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What role do changes in attentional skills play in the clinical benefits of mindfulness training?

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Content

Abstract

The practice of mindfulness meditation has increasingly been found to have effects on mental processes relevant to many psychological problems and disorders. The harnessing of attentional skills has a central role in historical accounts of this practice and has been proposed to be one of the central mechanisms through which the clinical benefits of this training occurs. I present an overview of studies that have investigated how this training affects our attentional skills. These have reported both behavioral improvements and alterations in brain structures involved in attention. When addressing the question of how improvements in attentional skills are involved in the observed clinical benefits of mindfulness training, the interplay of these skills with other core determinants for psychological health is also relevant. A central goal and feature of most modern psychotherapeutic approaches is the enhancing of emotional self-regulatory processes, and mindfulness seems to affect such capacities positively. However, the investigation of mindfulness and its effects pose some psychometrical challenges and other possible processes and mechanisms through which the demonstrated clinical effects could occur will also be discussed. A recent approach in which the human brain is viewed as intrinsically organized into dynamic, anticorrelated functional networks will be discussed as an alternative framework for understanding the role of attention in exerting clinical benefits.

Abstrakt

Det foreligger nå en økende mengde evidens for at trening i ”mindfulness” eller ”oppmerksomt nærvær” har en gunstig effekt på mentale prosser involvert i en rekke former for psykopatologi. Kultivering av oppmerksomhetsevner har en sentral plass i historiske nedtegnelser som omhandler denne buddhistiske meditasjonspraksisen og i de sekulariserte variantene av denne metoden slik de er integrert i vestlige behandlingsmodeller. Forbedring av fundamentale oppmerksomhetsevner blir også ansett som en av flere mulige sentrale mekanismer som kan forklare den virksomme prosessen og de positive resultatene. Det gis et overblikk over studier som har undersøkt hvordan trening i oppmerksomt nærvær har vist seg å påvirke slike fundamentale oppmeksomhetsevner. Blant disse rapporteres det om positive virkninger både på atferdsmessig- og nevropsykologisk nivå i kliniske og ikke-kliniske utvalg. For å kunne besvare hvorvidt forbedring av oppmerksomhetsevner kan anses som å spille en sentral rolle i de positive resultatene, vil også samspillet mellom slike evner og andre determinanter for psykisk helse ha relevans. Et sentralt mål i de fleste former for psykoterapi er å fremme evnen til å regulere affekter og trening i oppmerksomt nærvær viser seg å ha en gunstig effekt også på denne ferdigheten. Det knytter seg imidlertid en del psykometriske utfordringer til forskningen innen dette feltet. Andre mulige virksomme prosesser som kan ligge til grunn for den økende mengden av empirisk støtte for behandlingsmodeller som inkorporerer trening i oppmerksomt nærvær vil derfor kort diskuteres. Nyere tilnærminger for å forstå hjernens organisering hvor en anser hjernen som organisert i dynamiske, antikorrelerte nettverk vil også bli diskutert som et mulig rammeverk hvor en kan forstå hvorfor denne måten å dyrke oppmerksomhetsfunksjoner på gir seg utslag i forbedret psykisk helse.

1.0 Mindfulness training.

1.1 From eastern cultural roots to western psychological interventions.

The majority of research on mindfulness-based interventions has found that they are effective for both psychological and physical symptoms. Among psychological interventions incorporating mindfulness are Mindfulness-Based Stress Reduction (MBSR), Mindfulness-Based Cognitive Therapy (MBCT), Acceptance and Commitment Therapy (ACT), Dialectical Behavior Therapy (DBT) and variants of these approaches (Brown, Ryan & Creswell, 2007). Mindfulness enhancement is a central element in both MBSR and MBCT, while it is one of several key elements in ACT and DBT. Among these four approaches MBSR, which started to appear in medical and psychological literature 25 years ago, is considered more clearly rooted in eastern philosophy and psychology and has been the object of relatively more efficacy studies than the other interventions (Brown, Ryan & Creswell, 2007). In the MBSR approach mindfulness is most commonly defined as "paying attention, in a particular way, on purpose in the present moment and nonjudgmentally" (Kabat-Zinn, 1994, p.4). MBSR appears to be effective for chronic pain, anxiety disorders, general physiological well being, psoriasis and recurrent depression (Grossman, Niemann, Schmidt & Walach, 2004).

A next logical step after establishing that there are indeed clinical benefits of mindful-based interventions, is to search for the mechanisms through which these effects occurs. This has been attempted at levels of explanation ranging from mind to matter, from behavior, cognition and emotions to neuronal circuits and genes and the bidirectional influences between these levels. Although the investigation of the mechanisms through which the clinical benefits

manifest themselves are considered to be enriched by explorations from an introspectionistic, first person perspective, much is to be gained by complementing this research with a more objective third person scientific investigation (Moore et al, 2009). More precisely, we need to understand how harnessing attentional capacities through "paying attention a particular way, on purpose in the present moment and nonjudgmentally" affects attentional capacities which in themselves are central for psychological wellbeing and which also interact with other core determinants of psychological functioning, e.g., -regulation of emotion and affect.

Complementing the ancient eastern meditation practice of mindfulness with technological and methodological western advances makes it possible to discern how this training is related to functional and neural changes. The integration of psychology and the brain sciences in the investigation of the mechanisms of mindfulness can be seen for example in studies that use functional Magnetic Resonance Imaging (fMRI) to understand how this practice of a mindful awareness results in real neurobiological changes which are central for attentional functioning and over time can affect states and traits. Under this perspective, Buddhist meditation practice can be conceptualized in terms of mental or cognitive training that via neuroplasticity harnesses better attentional capacities (Lutz, Davidson & Dunne, in press).

In this paper I present an overview of the evidence from neurocognitive investigations of the effect of mindfulness meditation training, with emphasis on how this modulates the functioning of the attentional system.

1.2 The essence and cultural translation of mindfulness.

A challenge for western scientific inquiry is to avoid losing the essential features of the object of study – i.e., mindfulness meditation – that derives from its original religious and cultural

roots. Shapiro et al., (2006), argue that when western psychology attempted to extract the essence of mindfulness from its roots, the aspect of intention to some extent became lost. In Buddhism, the intention of mindfulness practice was enlightenment and compassion for all beings. For the person who is practicing mindfulness meditation, this intention is most often dynamic and evolving and often develops with deepening practice, awareness and insight and outcomes of the practice correlate with original intentions (Shapiro et al., 2006). For example, those whose goal was self-regulation, tend to attain self-regulation, so the consideration of why one practices meditation is important for understanding the process as a whole. Going back to the roots of mindfulness we also find that attentions role in attaining the goals with our mindfulness practice is central. Drawing on experience from earlier Indian contemplatives, the Buddha refined techniques for stabilizing and refining attention. Central premises for the method consisted in that "the mind is the primary source of human joy and misery", that "all phenomena are preceded by the mind" and that "when the mind is comprehended, all phenomena are comprehended" (Wallace, 2007, p.136). To be able to distinguish between the phenomena that are presented to the senses and the concepts we automatically impose upon them, training the mind is necessary and aims at stabilizing and refining attention. This in turn disciplines the mind as an instrument to investigate or examine mental objects, mental processes and the nature of consciousness (Wallace, 2007). Mindfulness and introspection are here seen as prerequisites for attaining attentional stability and vividness. Introspection function here as a quality control in the meditative process (Wallace, 2007).

The preconceptual, presymbolic nature of mindfulness and its embodied state all make its essence difficult to capture in word-based definitions. In western psychology it is often associated with the formal practice of mindfulness meditation, which has been called the heart

of Buddhist meditation. Mindfulness is however also inherently a state of consciousness and the practice can be seen as a scaffolding used to develop the state or skill of mindfulness (Shapiro et al., 2006). It can also be considered as an innate human capacity to deliberately pay full attention to where we are, to our actual experience and to learn from it (Hick & Bien, 2008). Central theorists like Kabat-Zinn, Shapiro, Schwartz, Bonner, Segal, Williams and Teasdale describe mindfulness as a nonelaborative, nonjudgmental, presentcentered awareness in which each thought, feeling, or sensation that arises in the attentional field is acknowledged (Hick & Bien, 2008). In traditional Buddhist texts essential features of mindfulness are described as "practice of bare attention, the attending to the bare facts of perception without reacting to them by deed, speech or mental comment…" (Hick & Bien, 2008). In a Zen metaphor the mindful state has been likened to that of a polished mirror simply reflecting what passes before it, not biased by conceptual thought. Mindfulness can thereby also be described as a certain quality of consciousness which emerges as a result of how one relates to the contents of that consciousness (thoughts, memories, impulses etc). Through mindfulness training one fosters a different way to relate to the contents of consciousness which is characterized by a more choiceful disengagement from conceptual thinking. This in turn prevents the thoughts and accompanying emotions to be colored by beliefs, prejudices and other biases (Brown, Ryan & Creswell, 2007). The development of attentional skills is a crucial component of mindfulness for the following reasons. A greater capacity for steadiness of awareness and attention will inhibit concepts, ideas and associated emotions from being automatically imposed onto the bare facts (Brown, Ryan & Creswell, 2007) and enhance the ability to return to an awareness of what is actually currently taking place. Fundamental to mindfulness is that it is present oriented. Although time travelling into the past and the future is adaptive in many instances, it can restrain current realities from being experienced as they actually are. The taking notice of not being present in the moment

is therefore an essential aspect of mindfulness. However note that being aware of what is occurring in the moment does not mean, and is considered conceptually distinct from, living for the moment (Brown, Ryan & Creswell, 2007). Another central feature of mindfulness consists in a flexibility of awareness and attention where one can switch between zeroing in on situational details and move back to gain a larger perspective, i.e., a choiceful alteration between focused attention and clear awareness. Through a participatory observation, awareness of the experiencing of thoughts, feeling, emotions etc. is parallel with being immersed in them (Brown, Ryan & Creswell, 2007).

Underlying assumptions of mindfulness as a concept and the MBSR approach are that humans often are operating on an "automatic pilot" mode and can be largely unaware of their moment to moment experience, that it is possible to gradually develop a capacity to sustain attention to mental content through regular practice. The unconscious reactiveness will in parallel be reduced and replaced by moment-to-moment awareness of experience laying the ground for a richer and more vital sense of life and give rise to more accurate perceptions of one's mental responses to external and internal stimuli. This mode of processing and the gathering of additional information have been found to facilitate effective action and to result in a greater sense of control (Grossman et al., 2004). Differentiation in the concept of wellness in which stress and ailments are considered natural elements which not excludes enjoyment of life is also a central resulting effect claimed to be manifest after training (Grossman et al., 2004). The techniques used to develop mindfulness can vary in the MBSR-approach, but all have in common teaching the participants to become more aware of thoughts and feelings and to change their relationship to them in which these are recognized as mental events rather than aspects of self or accurate reflections of reality (Bishop, 2002). The ability to step back from thoughts and feelings during stressful situations progresses with repeated practice and makes

the person less vulnerable for engaging in anxious worry or negative thinking patterns. This in turn will inhibit escalated cycles of stress reactivity and emotional distress (Bishop, 2002). All the techniques within the MBSR approach are taught after a same basic procedure but differ in objects of focus to sustain attention (Bishop, 2002).

1.0 Measuring mindfulness.

The increasing empirical evidence for the clinical benefits associated with mindfulness training has resulted not only in interest in the mechanisms through which the effects occur, but also in the need for psychometrically sound measures. A challenge consists however in translating mindfulness into concrete operational definitions as required by scientific methods and assessment. Diversity in the definitions, descriptions and instructions associated with mindfulness has resulted in a common agreement that it is most useful to consider it as a multifaceted construct. Among the instruments developed to measure the construct are measures of trait-like tendencies to be mindful and measures which assesses state mindfulness. Trait measures include The Freiburg Mindfulness Inventory, FMI, (Buchheld, Grossman, & Walach, 2001), Mindful Attention Awareness Scale, MAAS, (Brown & Ryan, 2003), the Kentucky Inventory of Mindfulness Skills, KIMS, (Baer et al., 2004), the Southampton Mindfulness Questionnaire, SMQ, (Chadwick, Hember, Mead, Lilley, & Dagnan, 2005), Philadelpia Mindfulness Scale (Cardaciotto, Herbert, Forman, Moitra, & Farrow, 2007) and the Five-Facet Mindfulness Questionnaire, FFMQ, (Baer et al., 2006). State-level measures include the Toronto Mindfulness Scale, TMS, (Lau et al., 2006). Subsets of the original MAAS have also been used as a trait measure in an experience sampling study in which participants were paged and asked to respond to the subset of this measure. In this

study the correlation between momentary-state mindfulness and baseline levels of mindfulness traits was investigated and found to be significant (Brown & Ryan, 2003).

The need for additional non-self report measures is increasingly acknowledged however. Schooler (2004) argues that the validity of these measures would be enhanced if they were shown to converge with more objective indicators of this particular subjective experience. To be able to answer the question of what role improved attentional capacities play in the clinical benefits of mindfulness training the combined use of the mindfulness measures and objective measures are essential. The combined use of neuroimaging-techniques such as fMRI , various measures of attentional performance and mindfulness measures facilitates a more objectively and scientific study of the possible mechanisms. The Attention Network Test, ANT (Fan, 2005) is one example of a test which assesses the efficiency of our attentional networks and has been used in combination with fMRI. The possibility to in fact have a look into the concomitant neural process in the brain during mindfulness practices makes it easier to find the central mechanisms and enhance the operationalization of mindfulness and the psychometrical quality of the research in this field. The more specific way these approaches have been combined in the search for central mechanisms in mindfulness will be commented on.

2.0 Defining mindfulness as an attentional skill in neurocognitive terms.

Mindfulness aims at enhancing attentional functions. This is reflected both in the definitions of the practice and in the task instructions given to participants. Usually these instructions initially involves bringing attention to an “attentional anchor” such as the breath, noting that distracters occurs and letting go of the distraction, and refocusing or reorienting attention back to the attentional anchor. Repeating this practice over time is in meditative texts

conceptualized as improving concentrative and receptive forms of attention. Cognitive neuroscience attempts to characterize these changes in terms of engaging and modifying the three principle subcomponents of the attentional system: alerting (or sustaining), orienting and executive control (Raz & Buhle, 2006). The three common agreed upon attentional functions correlate with different neural circuits (Fan et al., 2005) but are seen as cooperating and working together (Raz & Buhle, 2006). Reviews of mindfulness meditation in large support the notion that this form of meditation can be linked to all three attentional networks (Raz & Buhle, 2006; Brown, Ryan & Creswell, 2007).

3.1 How can concentrative and receptive attention as described in the meditation-literature be translated into neurocognitive models of attention?

Fan et al (2005) have studied performance on the ANT with functional MRI and they found that the receptive versus concentrative dichotomy described in meditative texts highly overlapped with activation patterns conceptualized in terms of dissociable dorsal and ventral attention systems. Based on behavioural, neuroimaging, lesion and electrophysical studies, Corbetta and Shulman (2002) propose that a bilateral dorsal frontoparietal system is involved in voluntary, top down orienting and that a right-lateralized ventral frontoparietal system is involved in stimulus-driven bottom-up attention. The voluntary dorsal system was found to be activated by presentation of cues indicating perceptual and response features of stimuli to which participants should direct their attention. In contrast, the involuntary ventral system showed activation in response to abrupt changes in sensory stimuli and detection of salient targets. Unexpected stimuli and stimuli outside the focus of attention and with low probability of occurrence were especially found to activate this ventral attention system (Corbetta & Shulman, 2002).

This dorsal/ ventral model is similar to Posner and Petersen (1990) tripartite model and, according to f (MRI) studies of the ANT (Fan et al 2005), activation patterns during alerting overlaps with the ventral system activity while orienting and conflict monitoring activates the dorsal system. The function and capacity for concentrative attention described in meditative texts is thereby analogous to the activation of the dorsal attention system described in Corbetta and Shulmans model and orienting and conflict monitoring in terms of Posner and Petersens (1990) model. Receptive capacity would in Corbetta and Shulmans (2002) terms be associated with activation of the ventral system and in Posner and Petersens (1990) terms the alerting network.

3.2 What can the study of meditation add to the field of attention research?

Although research in the field of attention has a long history, the inclusion of studies of atypical states of consciousness and attention are increasingly considered as informative in solving the questions which are still unanswered. Traditionally, attention has been studied within the framework of normal performance or of disease-related impairments. The inclusion of research on meditation and training related performance-improvements comes in combination with more recent findings within the field of neuroplasticity and advances in neuroimaging. Together these findings and techniques could be capable of accelerating our understanding of attention.

A fundamental questions still under investigation within the field of attention concerns how the “cross talk” between these systems operates, how one can alter the distribution of this limited form of information processing and how the alterations in attentional functions relate to aspects such as emotion regulation and other clinical benefits. The clinical benefits associated with mindfulness training have been increasingly documented (Brown, Ryan &

Creswell, 2007) and the synthesis of this training with knowledge of the associated neurophysiological and neuropsychological changes could inform about the possible role that changes in attentional skills have in the observed clinical benefits.

Functional changes are clinically interesting and relevant both on a state -and a trait level. State changes refers to the changes which occur while or immediately after meditation practice, while trait changes are those changes that occur gradually over time and are due to long-term transformations in brain activity and structure (Treadway & Lazar, in Didonna, 2009). Investigating mindfulness meditation and its effect on attentional functions can be seen as an extension of previous research demonstrating that the human brain is capable of plastic change in response to environmental stimulation. In this framework attentional capacities are considered as flexible skills and finding and implementing training-programs aimed at enhancing these capacities can be informed by studies that already have found training related changes.

3.0 Mindfulness training and its effect on attentional capacities.

4.1 Limitations, plasticity and effects of mindfulness training.

Attention is commonly considered a limited information processing ability. Some limitations however have been found to be amenable to changes through training (Slagter et al., 2007). The attentional blink deficit is one commonly studied example of a limitation in attentional capacity. When two visual targets embedded in a rapid stream of stimuli are presented in close temporal proximity, the second target is often not seen. This can be considered as a form of refractory period for target processing that arises due to limitations in attentional capacity at a response selection stage of processing. Slagter et al (2007) found that mental training in form of three months of Vipassana meditation, a variant of mindfulness meditation, increased

the control over limited attentional resources in the context of the attentional blink. The mental training appeared to reduce allocation of resources to the first target which increased the probability of detecting the second target and thereby reduced the attentional blink (Slagter et al., 2007). Those who showed the largest decrease in resources allocated to the first target generally showed the best ability to detect the second target. They found support for the view that the ability to detect the second target depends on the efficient deployment of resources to the first target. Simultaneously recorded electroencephalography (EEG) signals showed that those participants who performed best on the attentional blink task were those who exhibited the least amount of brain activity at the first stimulus. Not only did the training affect the allocation of resources to the first target, it also affected early second target elicited processes. Their results confirmed the view that controlling the distribution of attentional resources is a trainable skill and the usefulness of systematic mental training in enhancing information processing abilities was demonstrated.

Studies demonstrating cognitive and neural differences in attentional processing between experienced meditators and novices are in line with this view and these findings. Modulated functions in all the three attentional networks have been demonstrated after systematic mindfulness training (Brown, Ryan & Creswell, 2007) and the more precise effects that have been found will be presented next.

4.2 Mindfulness training and associated improvements in orienting and alerting subsystems of attention.

A commonly used test to assess improvements in attentional skills is the Attention Network Test (ANT) (Fan et al., 2002). This test was originally developed to provide a

measure of the efficacy of the three attentional networks associated with alerting, orienting and executive attention. Through examining the effects of cues and targets within a single reaction time task one can measure the efficacy of these three networks involved in attention. The combined use of the ANT and fMRI makes it possible to explore which brain areas are associated with the operation of these three networks. The ANT is a widely used test and is commonly administered to assess attentional capacities in both clinical and nonclinical populations (Fan et al., 2005).

The test has also increasingly been used to assess whether training results in improved functioning in subcomponents of attention. This was done in a study conducted by Jha, Krompinger & Baime (2006) who investigated how mindfulness training modulated functioning of the attentional systems. The hypothesis in this study was that mindfulness training could alter or enhance subcomponents of attention. The effect on the alerting and orienting attentional subsystems was investigated with the ANT (Attention Network Test) before and after mindfulness training. The effects of two types of mindfulness training were examined. One group of naïve meditators participated in an 8 week MBSR training program that emphasized concentrative skills. The other training group consisted of experienced meditators who took part in a 1 month intensive mindfulness retreat. The performances on the ANT test of these two training groups were compared to the performance of individuals in a control group who were meditation naïve and received no mindfulness training. After training, the MBSR training group had improved their orienting performance compared to before training while the experienced meditators had altered their alerting performance. The experienced meditators improved their capacity for exogenous stimuli detection compared to the individuals in the MBSR- training and the control group. This study demonstrated different forms of modulation of subcomponents of attentional functions related to amount of

experience when receiving/participating in this form of meditation training. Naive meditators participating in an eight week MBSR program improved their orienting performance, while experienced meditators participating in a one month intensive mindfulness retreat improved their alerting performance compared to before training. These findings match with the notion in meditative texts which describe a practice-related trajectory with an initial development of concentrative attention in the novice meditators and the cultivation of receptive attention in the more experienced meditators. As described under section 4.1, participants in the initial concentrative phase of meditation have been found to show activation patterns in brain regions which overlaps with structures and networks governing orienting and conflict monitoring attention. These were also those capacities found to be improved in the novices in this study. The more experienced meditators showed increased alerting performance after their mindfulness retreat which corresponds to the notion about improved receptive attention after more extensive mindfulness training.

One could argue that the proposed effects found in studies comparing expert and novice meditators are due to personality differences rather that practice. In a study conducted by Valentine and Sweet (1999) they found support for the contrary, that the effects was in fact a result of practice. In their study they found that experienced meditators performed superior to controls, short-term meditators and concentrative meditators on a test of sustained attention. The task consisted in counting rapidly-presented beeps which is a measure of sustained attention. All meditators were significantly better than the controls to detect all stimuli, which suggest that participants in the meditation groups had developed heightened attention. The mindfulness meditators however showed superior performance in comparison with concentrative meditators when the stimulus was unexpected. There was no difference between the two types of meditators when the stimulus was expected (Valentine & Sweet,

1999). The two meditation groups were also subdivided based on total number of meditation practice and subjects having more than 2 years of practice detected approximately 5 % more of the stimuli than the subjects with less than 2 years of practice. This last finding was taken as support for the notion that the effects were due to practice rather than to personality differences. The sample sizes in this study were quite small however (9-10 subjects per group).

4.3 The effect of mindfulness on cognitive flexibility.

The results in Jha, Krompinger & Baime's (2006) study suggest that receiving systematic mindfulness training as a meditation naive versus experienced meditator will lead to modulations in, respectively, orienting and alerting components of attention. An essential part of mindfulness training however consist in bringing ones complete attention to the present moment and re-invest attention back again to an attentional anchor after distraction has occurred. One would expect that this reorienting and reinvestment of attention would be highly dependent on attentional functions of conflict monitoring or executive control which are fundamental for cognitive flexibility. Cognitive flexibility has been defined as the ability to adapt cognitive processing strategies to face new and unexpected conditions and is intrinsically linked to attentional processes (Cañas, Quesada, Antolí & Fajardo, 2003; Moore & Malinowski, 2009). There are few studies examining the link between mindfulness training and enhancements in cognitive flexibility and these have shown ambiguous results.

Wenck-Sormaz (2005) found that meditation practice reduced habitual responding and Stroop interference. In a study conducted by Andersen et al (2007) however, eight weeks of MBSR-training were found to neither improve attentional functions in general, nor attention switching, nor Stroop interference. Important differences between these studies are both the

amount of time after practice which measures of the variables were administered and also that Anderson and colleagues used a modified version of the Stroop task. Reading is considered an automated process and the Stroop test (Stroop, 1935) is commonly considered to show the difficulty of interrupting the automatic process of reading words in proficient readers. Tasks in the Stroop test include attending to the colour in which words are printed, while ignoring the semantics of the words. The semantic activation of the word meaning must be overridden in order for participants to respond correctly when faced with incongruent words and colours. Improving reaction time performance in this task requires the re -investment of attention, deautomatisation and performing of non- habitual responses.

The link between mindfulness and cognitive flexibility has more recently been studied by Moore and Malinowski (2009) by administering a self report questionnaire that measures dispositional mindfulness, KIMS (Baer, Smith & Allen, 2004) in combination with the Stroop task and the d2-concentration and endurance test. The d2 concentration and endurance test (Brickenkamp, 1962) is a timed test for selective attention which allows for estimation of individual attention and concentration performance. It measures processing speed, rule-compliance, and quality of performance. Tasks consist in discriminating and selecting targets from visually similar non-targets. Two types of errors occur, errors of omission or errors of commission. In the KIMS participants rate the items in the test with respect to their general experience rather than to a specific time point. The items fall under the four subscales of observing, describing, acting with awareness and accepting without judgment.

The authors expected a reduction in Stroop interference as well as improvements in focused attention and processing speed in a group of Buddhist meditators experienced in mindfulness meditation compared to a meditation naive group. They also expected to find a positive

correlation between self-reported level of mindfulness (KIMS) and attentional performance and cognitive control. Findings confirmed these predictions. The experienced meditators performed significantly better on all attentional measures and correlations were of moderate to high strength. The positive correlations indicated that high levels of mindfulness were associated with high processing speed, good attentional and inhibitory control and good coordination of speed with accurate performance. Regression analyses in this study revealed that cognitive flexibility was best predicted by the combined influence of the KIMS sub-components “acting with awareness” and “observing” which together explained 60% of the variance in cognitive flexibility. These results support that mindfulness training indeed is intimately linked to improvements in attentional functions and cognitive flexibility and that previously automated processes can be interrupted, inhibited and brought back under cognitive control. Results also indicate which sub-components of mindfulness are most central for deautomatisation to occur.

A common challenge in many psychopathologies is to overcome such automated processes and habitual responding. On a state level this could for example have clinical implications for the handling of painful memories and sudden bursts of emotions within a session. Changes on a trait level would have implications for more chronic disorders and conditions such as mood disorders, depression and general anxiety. If attentional functions are trainable and mindfulness training facilitate bringing automated processes back under control, the possible role of changes in such attentional functions could possibly explain much of the clinical benefits associated with mindfulness training and be considered a central mechanism.

4.0 The effect of mindfulness on affect regulation.

4.1 The importance of affect regulation and affective style.

Enhancement of attentional capacities is in itself crucial for psychological wellbeing but also serves as basis for other core determinants for mental health such as regulation of emotion. Investigations of mindfulness meditation training have revealed that it involves brain regions also responsible for the regulation of emotion and affects (Davidson et al., 2003). Before presenting some of these results a conceptual overview will be presented of the link between attention, self-regulation and regulation of emotion and affect, in order to show how improved attentional skills via mindfulness training can serve as basis for improvements in the ability to regulate affect.

Dysregulation of affect, emotion, feelings and mood have been found to be common to most emotional disorders (Davidson, 2000) and the use of emotional self-regulatory processes constitutes the core of most modern psychotherapeutic approaches (Beauregard, 2001). Self-regulation refers to our ability to "modulate our behavior according to cognitive, emotional and behavioral demands of a situation" (Ruff & Rothbart, 1996, p.7 in Rueda, Posner & Rothbart, 2004) and emotional self-regulation to " a heterogeneous set of processes by which individuals influence, consciously and voluntarily, which emotions they have, when they have them, and how they experience and express them" (Gross, 1999; Beauregard, Levesque & Bourgouin, 2001, p 1). Emotions are considered multicomponential in nature and comprise both cognitive, experiential, behavioral and physiological dimensions. As a result, the regulation of them implies changes in one or more of these response domains and can be done by decreasing, maintaining or increasing both negative and positive emotions (Masters, 1991; Parrott, 1993; Langston 1994; Gross, 1999; Beauregard, 2001).

A distinction is commonly drawn between affect, feeling, emotion and mood. *Affect* refers to the feeling tone a person is experiencing at any particular point in time. Feeling tones vary primarily in terms of hedonic valence but can also vary in terms of energy or arousal. When the feeling tone is strong, has a clear cause and is in conscious awareness, the term *emotion* refers to those feelings (Baumeister & Vohs, 2004). The term *mood* is instead used to describe more enduring feeling states. The term *affect-regulation* will be used here to refer to the managment of these subjective feeling states. The concept of *affective style*, which refers to individual differences in emotional reactivity and regulation (Davidson, 2000), is also relevant for resilience and vulnerability for various forms of psychopathologies. Affective style is meant by Davidson (2000) to capture processes that singly or in combination modulate an individual's response to emotional challenges, dispositional mood and affect-relevant cognitive processes.

Individual differences, and associated vulnerability or resilience towards developing psychopathology have been demonstrated to be related to some specific parameters. These involve threshold to respond to emotion-eliciting stimuli, magnitude of response, latency to peak of response and to a recovery function (Davidson , 2000). The parameter referred to as *recovery function* has been found to be particularly important for enhancing resilience and decreasing vulnerability for mood and anxiety disorders. Failure to recover from negative events, especially when frequently exposed to these, will result in sustained elevations of activity in multiple systems, autonomous and endocrine, which have been demonstrated to be detrimental on all levels. On the other hand the ability for rapid recovery is regarded an important ingredient in resilience. Individuals high on resilience also experience negative affects, but this negative affect does not persist and they are relatively more capable of

meaning making in response to negative events. This ability is considered by Davidson (2000) to be essential for the capacity to show relatively more rapid decrements in various biological systems and distinguish more resilient individuals from more vulnerable individuals.

An important point is that the neural substrates subserving the parameters which determine affective style have plasticity and can therefore be developed through training. How then does mindfulness training affect the neurological underpinnings of emotion, affect and affective style and to what extent can the clinical benefits, -i.e. better capacity to regulate affect, be attributed to associated improvements in attentional skills?

To answer this question the structures and circuits governing the regulation of affect and affective style will be presented. How mindfulness meditation training has shown to affect the neural substrates of the affect-regulation system will also be discussed.

5.2 The neurocognitive substrates of affect regulation.

Investigations of the neural system that supports affect-regulation and affective style have revealed a central role for the frontal cortex (Lebrecht & Badre, 2008). Neuroimaging studies (fMRI) have demonstrated increased activation and involvement in lateral and medial frontal regions during reappraisal (Beauregard et al., 2001,) and changes in emotional response due to reappraisal success have been found to correlate with activity in the lateral prefrontal cortex (LPFC) (Lebrecht & Badre, 2008). Imaging studies has also revealed a central role of subcortical structures in the processing of affect such as the amygdale, extended amygdale, including nucleus accumbens (NAcc), insula, anterior cingulated cortex (ACC) and hippocampus (Phan et al., 2005). Lebrect & Badre (2008) state that the activation of the amygdale typically tracks the direction of emotional change. When the intention is to reduce

affect through cognitive effort such as reappraisal, activation in amygdale decreases. By contrast, when instructions involve intensifying a negative emotional reaction, increased activation in amygdale often occurs. The established role of prefrontal cortex in reappraisal success fits well with the inverse activation pattern between PFC, -and with observation that higher activation of the amygdale correlates with decreased ability to reappraise and regulate negative affect (Urry et al, 2006).

Together the findings suggest a network model for cognitive control of emotion in which the PFC regulates emotion by acting on subcortical structures (Lebrecht & Badre, 2008). A recent contribution in this field of affective neuroscience was made by Wager et al (2008) however in which support for two distinct pathways in the regulation of emotion was found. Both emanate from the ventrolateral prefrontal cortex, VLPFC, but the outcomes in terms of degree of reappraisal success and decrease in emotional response were found to be different dependent on whether the pathway included the amygdale or nucleus accumbens. When the pathway went from VLPFC through the amygdale this was associated with reappraisal failure and increase in emotional response. When the trajectory included nucleus accumbens this was associated with reappraisal success, i.e reduced negative response (Wager et al., 2008; Lebrecht & Badre, 2008). Lebrecht & Badre (2008) argue that the study conducted by Wager et al (2008) has delineated a more complex role for the PFC in this process. The VLPFC is usually considered as critical for goal-dependent emotional regulation but Wager and colleagues found that this region is not only involved in regulating the emotional response per se, but also in extracting emotional meaning from the stimuli. They further argue that this relates to the associated role of VLPFC for nonaffective cognitive control-processes such as retrieval, selection from memory and inhibitory functions (Wager et al., 2008; Lebrecht & Badre, 2008).

The medial prefrontal cortex, mPFC, is also included in the top-down prefrontal inhibition of limbic responses. Inhibition is in part mediated by projections through the mPFC. Besides having a central role in this inhibitory pathway, this structure has also been found to be active during self-relevant tasks such as monitoring one's own emotional state (Cahn & Polich, 2006).

The orbital sector of the PFC, OFC, has mostly been linked to rapid learning and relearning of response-incentive associations and is crucial for reversal learning (Davidson, 2000). Since a critical component in emotion-regulation consists in relearning of previous stimuli-incentive associations that previously might have been adaptive, this structure plays a key role in attaining regulation.

Besides these prefrontal regions, the anterior cingulated cortex (ACC), hippocampus and amygdale are also included in the networks for affect-regulation. The ACC has traditionally been considered to have a central role in conflict monitoring within the cognitive realm, but an affective ventral subdivision has also been proposed. Davidson (2000) suggest that it plays a key role in the regulation of emotion by recruiting other structures and further processing when conflict has been detected. As such it can be considered a form of initiator for the emotion-regulating network (Davidson, 2000) besides being a key structure for the integration of attention, motivation and motor control.

The hippocampus is implicated in formation and retrieval of both implicit and explicit memories and governs the context-dependent form of memory. It also has a central role in the regulation of the hypothalamic-pituitary- adrenal axis (HPA-axis) which is highly relevant for

both emotion generation and regulation. Davidson (2000) argue that the hippocampus structure is central in the context modulation of emotional behavior and that impaired hippocampal function results in emotional behavior being displayed in inappropriate contexts. Among the hormones and neurotransmitters involved in the formation of memory glucocoticoids play an essential role (Gabbard, Miller & Martinez, 2006). Sustained increased elevations of glucocorticoids however leads to neuronal degeneration of hippocampal cells and impairs encoding and retrieval. It also interferes with the process of long-term-potentiation (LTP). In this process, receptors are activated and various events are initiated which eventually results in the strengthening of synaptic connections between neurons which in turn is fundamental for forming memories (Gabbard, Miller & Martinez, 2006). Hyperactivity in the HPA-axis will therefore have negative implications for context appropriate regulation of emotion. By virtue of being the main ganglion in the autonomic nervous system, hyperactive functioning of the HPA-axis could explain many of the somatic components of psychiatric illness due to its role in increasing and sustaining elevated detrimental levels in various systems. This relates to Davidson's (2000) argument that vulnerability for psychopathologies is related to sustained elevations in various systems.

5.3 Demonstrated effects of mindfulness on the neural network governing affect-regulation.

The collective functioning of the structures and circuit outlined above and individual differences in this functioning such as asymmetries between the left and right prefrontal cortex and activation of the amygdale at rest, are considered key components of affective style (Davidson, 2000). Knowledge of the nature of plasticity which has been demonstrated in these circuits would be important when implementing clinical interventions to enhance its

function, and in particular when deciding whether mindfulness training can lead to trait-level changes.

EEG studies of the effect of mindfulness meditation on these circuits has shown inconsistent results (Cahn & Polich, 2006). However fMRI investigations have been somewhat more consistent in reporting activation of the emotion-regulating structures in response to mindfulness training. Activation of the DLPFC, involved in executive decision making, attention, and emotion regulation is consistently reported to be associated with mindfulness meditation (Baerentsen, 2001). Lazar et al., (2005) found increased cortical thickness in this area in experienced meditators and together these findings indicate trait-like changes in this region due to this form of meditation (Lazar et al., 2005). In their study, they further found that cortical thickness was not nonspecifically thicker everywhere. Associated structural changes were found specifically in areas important for sensory, cognitive and emotional processing (Lazar et al., 2005). The authors interpreted their results as structural evidence for experience-dependent cortical plasticity associated with mindfulness meditation practice.

The ACC, one of the main nodes in the executive attentional network which is central for initiating the emotion-regulating process has also been found to show increased activation in mindfulness-meditators. Besides governing emotion, this structure also activates in response to conflict monitoring, direction and integration of attention, motivation and motor control. The findings concerning ACC activation during mindfulness meditation are however somewhat inconsistent. Considering its central role in directing attention one could hypothetically expect greater activation in experienced meditators. Alternatively, enhanced capacity for sustained attention could result in less need for and activity in the ACC (Treadway & Lazar, 2009). Brefczynski-Lewis and collegues (2007) found that novice

meditators showed more activation in the ACC compared to Buddhist monks (Brefczynski-Lewis et al., 2007). However in trying to replicate the finding, an inverse pattern was found by Hözel et al (2007): now experienced mindfulness meditators showed more ACC activity than novices have been found.

As mentioned above, Davidson (2000) suggests that difference in affective style is related to different activation patterns at rest in left and right hemispheres. Patients suffering from depression and anxiety have been found to have increased EEG power in the right half of the brain while at rest, while more psychologically healthy individuals have been found to have greater activity on the left. Building on these findings, Davidson et al., (2003) measured such EEG patterns in healthy subjects before and after they had participated in an 8 week MBSR intervention. They found a leftward shift in the resting EEG patterns after 8 weeks of practice. Importantly these changes were found to be persistent 3 months after participating in this training program. These changes were also associated with improved immune functioning. The authors interpreted the findings as support for the notion that meditation promotes brainplasticity and emotional development. They also excluded a common argument among critiques of MBSR consisting in that the effects could be due to preexisting biological differences among meditators and nonmeditators.

In historical accounts of mindfulness noticing and labeling aspects of experience, instead of suppressing or avoiding mental content, is supposed to promote effective recognition of, detachments from and regulation of affect. Building on these assumptions, Creswell et al (2007) conducted a study which investigated the relationship between mindfulness and affect regulation. They found that individuals high on dispositional mindfulness, assessed by MAAS, showed greater prefrontal regulation of affect during an affect labeling task compared

to participants low in mindfulness. More specifically they found a strong inverse relationship between activity in PFC regions and the right amygdale in those participants high on mindfulness while participants who were low in mindfulness did not show these effects. The authors interpreted this as a neural evidence for associations among mindfulness, affect labeling and improved neural affect regulation and that mindfulness can be associated with enhancements in these affect- regulation pathways. The authors further argued that their findings fit with fMRI findings which have demonstrated activation of the VLPFC while engaging in labeling of affective stimuli and associated downregulation of amygdala activation. They also interpreted their finding of a strong positive association between dispositional mindfulness and activation of the mPFC as consistent with this regions role in the regulation of limbic responses. This region is also commonly active during self-relevant tasks and when one monitors one's own emotions. The activation of the mPFC therefore also match with the instructions concerning embracing versus suppressing emotions when one is practicing mindfulness meditation. However, increased activity in this structure is commonly observed to be transient among experienced meditators. An initially increased activation due to embracing instead of suppressing mental content seem to be common among those with mindfulness meditation experience. Important however is that the increase in mPFC activation is typically followed by a decrease in this region. This could possibly be due to improved attentional skills and capacity to return attention to the present moment.

5.4 The effect of mindfulness on modes of self-reference.

The role of mindfulness in modulating the relative activity of two different styles of self-reference is also relevant for affect-regulation. The notion about an explanatory -'*me*'- which makes sense of the -'*I*'- acting in the present moment (James, 1890) was termed the -'*narrative self*-' by Gallagher (2004), distinguishing it from an agentic -'*I*'-.

The neural substrates of these two modes of self reference have been found and, important for the regulation of affect, been associated with differing vulnerability for psychopathology (Watkins & Teasdale, 2001). The effect of mindfulness on the neural substrates of these modes of self reference is therefore of great interest.

This effect was studied by Farb et al (2007),- using fMRI. Both novices and participants who had attended an eight week course in MBSR meditation were trained to use two types of attentional focus on positive and negative personality trait adjectives which were designed to arouse self –referential thought. These two attentional modes consisted in an experiential focus (EF) versus a narrative focus (NF). The EF mode consisted in monitoring one's moment- to-moment experiences in response to the trait-stimuli with a non-conceptual attention to thoughts, feelings and bodily states and use of meta-awareness to return attention to the present experience when distracted, -i.e mindfulness. In the NF mode participants were instructed to reflect about what the trait- adjectives, implied about them as a person.
This last mode is also characteristic of rumination, mind-wandering and resting attention.

They found that in the novices, EF yielded reductions in self-referential cortical midline regions, medial prefrontal cortex, mPFC, associated with NF. In those trained in MBSR, the EF resulted in relatively more marked and pervasive reductions in the cortical midline regions, mPFC, in comparison to the meditation naives. Those more experienced in MBSR also showed increased engagement of a right lateralized network which included the lateral PFC and the insua, a viscerosomatic area, secondary somatosensory cortex and the inferior parietal lobule. A reduction in the coupling between the right insula and the mPFC is relevant for regulating affect in that this facilitates a decoupling of the narrative focus. Not only does this have implications for avoiding narrative chatter, rumination and self-referential

judgments (Siegel, 2007). It have also been argued to facilitate the ability to free attentional resources so that we are more able to distinguish between primary bottom up input and secondary top-down chatter of prior learning. Developing this state, and ultimately trait, through attentional training in turn facilitates the altering of habitual patterns in both general and psychopathological conditions. This last argument has been proposed as a common mechanism in the clinical benefits of mindfulness training (Siegel, 2007).

6.0 Findings and limitations.

Attention has been proposed to be one mechanism through which mindfulness may lead to clinical benefits. This thesis has presented some findings concerning how mindfulness meditation engages and possibly modifies our attentional systems in ways that promote mental health. Objective measures assessing attentional functions have complemented self-report measures of mindfulness and generally suggest a positive correlation between level of mindfulness and attentional capacities. Mindfulness meditation seems to require and modify sustained attention through the instruction to maintain focus on present experience such as the breath. While inhibiting further engagement in habitual and often self-referent thought processes, so that the meditator can reorient to the present, selective attentional processes are engaged. To be able to switch between mental sets the conflict monitoring attentional system seems to be required. Improved performance on objective measures of attentional capacities, such as the ANT, the Stroop test and the D2 concentration and endurance test have been reported. The same activities have also been shown to be captured in terms of dissociable dorsal and ventral attentional systems.

The increasing ability to flexibly control what we attend to seems to facilitate the ability to regulate affect. On the neurological level concomitants of the practice have revealed that neural networks underlying both attention and regulation of affect are engaged and to some extent modified after practice. Baseline changes in affective style have also been proposed to result from engaging in mindfulness training. fMRI has to some extent validated that mindfulness training affect structures that theoretically have been associated with attention and regulation of affect.

However there are a number of concerns that should be considered before uncritically accepting that mindfulness has a positive influence on attentional skills and our ability to regulate affect.

First, some studies use self-report measures to assess mindfulness and such measures are typically vulnerable to demand-characteristics. In addition, and most relevant for the use of these in mindfulness research, novices typically have greater difficulty in reporting what they experience than more experienced participants who have much more refined and detailed reports when answering these self-report measures.

Second, those experienced in mindfulness often have experience from several meditation practices (Lutz, Dunne & Davidson, in press). Different meditation practices are often aimed at affecting the mind in different ways, and the combined use of them is common among experienced meditators. Trying to trace the exact origin of behavioural changes that accompany meditation is therefore made more complex.

Third, it may not be the case that mindfulness meditation is a causal factor which leads to improved attentional capacity and in turn to improved self-regulation and improved well-being. For example, Masicampo and Baumeister (2007) argue that it is the successful ability to self-regulate that leads to both well-being and to higher dispositional mindfulness. Masicampo and Baumeister (2007) therefore propose that future research on mindfulness would benefit from controlling for the potential overlap between self-regulatory exercises and mindfulness meditation practices.

In order to be able to distinguish mindfulness from other practices and to reach a sound operational definition, the perspective presented next could be a fruitful complement.

7.0 Attention in context,

7.1 Determining the effects of one mechanism within a systemic approach to mind.

Buddhism has a postmodern, systemic view of the mind. Under this perspective the mechanisms through which the clinical benefits manifest themselves are understood holistically. In the approach to understanding brain organization which will be presented next, attentions role in facilitating clinical benefits is understood both in terms of its associated engaged brain activity but also in light of what is being disengaged.

7.2 Attention as organized into dynamic, anticorrelated networks.

Among the findings in this thesis which are relevant for explaining the role of attention in the clinical benefits of mindfulness training is the seemingly negative association between attentional capacity and the experiencing of negative emotional states.

The use of cognitive, and especially attention demanding, tasks for handling negative emotional states is not new and has been used therapeutically in treatment of both anxiety and depression (Clark & Fairburn, 1997; Fox et al., 2005). Most studies on the effect of such interventions however concerns suppression of negative emotions instead of an embracing, experiential attitude which characterize mindfulness. What is common for these approaches however, is the engagement of attentional networks.

The negative relation between engaging in attention demanding tasks and experiencing self-referential thoughts and emotions has previously been explained in terms of competition for processing resources. This approach has more recently been extended by a newer approach which suggests that the brain is intrinsically organized into dynamic, anticorrelated functional networks (Fox et al., 2005). This approach for understanding the organization of brain activity is relevant when discussing the role of attention in the clinical benefits associated with mindfulness training. Within this more recent approach the clinical benefits can possibly be understood in terms of engaged versus disengaged distributed brain networks.

In brief this recent approach is based on findings which suggest that the brain is organized into widely distributed diametrically opposed brain networks (Fox et al., 2005). While engaging in attention-demanding tasks, activity in some regions, such as frontal and parietal regions, exhibit activity increase. This relates to top-down attentional control. Importantly however is that engaging in such tasks also leads to decrease in regions that are not relevant for the task, the task negative network. Some disengaged regions during attention demanding tasks are regions such as the posterior cingulate, medial and lateral parietal cortex and medial prefrontal cortex, MPFC (Fox et al., 2005). Fox et al (2005) also found that the relative amount of activity in this task negative network, was attenuated when participants

experienced self-referential aspects of the task such as intrusion of task-independent thoughts, emotions and episodic memory. These findings could perhaps relate to Farb et al's., (2007) findings in which narrative focus yielded activation in cortical midline structures such as the MPFC. Those who were trained in MBSR were found to have a larger amount of reductions in self-referential regions such as the MPFC when they engaged in the experiential mode. Those who had more experience with MBSR training were also found to have a relatively larger increase in the right-lateralized network, including the LPFC and a reduction in the coupling between the right insula and the MPFC. This in turn is preventive for rumination and the experience of associated negative affects.

This approach also seems relevant for the discussion about baseline activity and associated resilience or vulnerability towards psychiatric conditions. These dichotomically activated networks have been found to be represented intrinsically in the resting human brain (Fox et al., 2005). Davidson's (2000) notions about different baseline asymmetric activations between left and right prefrontal cortex and activation in the amygdale at rest, goes well with the notions about dichotomically activated networks in the resting human brain.

So the question is then how mindfulness training affects these asymmetries or dichotomically activated networks. More precisely, it would be interesting to explore whether mindfulness meditation could work in terms of making the dichotomy between attention networks and self-referential, ruminative, emotion generating networks more pronounced.
Some of the findings in this thesis could be in line with that proposal. Such anticorrelations could however be more relevant in earlier stages of the meditation practice than in later stages in which the practice has become more effortless. How mindfulness affect also other anticorrelated networks, at particular stages in the practice, and how this could possibly

alleviate various forms of psychopathology would be interesting to explore. But first it seems crucial to determine whether it is mindfulness per se that exerts this influence. The conceptual concerns and difficulty in reaching an operational definition of mindfulness could benefit from these findings. To fully capture the mechanisms through which mindfulness exerts its benefits it seems essential not only to embrace associated activity in engaged networks, but also what occurs in terms of disengagement. Mindfulness might engage responses both on a state and a trait level which is determined not only of those structures and functions that are engaged, but also of those that are deactivated. These patterns however might change character during the progress of the practice and could be relevant to explore further.

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