concerned with the development of focused attention, could be associated with significant improvements in selective and executive attention whereas the following phases, which are characterized by an open monitoring of internal and external stimuli, could be mainly associated with improved unfocused sustained attention abilities. Additionally, MMPs could enhance working memory capacity and some executive functions. However, many of the included studies show methodological limitations and negative results have been reported as well, plausibly reflecting differences in study design, study duration and patients' populations. Accordingly, even though findings here reviewed provided preliminary evidence suggesting that MMPs could enhance cognitive functions, available



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evidence should be considered with caution and further high quality studies investigating more standardized mindfulness meditation programs are needed.

Eberth, J., & Sedlmeier, P. (2012). The effects of mindfulness meditation: A meta-analysis. *Mindfulness*, 3(3), 174-189. doi: 10.1007/s12671-012-0101-x

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

Greenberg, J., & Meiran, N. (2013). Is mindfulness meditation associated with “feeling less?”. *Mindfulness*, 1-6. doi: 10.1007/s12671-013-0201-2

Following previous research which has suggested that mindfulness meditators are less affected by emotional stimuli, the current study examined the hypothesis that mindfulness meditation is associated with decreased emotional engagement, by inducing moods and asking participants to generate as many autobiographical memories opposite in valence as possible. Experienced mindfulness meditators took twice as long as non-meditators to generate the first opposite mood memory yet generated the same total number of memories as non-meditators. Contrary to the initial hypothesis, results indicate that mindfulness may be associated with increased emotional engagement, increased contact with emotions, and rapid recovery from the emotional experience. The effect of mindfulness on implicit and explicit aspects of emotion is discussed, as well as potential implications for treatment of related disorders.



Gronick, W. S., Bridges, L.J., Connell, J.P. (1996). Emotion regulation in two-year-olds: Strategies and emotion expression in four contexts. *Child Development*, 67, 928-941.

A descriptive study of the modulation of negative emotion in the toddler period was conducted by examining expressions of negative emotion and the strategies used to reduce or change these expressions. 6 strategies were identified and evaluated in terms of their frequency of use in different situations, relations with emotional expressiveness, and cross-situational consistency, 37 2-year-olds were seen in 2 laboratory contexts (delay and separation) each with 2 variants. Emotion regulation strategies and emotional expressiveness were coded from video-tapes of children's behavior in these 4 situations. Findings suggest that active engagement was most commonly used and most negatively associated with child distress. Use of strategies varied by context, and there was more cross-situational consistency in use of strategies that were more negatively or positively associated with distress within a given context than in use of particular strategies without consideration of their within-context significance.

Hölzel, B. K., Carmody, J., Evans, K., Hoge, E. A., Dusek, J. A., Morgan, L., Pitman, R. K., & Lazar, S. W. (2010). Stress reduction correlates with structural changes in the amygdala. *Social Cognitive and Affective Neuroscience*, 5(1), 11-17.

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.

Hölzel, B. K., Carmody, J., Vangel, M., Congleton, C., Yerramsetti, S. M., Gard, T., & Lazar, S. W. (2011). Mindfulness practice leads to increases in regional brain gray matter density. *Psychiatry Research: Neuroimaging*, 191, 36-43.

Therapeutic interventions that incorporate training in mindfulness meditation have become increasingly popular, but to date little is known about neural mechanisms



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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.

Hölzel, B. K., Lazar, S. W., Gard, T., Schuman-Olivier, Z., Vago, D. R., & Ott, U. (2011). How does mindfulness meditation work? proposing mechanisms of action from a conceptual and neural perspective. *Association for Psychological Science*, 6(6), 537-559.

Cultivation of mindfulness, the nonjudgmental awareness of experiences in the present moment, produces beneficial effects on well-being and ameliorates psychiatric and stress-related symptoms. Mindfulness meditation has therefore increasingly been incorporated into psychotherapeutic interventions. Although the number of publications in the field has sharply increased over the last two decades, there is a paucity of theoretical reviews that integrate the existing literature into a comprehensive theoretical framework. In this article, we explore several components through which mindfulness meditation exerts its effects: (a) attention regulation, (b) body awareness, (c) emotion regulation (including reappraisal and exposure, extinction, and reconsolidation), and (d) change in perspective on the self. Recent empirical research, including practitioners' self-reports and experimental data, provides evidence supporting these mechanisms. Functional and structural neuroimaging studies have begun to explore the neuroscientific processes underlying these components. Evidence suggests that mindfulness practice is associated with neuroplastic changes in the anterior cingulate cortex, insula, temporo-parietal junction, fronto-limbic network, and default mode network structures. The authors suggest that the mechanisms described here work synergistically, establishing a process of enhanced self-regulation. Differentiating between these components seems useful to guide future basic research and to specifically target areas of development in the treatment of psychological disorders.

Jang, J. H., Jung, H. W., Kang, D. H., Byun, M. S., Kwon, S. J., Choi, C. H., & Kwon, J. S. (2011). Increased default mode network connectivity associated with meditation. *Neuroscience Letters*, 487, 358–362 .



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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 ($x\ y\ z = 3\ 39\ -21$) 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.

Kerr, E. C., Sacchet, M. D., Lazar, S. W., Moore, C. I., & Jones, S. R. (2013). Mindfulness starts with the body: Somatosensory attention and top-down modulation of cortical alpha rhythms in mindfulness meditation. *Frontiers in Human Neuroscience*, 7(12), 1-15.

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.



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Kozasa, E. H., Sato, J. R., Lacerda, S. S., Barreiros, M. A., Radvany, J., Russell, T. A., Sanches, L. G., & Mello, L. E. (2012). Meditation training increases brain efficiency in an attention task. *Neuroimage*, 59(1), 745-749.

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.

Lazar, S. W., Kerr, C. E., Wasserman, R. H., Gray, J. R., Greved, D. N., Treadway, M. T., McFarvey, M., & Quinn, B. T. (2005). Meditation experience is associated with increased cortical thickness. *Neuroreport*, 16(17), 1893-1897.

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.

Luberto, C., Cotton, S., & McLeish, A. (2012). Mindfulness skills and emotion regulation: The mediating role of coping self-efficacy. *Mindfulness*, 1-8.

We examined coping self-efficacy as one potential mediator of the relationship between four specific mindfulness skills (observing, describing, acting with awareness, and



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accepting without judgment) and emotion regulation difficulties. Participants were 180 undergraduate students (M age = 21.13; 71 % female; 82 % Caucasian) who completed self-report measures for course credit. Pearson correlations, independent samples t test, and ANOVAs were used to examine bivariate relationships between study variables. Simple mediation was examined in a path analysis framework by testing the indirect effect of mindfulness skills on emotion regulation difficulties through coping self-efficacy. Results indicated that a greater use of describing, acting with awareness, and accepting without judgment were associated with greater coping self-efficacy, and coping self-efficacy partially mediated the relationship between each of those skills and emotion regulation difficulties (indirect effects: b weight = -0.26 to -0.29 , $p < 0.01$). The mindfulness skill of observing was not related to coping self-efficacy or emotion regulation difficulties. Findings suggest that coping self-efficacy partially explains the relationships between mindfulness and emotion regulation difficulties. Clinicians administering mindfulness-based interventions should be aware of the role of coping self-efficacy in the relationship between mindfulness and emotion regulation.

Luders, E., Toga, A. W., Lepore, N., & Gaser, C. (2009). The underlying anatomical correlates of long-term meditation: Larger hippocampal and frontal volumes of gray matter. *Neuroimage*, 45(3), 672–678.

Although the systematic study of meditation is still in its infancy, research has provided evidence for meditation-induced improvements in psychological and physiological well-being. Moreover, meditation practice has been shown not only to benefit higher-order cognitive functions but also to alter brain activity. Nevertheless, little is known about possible links to brain structure. Using high-resolution MRI data of 44 subjects, we set out to examine the underlying anatomical correlates of long-term meditation with different regional specificity (i.e., global, regional, and local). For this purpose, we applied voxel-based morphometry in association with a recently validated automated parcellation approach. We detected significantly larger gray matter volumes in meditators in the right orbito-frontal cortex (as well as in the right thalamus and left inferior temporal gyrus when co-varying for age and/or lowering applied statistical thresholds). In addition, meditators showed significantly larger volumes of the right hippocampus. Both orbito-frontal and hippocampal regions have been implicated in emotional regulation and response control. Thus, larger volumes in these regions might account for meditators' singular abilities and habits to cultivate positive emotions, retain emotional stability, and engage in mindful behavior. We further suggest that these regional alterations in brain structures constitute part of the underlying neurological correlate of long-term meditation independent of a specific style and practice. Future longitudinal analyses are necessary to establish the presence and direction of a causal link between meditation practice and brain anatomy.

Lutz, A., Brefczynski-Lewis, J., Johnstone, T., & Davidson, R. J. (2008). Regulation of the neural circuitry of emotion by compassion meditation: effects of meditative expertise. *PLoS One*, 3(3), e1897. doi: 10.1371/journal.pone.0001897



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Recent brain imaging studies using functional magnetic resonance imaging (fMRI) have implicated insula and anterior cingulate cortices in the empathic response to another's pain. However, virtually nothing is known about the impact of the voluntary generation of compassion on this network. To investigate these questions we assessed brain activity using fMRI while novice and expert meditation practitioners generated a loving-kindness-compassion meditation state. To probe affective reactivity, we presented emotional and neutral sounds during the meditation and comparison periods. Our main hypothesis was that the concern for others cultivated during this form of meditation enhances affective processing, in particular in response to sounds of distress, and that this response to emotional sounds is modulated by the degree of meditation training. The presentation of the emotional sounds was associated with increased pupil diameter and activation of limbic regions (insula and cingulate cortices) during meditation (versus rest). During meditation, activation in insula was greater during presentation of negative sounds than positive or neutral sounds in expert than it was in novice meditators. The strength of activation in insula was also associated with self-reported intensity of the meditation for both groups. These results support the role of the limbic circuitry in emotion sharing. The comparison between meditation vs. rest states between experts and novices also showed increased activation in amygdala, right temporo-parietal junction (TPJ), and right posterior superior temporal sulcus (pSTS) in response to all sounds, suggesting, greater detection of the emotional sounds, and enhanced mentation in response to emotional human vocalizations for experts than novices during meditation. Together these data indicate that the mental expertise to cultivate positive emotion alters the activation of circuitries previously linked to empathy and theory of mind in response to emotional stimuli.

Lutz, A., Slagter, H. A., Dunne, J. D., & Davidson, R. J. (2008). Attention regulation and monitoring in meditation. *Trends in Cognitive Sciences*, 12(4), 163-169.

This article explores initial findings and the implications of neuroscientific research on meditation. Meditation is conceptualized here as a family of complex emotional and attentional regulatory training regimes developed for various ends, including the cultivation of well-being and emotional balance. The review focuses on the mental processes and the underlying neural circuitry that are critically involved in two styles of meditation. One style, Focused Attention (FA) meditation, entails the voluntary focusing of attention on a chosen object. The other style, Open Monitoring (OM) meditation, involves non-reactive monitoring of the content of experience from moment to moment. We discuss the potential regulatory functions of these practices on attention and emotion processes and their putative long-term impact on the brain and behavior.

Todd, R. M., Cunningham, W. A., Anderson, A. K., & Thompson, E. (2012). Affect-biased attention as emotion regulation. *Trends Cogn Sci*, 16(7), 365-372. doi: 10.1016/j.tics.2012.06.003

The affective biasing of attention is not typically considered to be a form of emotion regulation. In this article, we argue that 'affect-biased attention' – the predisposition to



attend to certain categories of affectively salient stimuli over others – provides an important component of emotion regulation. Affect-biased attention regulates subsequent emotional responses by tuning one’s filters for initial attention and subsequent processing. By reviewing parallel research in the fields of emotion regulation and affect-biased attention, as well as clinical and developmental research on individual differences in attentional biases, we provide convergent evidence that habitual affective filtering processes, tuned and re-tuned over development and situation, modulate emotional responses to the world. Moreover, they do so in a manner that is proactive rather than reactive.

Regulation Skills in Relation to Education

Gibbons, C., Felteau, M., Cullen, N., Marshall, S., Dubois, S., Maxwell, H., Bédard, M. (2012). Training clinicians to deliver a mindfulness intervention. *Mindfulness*, 1-6. doi: 10.1007/s12671-012-0170-x

Mindfulness-based cognitive therapy (MBCT) is a relatively new therapeutic approach that is rooted in mindfulness-based stress reduction and cognitive behavioral therapy. Leading MBCT requires a radically different method than other forms of group facilitation. We are currently conducting a multi-site, randomized controlled trial (RCT) of a mindfulness intervention for individuals with a traumatic brain injury where the development of the facilitators' capacity to provide the intervention is as important to the study as the RCT component itself. Thus, the first year of the study was devoted to training ten clinicians to deliver the intervention. The training included a 2-day retreat to introduce mindfulness, teleconferences, support from an experienced instructor and other facilitators within the group, a 5-day professional MBCT training program, and the development of a personal meditation practice. It culminated with trialing the intervention with “healthy” participants (e.g., friends, family, colleagues). Sessions from six facilitators were recorded and assessed by an external reviewer experienced in the delivery of MBCT who provided qualitative feedback. Four facilitators demonstrated consistency and adherence to the skills assessed. Upon completion of the trial intervention, 93.5 % of healthy group participants indicated that the classes were engaging or stimulating and 96.9 % reported that they used the skills acquired. We feel we provided a training program that remained flexible to the needs of the facilitators.

Gordon, W., Shonin, E., Sumich, A., Sundin, E., & Griffiths, M. (2013). meditation awareness training (mat) for psychological well-being in a sub-clinical sample of university students: A controlled pilot study. *Mindfulness*, 1-11. doi: 10.1007/s12671-012-0191-5

Mindfulness has been practiced in the Eastern world for over twenty-five centuries but has only recently become popular in the West. Today, interventions such as “Mindfulness-Based Cognitive Therapy” are used within the Western health setting and have proven to be successful techniques for reducing psychological distress. However, a limitation of such interventions is that they tend to apply the practices of mindfulness in an “out of context” manner. To overcome this, a newly formed Meditation Awareness



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Training (MAT) program focuses on the establishment of solid meditative foundations and integrates various support practices that are traditionally assumed to effectuate a more sustainable quality of well-being. The aim of this pilot study was to assess the feasibility and effectiveness of MAT for improving psychological well-being in a sub-clinical sample of higher education students with issues of stress, anxiety, and low mood. Utilizing a controlled design, participants of the study (n = 14) undertook an 8-week MAT program and comparisons were made with a control group (n = 11) on measures of self-assessed psychological well-being (emotional distress, positive affect, and negative affect) and dispositional mindfulness. Participants who received MAT showed significant improvements in psychological well-being and dispositional mindfulness over controls. MAT may increase emotion regulation ability in higher education students with issues of stress, anxiety, and low mood. Individuals receiving training in mindfulness meditation may benefit by engendering a broader, more ethically informed, and compassionate intention for their mindfulness practice.

Ramsburg, J., & Youmans, R. (2013). Meditation in the higher-education classroom: meditation training improves student knowledge retention during lectures. *Mindfulness*, 1-11. doi: 10.1007/s12671-013-0199-5

The cognitive skills required for successful knowledge retention may be influenced by meditation training. The current studies examined the effects of meditation on the knowledge retention of students. In three experimental studies, participants from three introductory psychology courses randomly received either brief meditation training or rest, listened to a class lecture, then took a post-lecture quiz that assessed students' knowledge of the lecture material. The results indicated that meditation improved students' retention of the information conveyed during the lecture in each of the three experiments. Mood, relaxation, and class interest were not affected by the meditation training. Limitations and implications are discussed.

Shapiro, S. L., Brown, K. W., & Astin, J. O. H. N. (2011). Toward the integration of meditation into higher education: A review of research evidence. *Teachers College Record*, 113(3), 493-528.

There is growing interest in the integration of meditation into higher education (Bush, 2006). This paper reviews empirical evidence related to the use of meditation to facilitate the achievement of traditional educational goals, to help support student mental health under academic stress, and to enhance education of the "whole person." Drawing on four decades of research conducted with two primary forms of meditation, we demonstrate how these practices may help to foster important cognitive skills of attention and information processing, as well as help to build stress resilience and adaptive interpersonal capacities. This paper also offers directions for future research, highlighting the importance of theory-based investigations, increased methodological rigor, expansion of the scope of education-related outcomes studied, and the study of best practices for teaching meditation in educational settings.



Regulation Skills in Relation to Diseases & Disorders

Beer, M., Ward, L., & Moar, K. (2013). The relationship between mindful parenting and distress in parents of children with an autism spectrum disorder. *Mindfulness*, 1-11. doi: 10.1007/s12671-012-0192-4

Parenting a child with an autism spectrum disorder (ASD) can be highly challenging. Extensive behaviour problems associated with the disorder may contribute to poor psychological health amongst parents. It is important to investigate factors that are related to parental well-being and that may be amenable to intervention. The current study investigated mindful parenting amongst parents of children with ASD. Participants (N = 28) completed a questionnaire about their child's behaviour problems, parental stress, depressive and anxiety symptoms and mindful parenting, along with open-ended questions about mindful parenting practices and general parenting experiences. Higher levels of mindful parenting were related to lower levels of depressive symptoms and stress. There was no relationship between mindful parenting and anxiety symptoms. Higher levels of child behaviour problems were associated with more severe parental depressive symptoms, anxiety symptoms and stress and lower levels of mindful parenting. Contrary to expectations, preliminary analyses using partial correlations indicated that mindful parenting did not mediate the relationship between child behaviour problems and parental distress. Thematic analysis of the open-ended mindful parenting questions yielded four main themes: examples of mindful parenting practices, specific strategies, advantages of mindful parenting and difficulties in adopting these practices. Three themes regarding general parenting experiences emerged: parent and family problems, positive feelings towards the child and parenting approaches. Mindful parenting may have benefits for parents' psychological health. Further research exploring the effectiveness of mindful parenting interventions is warranted.

Chapman, M., Hare, D., Caton, S., Donalds, D., McInnis, E., & Mitchell, D. (2013). The Use of Mindfulness with People with Intellectual Disabilities: a Systematic Review and Narrative Analysis. *Mindfulness*, 1-11. doi: 10.1007/s12671-013-0197-7

This paper presents a systematic review of the evidence on the effectiveness of mindfulness for people with intellectual disabilities. Primary studies published in the English language between 1980 and 2012 were identified from electronic databases, experts and citation tracking. Eleven relevant studies evaluating mindfulness training and practice were identified: seven studies with people with intellectual disabilities, two studies with staff members or teams and two studies with parents. The studies found improvements in aggression and sexual arousal for people with intellectual disabilities after mindfulness training. Training staff led to benefits for people with intellectual disabilities, decreased use of physical restraint for aggressive behaviour and increased job satisfaction. Training parents led to improved parental satisfaction and well-being and improved parent-child interactions. The reported positive findings suggest that service providers, people with intellectual disabilities and their families may want to consider mindfulness approaches. However, the findings have to be interpreted with caution due to methodological weaknesses identified in the studies. Further high-quality in-



research is needed before the reported improvements can be more confidently attributed to mindfulness

Goldin, P. R., & Gross, J. J. (2010). Effects of mindfulness-based stress reduction (MBSR) on emotion regulation in social anxiety disorder. *American Psychological Association, 10(1), 83-91.*

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.

Hale, L., Strauss, C., & Taylor, B. L. (2012). The Effectiveness and Acceptability of Mindfulness-Based Therapy for Obsessive Compulsive Disorder: A Review of the Literature. *Mindfulness, 1-8.*

Cognitive behaviour therapy (CBT) is the recommended psychological therapy for obsessive compulsive disorder (OCD). However, CBT is not a panacea with only moderate response rates and relatively high drop-out rates. A mindfulness-based approach could enable people to notice intrusive thoughts without attaching significance and meaning to them. The purpose of this paper is to establish a rationale for using mindfulness for OCD and then to review the evidence for mindfulness-based approaches for OCD and to address three questions: (1) is mindfulness-based therapy effective in reducing symptoms of OCD? (2) is mindfulness-based therapy acceptable to people diagnosed with OCD, and (3) if effective, what are the mechanisms of change following mindfulness-based therapy for OCD? An electronic literature search was conducted using six databases. The final papers selected for review consisted of four empirical studies investigating mindfulness techniques in the treatment of OCD. The four empirical research papers retrieved included two single case studies, one A-B-C replication case series and one quasi-randomised controlled trial of a mindfulness group. All of the studies reviewed found positive effects of mindfulness on symptoms of OCD. This



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literature review provides an early indication that mindfulness-based therapy has promise as an intervention for the treatment of OCD. However, the conclusions drawn are limited by the designs used in the studies. The largest, arguably most rigorous study to date was conducted among a non-clinical sample.

Haydicky, J., Wiener, J., Badali, P., Milligan, K., & Ducharme, J. M. (2012). Evaluation of a Mindfulness-based Intervention for Adolescents with Learning Disabilities and Co-occurring ADHD and Anxiety. *Mindfulness*, 1-14.

The current study evaluated the impact of a 20-week mindfulness training program on executive function (EF), internalizing and externalizing behavior and social skills in a clinical sample of adolescent boys with learning disabilities (LD). Integra Mindfulness Martial Arts (MMA) is a manualized group treatment program incorporating elements of mindfulness meditation, cognitive behavioral therapy (CBT), behavior modification and mixed martial arts. Adolescents (ages 12–18; n = 60) with LD were assigned to the MMA or wait list control group (WL). Adolescents and their parents completed standardized questionnaires before and after training. Subgroup analyses were conducted to investigate the impact of the intervention on youth with co-occurring attention deficit/hyperactivity disorder (ADHD) or anxiety. Compared to the WL group, MMA participants with co-occurring ADHD (14 MMA, 14 WL) improved on parent-rated externalizing behavior, oppositional defiant problems and conduct problems. Boys with elevated hyperactive/impulsive symptoms (12 MMA, 17 WL) improved on parent-rated social problems and monitoring skills. Boys with elevated inattentive symptoms (15 MMA, 18 WL) improved on parent-rated social problems. Boys with elevated anxiety (12 MMA, 17 WL) reported decreased anxiety. MMA shows promise as an alternative treatment option for youth with LD and co-occurring difficulties.

Kalill, K., Treanor, M., & Roemer, L. (2013). The importance of non-reactivity to posttraumatic stress symptoms: a case for mindfulness. *Mindfulness*, 1-8. doi: 10.1007/s12671-012-0182-6

Mindfulness has shown promise in the treatment of several disorders, but the empirical literature regarding mindfulness and post-traumatic stress symptoms is limited. The current study examined the relationship among self-reported levels of mindfulness facets and post-traumatic stress symptoms after controlling for negative affect, age, number of traumas, and years since the trauma occurred. Participants were 157 students at an urban commuter university who completed measures online and endorsed experiencing fear, horror, or helplessness during a potentially traumatic event. Participants were predominantly female (77 %) and ranged in age from 18 to 64 years (mean = 26, SD = 4.73). Results indicated that the ability to describe emotional experiences was uniquely associated with lower hyperarousal scores, while non-reactivity to inner experiences was uniquely associated with lower overall post-traumatic stress symptoms, as well as lower re-experiencing and hyperarousal scores. Results are discussed in terms of the potential for mindfulness as an intervention for post-traumatic stress symptoms.



Katz, D., & Toner, B. (2012). A Systematic Review of Gender Differences in the Effectiveness of Mindfulness-Based Treatments for Substance Use Disorders. *Mindfulness*, 1-14.

Substance use disorder (SUD) onset, trajectory, comorbidity, and outcome can differ greatly according to sex and gender. Mindfulness-based interventions are promising treatments for SUD; however, as of yet, no systematic review has organized the results of studies examining these treatments according to gender. The purpose of this review was to determine whether gender influences the efficacy and effectiveness of mindfulness-based treatments (MBTs) for substance use. A systematic review was conducted on journal databases, and out of 36 papers that met the criteria for inclusion, 6 included participant gender as a variable. Two papers based on one randomized controlled trial study failed to find gender differences in the efficacy of MBTs for substance use, though a number of quasi-experimental studies and case series did find that women gravitated more towards MBTs or that women may have benefitted more from mindfulness interventions. Overall, MBTs hold promise as treatments for SUD. Additional research on mindfulness-based interventions for SUDs is needed that includes gender as a variable.

Kristeller, J., Wolever, R., & Sheets, V. (2013). Mindfulness-based eating awareness training (mb-eat) for binge eating: A randomized clinical trial. *Mindfulness*, 1-16. doi: 10.1007/s12671-012-0179-1

Binge eating is characterized by significant imbalance in food intake regulation and is often comorbid with obesity and depression. Mindfulness-based approaches may reduce compulsive overeating, address associated behavioral and emotional dysregulation, and promote internalization of change. This randomized trial explored the efficacy of Mindfulness-Based Eating Awareness Training (MB-EAT), a 12-session group treatment, in comparison to a psychoeducational/cognitive-behavioral intervention (PECB) and a wait list control. MB-EAT incorporates sitting and guided mindfulness practices to cultivate greater awareness of hunger and fullness cues, sensory-specific satiety, and emotional and other triggers for eating. The two-site study randomized 150 overweight or obese (body mass index = 40.3) individuals (12 % men; 14 % African-American/Hispanic; average age = 46.6 years), 66 % of whom met the full DSM-IV-R criteria for binge eating disorder (BED). Compared to the wait list control, MB-EAT and PECB showed generally comparable improvement after 1 and 4 months post-intervention on binge days per month, the Binge Eating Scale, and depression. At 4 months post-intervention, 95 % of those individuals with BED in MB-EAT no longer met the BED criteria vs. 76 % receiving PECB; furthermore, binges that occurred were likely to be significantly smaller. Amount of mindfulness practice predicted improvement on a range of variables, including weight loss ($r = -0.38, p < 0.05$). Results suggest that MB-EAT decreased binge eating and related symptoms at a clinically meaningful level, with improvement related to the degree of mindfulness practice.



Lamis, D., & Dvorak, R. (2013). Mindfulness, nonattachment, and suicide rumination in college students: The mediating role of depressive symptoms. *Mindfulness*, 1-10. doi: 10.1007/s12671-013-0203-0

This study examined the relations among mindfulness, nonattachment, depressive symptoms, and suicide rumination in undergraduate college students ($N = 552$). Hypothesized pathways and mediation were tested using path analysis. As hypothesized, depressive symptoms were negatively associated with both mindfulness and nonattachment; and suicide rumination was negatively related to mindfulness and nonattachment, and positively associated with depressive symptoms. Moreover, the mindfulness–suicide rumination and nonattachment–suicide rumination associations were both in part, mediated by depressive symptoms. Implications for the improved treatment of young adults at risk for depression and suicidal behaviors are discussed.

Masuda, A., Hill, M. L., & Tone, E. B. (2012). The Role of Mindfulness and Disordered Eating Cognitions in Psychological Distress among College Females with Elevated Disordered Eating. *Mindfulness*, 1-7.

The present study investigated whether mindfulness and different forms of maladaptive eating-related cognitions (i.e., fear of gaining weight, belief that social approval is contingent on weight/appearance, and self-worth from feeling in control of eating) separately and independently accounted for unique variance in psychological distress among adult females with elevated eating pathology. Ethnically diverse nonclinical college females ($N = 738$) completed a web-based survey; data from 91 of these participants who endorsed elevated eating pathology were selected for analyses. Mindfulness and fear of gaining weight, but not self-worth or perceived importance of appearance for gaining social approval, accounted for unique variance in psychological distress after controlling for age, ethnicity and body mass index (BMI). The present study suggests that not all forms of disordered eating cognitions are uniquely associated with psychological distress among females with elevated eating pathology and that mindfulness is a useful concept for understanding psychological distress in this group.

Michalak, J., Burg, J., & Heidenreich, T. (2012). Don't Forget Your Body: Mindfulness, Embodiment, and the Treatment of Depression. *Mindfulness*, 1-10.

During the past decade, Mindfulness-Based Cognitive Therapy (MBCT) aiming at relapse prevention in depression has been developed and empirically tested. All exercises taught during MBCT are based on the development of a heightened awareness of one's body. The important role of the body is also stressed in a recently emerging interdisciplinary field of research termed 'embodiment.' This research program focuses on the interactions between bodily, cognitive, and emotional processes. Based on the obvious role of the body in MBCT and on the theoretical and empirical evidence highlighting the role of the body in emotional processes, we argue that considering embodied processes might be a useful perspective for research on the etiology of depression and for mechanisms of action in MBCT.



Miodrag, N., Lense, M., & Dykens, E. (2012). A pilot study of a mindfulness intervention for individuals with williams syndrome: Physiological outcomes. *Mindfulness*, 1-11. doi: 10.1007/s12671-012-0178-2

Mindfulness-based interventions have received little attention in the world of intellectual and developmental disabilities. No studies have assessed the role of mindfulness practice in relation to Williams syndrome (WS)—a neurodevelopmental disorder associated with high rates of anxiety, and attentional and social difficulties. Our aim was to demonstrate the feasibility of a mindfulness intervention for adults with Williams syndrome. We examined the physiological [salivary cortisol and alpha-amylase (sAA)] responses following a brief, 5-day mindfulness intervention in 24 individuals with WS. We also evaluated how their psychological (self-reported anxiety) and behavioral (parent/caregiver reports of somatic complaints and attention problems) states related to these physiological outcomes. As a group, cortisol levels decreased each day following mindfulness sessions. Both cortisol and self-rated anxiety levels followed the same pattern across mindfulness sessions, with ratings declining in response to each session. sAA levels during sessions 1 and 2 were significantly higher than during sessions 4 and 5. Greater somatic problems significantly predicted higher cortisol levels during the mindfulness intervention, while greater CBCL Attention Problems significantly predicted lower sAA levels during the intervention. Our findings underscore the utility of mindfulness practice as a tool to reduce stress-related symptoms in persons with WS.

Perich, T., Manicavasagar, V., Mitchell, P. B., & Ball, J. R. (2012). Mindfulness-Based Approaches in the Treatment of Bipolar Disorder: Potential Mechanisms and Effects. *Mindfulness*, 1-6.

Mindfulness-based approaches are popular in the treatment of a variety of psychiatric disorders. This article examines how mindfulness-based inventions may assist in the management of bipolar disorder and in addressing common comorbidities, such as anxiety disorders. We also examine how mindfulness mediation may ameliorate cognitive deficits associated with bipolar disorder and reduce the impact of stress in managing day-to-day life events. Initial results of mindfulness-based cognitive therapy studies for those with bipolar disorder are promising; however, further research is needed to examine the efficacy of these approaches in the long term management of this disorder.

Localization of Function

Buckner, R. L., Andrews-Hanna, J. R., & Schacter, D. L. (2008). The brain's default network anatomy, function, and relevance to disease. *New York Academy of Sciences*, 1124, 1-38.

Thirty years of brain imaging research has converged to define the brain's default network—a novel and only recently appreciated brain system that participates in internal modes of cognition. Here we synthesize past observations to provide strong evidence that the default network is a specific, anatomically defined brain system preferentially active



when individuals are not focused on the external environment. Analysis of connective anatomy in the monkey supports the presence of an interconnected brain system. Providing insight into function, the default network is active when individuals are engaged in internally focused tasks including autobiographical memory retrieval, envisioning the future, and conceiving the perspectives of others. Probing the functional anatomy of the network in detail reveals that it is best understood as multiple interacting subsystems. The medial temporal lobe subsystem provides information from prior experiences in the form of memories and associations that are the building blocks of mental simulation. The medial prefrontal subsystem facilitates the flexible use of this information during the construction of self-relevant mental simulations. These two subsystems converge on important nodes of integration including the posterior cingulate cortex. The implications of these functional and anatomical observations are discussed in relation to possible adaptive roles of the default network for using past experiences to plan for the future, navigate social interactions, and maximize the utility of moments when we are not otherwise engaged by the external world. We conclude by discussing the relevance of the default network for understanding mental disorders including autism, schizophrenia, and Alzheimer's disease.

Paus, T. (2001). Primate anterior cingulate cortex: Where motor control, drive and cognition interface. *Nature Reviews Neuroscience*, 2, 417-424.

Controversy surrounds the function of the anterior cingulate cortex. Recent discussions about its role in behavioural control have centred on three main issues: its involvement in motor control, its proposed role in cognition and its relationship with the arousal/drive state of the organism. I argue that the overlap of these three domains is key to distinguishing the anterior cingulate cortex from other frontal regions, placing it in a unique position to translate intentions to actions.

Neuroplasticity

Ahissar, M., & Hochstein, S. (1997). Task difficulty and the specificity of perceptual learning. *Nature*, 387(6631), 401-406.

Practising simple visual tasks leads to a dramatic improvement in performing them. This learning is specific to the stimuli used for training. We show here that the degree of specificity depends on the difficulty of the training conditions. We find that the pattern of specificities maps onto the pattern of receptive field selectivities along the visual pathway. With easy conditions, learning generalizes across orientation and retinal position, matching the spatial generalization of higher visual areas. As task difficulty increases, learning becomes more specific with respect to both orientation and position, matching the fine spatial retinotopy exhibited by lower areas. Consequently, we enjoy the benefits of learning generalization when possible, and of fine grain but specific training when necessary. The dynamics of learning show a corresponding feature. Improvement begins with easy cases (when the subject is allowed long processing times) and only subsequently proceeds to harder cases. This learning cascade implies that easy conditions guide the learning of hard ones. Taken together, the specificity and dynamics suggest that learning proceeds as a countercurrent along the cortical hierarchy. Improvement begins at



higher generalizing levels, which, in turn, direct harder-condition learning to the subdomain of their lower-level inputs. As predicted by this reverse hierarchy model, learning can be effective using only difficult trials, but on condition that learning onset has previously been enabled. A single prolonged presentation suffices to initiate learning. We call this single-encounter enabling effect 'eureka'.

Anderson, B. J., Li, X., Alcantara, A. A., Isaacs, K. R., Black, J. E., & Greenough, W. T. (2004). Glial hypertrophy is associated with synaptogenesis following motor-skill learning, but not with angiogenesis following exercise. *Glia*, 11(1), 73-80.

Rats reared from weaning in a complex environment have an increase in 1) glial surface area, 2) capillary volume, and 3) the number of synapses, per neuron. In that paradigm it has not been possible to determine whether the glial increase more closely correlates with the increase in synaptic numbers or with angiogenesis. More recently we have found that rats that exercised had an increase in the density of capillaries without an increase in the synaptic numbers, whereas rats that learned new motor skills had a greater number of synapses per neuron without an increase in the density of capillaries. Those findings provided the opportunity to investigate whether changes in glial volume in the cerebellum correspond to changes in the number of synapses or in capillary volume. Glial area fraction estimates were obtained using point counts on electron micrographs from the previous studies. The skill learning group had a greater volume of molecular layer per Purkinje cell, and also a greater volume of glia per Purkinje cell, than rats in either an inactive group or rats in two exercise groups. No significant differences were found in glial volume per synapse and glial volume per capillary across groups, although there was a tendency for glial volume per capillary to be lower in the exercise groups. The data indicate that glial volume correlates with synaptic numbers and not with capillary density.

Draganski, B., Gaser, C., Busch, V., Schuierer, G., Bogdahn, U., & May, A. (2004). Neuroplasticity: changes in grey matter induced by training. *Nature*, 427(6972), 311-312.

Does the structure of an adult human brain alter in response to environmental demands^{1, 2}? Here we use whole-brain magnetic-resonance imaging to visualize learning-induced plasticity in the brains of volunteers who have learned to juggle. We find that these individuals show a transient and selective structural change in brain areas that are associated with the processing and storage of complex visual motion. This discovery of a stimulus-dependent alteration in the brain's macroscopic structure contradicts the traditionally held view that cortical plasticity is associated with functional rather than anatomical changes

Kilgard, M. P., Pandya, P. K., Vazquez, J., Gehi, A., Schreiner, C. E., & Merzenich, M. M. (2001). Sensory input directs spatial and temporal plasticity in primary auditory cortex. *Journal of Neurophysiology*, 86(1), 326-338.



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Neurons in the rat primary auditory cortex (A1) generally cannot respond to tone sequences faster than 12 pulses per second (pps). To test whether experience can modify this maximum following rate in adult rats, trains of brief tones with random carrier frequency but fixed repetition rate were paired with electrical stimulation of the nucleus basalis (NB) 300 to 400 times per day for 20–25 days. Pairing NB stimulation with 5-pps stimuli markedly decreased the cortical response to rapidly presented stimuli, whereas pairing with 15-pps stimuli significantly increased the maximum cortical following rate. In contrast, pairing with fixed carrier frequency 15-pps trains did not significantly increase the mean maximum following rate. Thus this protocol elicits extensive cortical remodeling of temporal response properties and demonstrates that simple differences in spectral and temporal features of the sensory input can drive very different cortical reorganizations.

Maguire, E. A., Gadian, D. G., Johnsrude, I. S., Good, C. D., Ashburner, J., Frackowiak, R. S. J., & Frith, C. D. (2000). Navigation-related structural change in the hippocampi of taxi drivers. *Proceedings of the National Academy of Sciences*, 97(8), 4398 – 4403.

Structural MRIs of the brains of humans with extensive navigation experience, licensed London taxi drivers, were analyzed and compared with those of control subjects who did not drive taxis. The posterior hippocampi of taxi drivers were significantly larger relative to those of control subjects. A more anterior hippocampal region was larger in control subjects than in taxi drivers. Hippocampal volume correlated with the amount of time spent as a taxi driver (positively in the posterior and negatively in the anterior hippocampus). These data are in accordance with the idea that the posterior hippocampus stores a spatial representation of the environment and can expand regionally to accommodate elaboration of this representation in people with a high dependence on navigational skills. It seems that there is a capacity for local plastic change in the structure of the healthy adult human brain in response to environmental demands.

Pittenger, C., & Duman, R. S. (2007). Stress, depression, and neuroplasticity: a convergence of mechanisms. *Neuropsychopharmacology*, 33(1), 88-109.

Increasing evidence demonstrates that neuroplasticity, a fundamental mechanism of neuronal adaptation, is disrupted in mood disorders and in animal models of stress. Here we provide an overview of the evidence that chronic stress, which can precipitate or exacerbate depression, disrupts neuroplasticity, while antidepressant treatment produces opposing effects and can enhance neuroplasticity. We discuss neuroplasticity at different levels: structural plasticity (such as plastic changes in spine and dendrite morphology as well as adult neurogenesis), functional synaptic plasticity, and the molecular and cellular mechanisms accompanying such changes. Together, these studies elucidate mechanisms that may contribute to the pathophysiology of depression. Greater appreciation of the convergence of mechanisms between stress, depression, and neuroplasticity is likely to lead to the identification of novel targets for more efficacious treatments.



Recanzone, G. H., Merzenich, M. M., Jenkins, W. M., Grajski, K. A., & Dinse, H. R. (1992). Topographic reorganization of the hand representation in cortical area 3b owl monkeys trained in a frequency-discrimination task. *Journal of Neurophysiology*, 67(5), 1031-1056.

Adult owl monkeys were trained to detect differences in the frequency of a tactile flutter-vibration stimulus above a 20-Hz standard. All stimuli were delivered to a constant skin site restricted to a small part of a segment of one finger. The frequency-difference discrimination performance of all but one of these monkeys improved progressively with training. 2. The distributed responses of cortical neurons ("maps") of the hand surfaces were defined in detail in somatosensory cortical area 3b. Representations of trained hands were compared with those of the opposite, untrained hand, and to the area 3b representations of hands in a second set of monkeys that were stimulated tactually in the same manner while these monkeys were attending to auditory stimuli (passive stimulation controls). 3. The cortical representations of the trained hands were substantially more complex in topographic detail than the representations of unstimulated hands or of passively stimulated control hands. 4. In all well-trained monkeys the representations of the restricted skin location trained in the behavioral task were significantly (1.5 to greater than 3 times) greater in area than were the representations of equivalent skin locations on control digits. However, the overall extents of the representations of behaviorally stimulated fingers were not larger than those of control fingers in the same hemisphere, or in opposite hemisphere controls. 5. The receptive fields representing the trained skin were significantly larger than receptive fields representing control digits in all but one trained monkey. The largest receptive fields were centered in the zone of representation of the behaviorally engaged skin, but they were not limited to it. Large receptive fields were recorded in a 1- to 2-mm-wide zone in the area 3b maps of trained hands. 6. Receptive-field sizes were also statistically significantly larger on at least one adjacent, untrained digit when compared with the receptive fields recorded on the homologous digit of the opposite hand. 7. There was an increase in the percent overlaps of receptive fields in the cortical zone of representation of the trained skin. A significant number of receptive fields were centered on the behaviorally trained skin site. 8. The effects of increased topographic complexity, increased representation of the trained skin location, increased receptive-field size, and increased receptive-field overlap were not observed in the representations of the untrained hands in these same monkeys. Only modest increases in topographic complexity were recorded in the representations of passively stimulated hands, and no effects on receptive-field size or overlap were noted.

Singer, W. (1995). Development and plasticity of cortical processing architectures. *Science*.

One of the basic functions of the cerebral cortex is the analysis and representation of relations among the components of sensory and motor patterns. It is proposed that the cortex applies two complementary strategies to cope with the combinatorial problem posed by the astronomical number of possible relations: (i) the analysis and representation



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of frequently occurring, behaviorally relevant relations by groups of cells with fixed but broadly tuned response properties; and (ii) the dynamic association of these cells into functionally coherent assemblies. Feedforward connections and reciprocal associative connections, respectively, are thought to underlie these two operations. The architectures of both types of connections are susceptible to experience-dependent modifications during development, but they become fixed in the adult. As development proceeds, feedforward connections also appear to lose much of their functional plasticity, whereas the synapses of the associative connections retain a high susceptibility to use-dependent modifications. The reduced plasticity of feedforward connections is probably responsible for the invariance of cognitive categories acquired early in development. The persistent adaptivity of reciprocal connections is a likely substrate for the ability to generate representations for new perceptual objects and motor patterns throughout life.

van Praag, H., Kempermann, G., & Gage, F. H. (2000). Neural consequences of environmental enrichment. *Nature Reviews Neuroscience*, 1(3), 191-198.

Neuronal plasticity is a central theme of modern neurobiology, from cellular and molecular mechanisms of synapse formation in *Drosophila* to behavioural recovery from strokes in elderly humans. Although the methods used to measure plastic responses differ, the stimuli required to elicit plasticity are thought to be activity-dependent. In this article, we focus on the neuronal changes that occur in response to complex stimulation by an enriched environment. We emphasize the behavioural and neurobiological consequences of specific elements of enrichment, especially exercise and learning.

Woollett, K., Spiers, H. J., & Maguire, E. A. (2009). Talent in the taxi: a model system for exploring expertise. *Philosophical Transactions of the Royal Society*, 364, 1407-1416.

While there is widespread interest in and admiration of individuals with exceptional talents, surprisingly little is known about the cognitive and neural mechanisms underpinning talent, and indeed how talent relates to expertise. Because many talents are first identified and nurtured in childhood, it can be difficult to determine whether talent is innate, can be acquired through extensive practice or can only be acquired in the presence of the developing brain. We sought to address some of these issues by studying healthy adults who acquired expertise in adulthood. We focused on the domain of memory and used licensed London taxi drivers as a model system. Taxi drivers have to learn the layout of 25 000 streets in London and the locations of thousands of places of interest, and pass stringent examinations in order to obtain an operating licence. Using neuropsychological assessment and structural and functional magnetic resonance imaging, we addressed a range of key questions: in the context of a fully developed brain and an average IQ, can people acquire expertise to an exceptional level; what are the neural signatures, both structural and functional, associated with the use of expertise; does expertise change the brain compared with unskilled control participants; does it confer any cognitive advantages, and similarly, does it come at a cost to other functions? By studying retired taxi drivers, we also consider what happens to their brains and



behaviour when experts stop using their skill. Finally, we discuss how the expertise of taxi drivers might relate to the issue of talent and innate abilities. We suggest that exploring talent and expertise in this manner could have implications for education, rehabilitation of patients with cognitive impairments, understanding individual differences and possibly conditions such as autism where exceptional abilities can be a feature.

Memory & Executive (Cognitive) Functions

Baddeley, A. D., & Hitch, G. (1986). Working memory.

The term working memory refers to a brain system that provides temporary storage and manipulation of the information necessary for such complex cognitive tasks as language comprehension, learning, and reasoning. This definition has evolved from the concept of a unitary short-term memory system. Working memory has been found to require the simultaneous storage and processing of information. It can be divided into the following three subcomponents: (i) the central executive, which is assumed to be an attentional-controlling system, is important in skills such as chess playing and is particularly susceptible to the effects of Alzheimer's disease; and two slave systems, namely (ii) the visuospatial sketch pad, which manipulates visual images and (iii) the phonological loop, which stores and rehearses speech-based information and is necessary for the acquisition of both native and second-language vocabulary.

Corcoran, K. A., Desmond, T. J., Frey, K. A., & Maren, S. (2005). Hippocampal inactivation disrupts the acquisition and contextual encoding of fear extinction. *The Journal of Neuroscience*, 25(39), 8978 – 8987.

In recent studies, inactivation of the dorsal hippocampus before the retrieval of extinguished fear memories disrupted the context-dependent expression of these memories. In the present experiments, we examined the role of the dorsal hippocampus in the acquisition of extinction. After pairing an auditory conditional stimulus (CS) with an aversive footshock [unconditional stimulus (US)], rats received an extinction session in which the CS was presented without the US. In experiment 1, infusion of muscimol, a GABAA receptor agonist, into the dorsal hippocampus before the extinction training session decreased the rate of extinction. Moreover, when later tested for fear to the extinguished CS, all rats that had received hippocampal inactivation before extinction training demonstrated renewed fear regardless of the context in which testing took place. This suggests a role for the dorsal hippocampus in both acquiring the extinction memory and encoding the CS– context relationship that yields the context dependence of extinction. In experiment 2, inactivation of the dorsal hippocampus before testing also disrupted the context dependence of fear to the extinguished CS. In experiment 3, quantitative autoradiography revealed the boundaries of muscimol diffusion after infusion into the dorsal hippocampus. Together, these results reveal that the dorsal hippocampus is involved in the acquisition, contextual encoding, and context-dependent retrieval of fear extinction. Learning and remembering when and where aversive events occur is essential for adaptive emotional regulation.



Dash, P. K., Hebert, A. E., & Runyan, J. D. (2004). A united theory for systems and cellular memory consolidation. *Brain Research Reviews*, 45, 30-37.

The time-limited role of the hippocampus for explicit memory storage has been referred to as systems consolidation where learning-related changes occur first in the hippocampus followed by the gradual development of a more distributed memory trace in the neocortex. Recent experiments are beginning to show that learning induces plasticity-related molecular changes in the neocortex as well as in the hippocampus and with a similar time course. Present memory consolidation theories do not account for these findings. In this report, we present a theory (the C theory) that incorporates these new findings, provides an explanation for the length of time for hippocampal dependency, and that can account for the apparent longer consolidation periods in species with larger brains. This theory proposes that a process of cellular consolidation occurs in the hippocampus and in areas of the neocortex during and shortly after learning resulting in long-term memory storage in both areas. For a limited time, the hippocampus is necessary for memory retrieval, a process involving the coordinated reactivation of these areas. This reactivation is later mediated by longer extrahippocampal connectivity between areas. The delay in hippocampal-independent memory retrieval is the time it takes for gene products in these longer extrahippocampal projections to be transported from the soma to tagged synapses by slow axonal transport. This cellular transport event defines the period of hippocampal dependency and, thus, the duration of memory consolidation. The theoretical description for memory consolidation presented in this review provides alternative explanations for several experimental observations and presents a unification of the concepts of systems and cellular memory consolidation.

Heeren, A., Van Broeck, N., & Philippot, P. (2009). The effects of mindfulness on executive processes and autobiographical memory specificity. *Behaviour research and therapy*, 47(5), 403-409.

Previous studies have found that mindfulness training reduces overgeneral memories and increases autobiographical memory specificity (e.g., [Williams, J. M. G., Teasdale, J. D., Segal, Z. V., & Soulsby, J. (2000). Mindfulness-based cognitive therapy reduces overgeneral autobiographical memory in formerly depressed patients. *Journal of Abnormal Psychology*, 109, 150-155]). However, little work has investigated the mechanisms underlying this effect. The present study explored the role of executive processes as a mediator of MBCT effects in an unselected sample. An autobiographical memory task, a cognitive inhibition task, a motor inhibition task, a cognitive flexibility task and a motor flexibility task were administered before and after intervention. Compared to matched controls, MBCT participants showed increased autobiographical memory specificity, decreased overgenerality, and improved cognitive flexibility capacity and capacity to inhibit cognitive prepotent responses. Mediation analyses indicated that changes in cognitive flexibility partially mediate the impact of MBCT on overgeneral memories. Results are discussed in terms of Conway's [2005. Memory and the self. *Journal of Memory and Language*, 53, 594-628] autobiographical memory model.



Jha, A. P., Stanley, E. A., Kiyonaga, A., Wong, L., & Gelfand, L. (2010). Examining the protective effects of mindfulness training on working memory capacity and affective experience. *Emotion, 10(1)*, 54.

We investigated the impact of mindfulness training (MT) on working memory capacity (WMC) and affective experience. WMC is used in managing cognitive demands and regulating emotions. Yet, persistent and intensive demands, such as those experienced during high-stress intervals, may deplete WMC and lead to cognitive failures and emotional disturbances. We hypothesized that MT may mitigate these deleterious effects by bolstering WMC. We recruited 2 military cohorts during the high-stress predeployment interval and provided MT to 1 (MT, n = 31) but not the other group (military control group, MC, n = 17). The MT group attended an 8-week MT course and logged the amount of out-of-class time spent practicing formal MT exercises. The operation span task was used to index WMC at 2 testing sessions before and after the MT course. Although WMC remained stable over time in civilians (n = 12), it degraded in the MC group. In the MT group, WMC decreased over time in those with low MT practice time, but increased in those with high practice time. Higher MT practice time also corresponded to lower levels of negative affect and higher levels of positive affect (indexed by the Positive and Negative Affect Schedule). The relationship between practice time and negative, but not positive, affect was mediated by WMC, indicating that MT-related improvements in WMC may support some but not all of MT's salutary effects. Nonetheless, these findings suggest that sufficient MT practice may protect against functional impairments associated with high-stress contexts.

Klingberg, T. (2010). Training and plasticity of working memory. *Trends in Cognitive Sciences, 14(7)*, 317.

Working memory (WM) capacity predicts performance in a wide range of cognitive tasks. Although WM capacity has been viewed as a constant trait, recent studies suggest that it can be improved by adaptive and extended training. This training is associated with changes in brain activity in frontal and parietal cortex and basal ganglia, as well as changes in dopamine receptor density. Transfer of the training effects to non-trained WM tasks is consistent with the notion of training-induced plasticity in a common neural network for WM. The observed training effects suggest that WM training could be used as a remediating intervention for individuals for whom low WM capacity is a limiting factor for academic performance or in everyday life.

Laroche, S., Davis, S., & Jay, T. M. (2000). Plasticity at hippocampal to prefrontal cortex synapses: dual roles in working memory and consolidation. *Hippocampus, 10(4)*, 438-446.

The involvement of the hippocampus and the prefrontal cortex in cognitive processes and particularly in learning and memory has been known for a long time. However, the specific role of the projection which connects these two structures has remained elusive.



By: Matthew Evrard, Rushing to Yoga Foundation

The existence of a direct monosynaptic pathway from the ventral CA1 region of the hippocampus and subiculum to specific areas of the prefrontal cortex provides a useful model for conceptualizing the functional operations of hippocampal-prefrontal cortex communication in learning and memory. It is known now that hippocampal to prefrontal cortex synapses are modifiable synapses and can express different forms of plasticity, including long-term potentiation, long-term depression, and depotentiation. Here we review these findings and focus on recent studies that start to relate synaptic plasticity in the hippocampo-prefrontal cortex pathway to two specific aspects of learning and memory, i.e., the consolidation of information and working memory. The available evidence suggests that functional interactions between the hippocampus and prefrontal cortex in cognition and memory are more complex than previously anticipated, with the possibility for bidirectional regulation of synaptic strength as a function of the specific demands of tasks.

Squire, L. R. (2004). Memory systems of the brain: A brief history and current perspective. *Neurobiology of Learning and Memory*, 82, 171-177.

The idea that memory is composed of distinct systems has a long history but became a topic of experimental inquiry only after the middle of the 20th century. Beginning about 1980, evidence from normal subjects, amnesic patients, and experimental animals converged on the view that a fundamental distinction could be drawn between a kind of memory that is accessible to conscious recollection and another kind that is not. Subsequent work shifted thinking beyond dichotomies to a view, grounded in biology, that memory is composed of multiple separate systems supported, for example, by the hippocampus and related structures, the amygdala, the neostriatum, and the cerebellum. This article traces the development of these ideas and provides a current perspective on how these brain systems operate to support behavior.

Squire, L. R. (1992). Memory and the hippocampus: A synthesis from findings with rats, monkeys, and humans. *Psychological Review*, 99(2), 195-231.

This article considers the role of the hippocampus in memory function. A central thesis is that work with rats, monkeys, and humans—which has sometimes seemed to proceed independently in 3 separate literatures—is now largely in agreement about the function of the hippocampus and related structures. A biological perspective is presented, which proposes multiple memory systems with different functions and distinct anatomical organizations. The hippocampus (together with anatomically related structures) is essential for a specific kind of memory, here termed *declarative memory* (similar terms include *explicit* and *relational*). Declarative memory is contrasted with a heterogeneous collection of nondeclarative (implicit) memory abilities that do not require the hippocampus (skills and habits, simple conditioning, and the phenomenon of priming). The hippocampus is needed temporarily to bind together distributed sites in neocortex that together represent a whole memory.

