THE NEUROSCIENCE OF MEDITATION:

CONNECTING RESEARCH WITH DOCTRINE ON ATTENTION

By

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Abstract

Psychological and neuroscientific research on meditation and mindfulness has developed quickly over the past twenty years. Most research studies have methodological flaws and ambiguous results. The purpose of this review is to discuss these major methodological flaws and to clear up these ambiguities. Since there are many components to meditation and mindfulness this review focuses primarily on the research done on attention and its regulation. To clear up the ambiguities this review analyses the psychological and neuroscientific results of modern meditation research on attention in the context of Buddhist doctrine on meditation.

Common results such as increased activity in the PFC or ACC during meditation on attentional tasks or enhanced performance on the Attention Network Task (ANT) in conflict monitoring and alerting suggest that meditation helps attention performance and regulation. The analyses connects these results to the theory of "monkey mind" and concepts of non-attachment in Buddhist doctrine. The correlation between the two areas, scientific research and anthropological study, strongly supports the results of scientific research. Although the methodologies may be flawed and imperfect, the results are promising and the field of research on meditation positively correlates with religious doctrine.

Introduction

Many research studies on meditation have been conducted over the past fifty years or so. A majority of these studies have been described as methodologically flawed and thus, unreliable. Until recently most of these studies (psychological, neurological, or physiological) have been considered inconclusive due to their psychological methodological issues. Current researchers in this field still dispute the validity of most research methodologies in regards to meditation. The

purpose of this paper is to focus in on some of the more recent studies conducted on the neurophysiology of meditation, decipher the results, and determine if there are any correlations with the doctrinal backgrounds of meditation; whether what is being concluded scientifically matches what is expected to be achieved according to the doctrine.

Research on the neurophysiology of meditation has reported increased activity and decreased activity of several brain regions that seem to correlate with stress, anxiety, depression, sympathetic and parasympathetic nervous response, attention, and pain regulation. Neurologically, much of what occurs in the brain and within the nervous system affects the whole body. Although the central dogma of neuroscience may report certain brain regions in correlation with certain psychological responses it is important to remember that correlation does not equate causation. Just because activity of a particular brain region correlates with a molecular or psychological response does not mean that this activation is the cause of said response. It is also important to keep in mind that just because activation of the same particular brain region may be necessary for a particular response does not mean that it is sufficient in and of itself. This paper takes into account these fallacies and attempts to qualify what knowledge is currently held in regards to brain functioning and psychological response. This paper also does not claim whether or not the current methodology is sound, but instead attempts to determine whether or not the research of meditation is on a positive path when put back into perspective within the religious doctrine surrounding these practices.

Contemplative research has a growing interest and perspective becomes important. First, the scientific research and methodology must be sound. Second, the purpose of meditation must not be obscured by the science. The statements of religious doctrine and self-report would, hopefully, match what is being seen scientifically because the purpose of researching meditation

and other religious techniques developed to improve well-being is to determine whether their reported effects hold up on an objective level as well. The purpose of this paper is to bring the research back into perspective with the doctrine and determine whether or not there is a correlation. That is not to say that the subjective experience is not important. In fact, the subjective experience, especially in regards to psychology and religion, should often hold a superiority to the objective. The objective is merely there to support the subjective in most regards.

In order to avoid any conflict between the scholar of religion and anthropology and the psychologist and neuroscientist a background for both areas of expertise has been created before attempting to understand the contemplative research and to connect these two fields of study.

Background to Mindfulness and Meditation

Meditation is often described as a complex practice riddled with intricate metaphysical philosophies. There are a variety of different forms of meditation, each of which uphold specific core philosophies and techniques, none of which are exactly the same. Understanding that a variety of meditative practices exists is critical to keep in mind when discussing meditation in any context. This paper does not intentionally lump together the variety of practices but, instead, attempts to outline underlying fundamental similarities between practices for scientific research. For the purposes of this paper I will discuss meditation primarily in regards to mindfulness meditation and Buddhist philosophies of meditation, specifically Zen and Tibetan Buddhism. The reason for choosing these specific traditions is due to the influence of Zen and Tibetan Buddhist philosophy on the development of mindfulness meditation.

Within Western society there has been an increase in curiosity of meditation and other Eastern philosophies over the past fifty years and over the past twenty years scientific research has increasingly taken an interest in meditation. Most scientific research utilizes mindfulness meditation, in part due to its effectiveness and its utilization by Jon Kabat-Zinn in regards to stress reduction. Mindfulness meditation is practiced with eyes closed, seated in a cross-legged position while maintaining a straight back. Attention is focused on the breath either through the movement of the abdomen or the flow of air through the nostrils. This is extremely close to the practice of *zazen* "sitting meditation" within Zen Buddhism. Whenever one becomes aware of mind-wandering or becomes distracted from their breath they are taught to return their focus to their breathing.

As is previously explained, meditation is often described as complicated and difficult to understand or interpret, which often deters to most potential practitioners. Some will complain that meditation is difficult, they cannot do it, it's boring, or they don't see the point. The biggest difficulty arises in regards to attention regulation. Novices and uneducated meditators may develop negative affectivity in relation to meditation because they find believe that the goal is to silence the mind and sit quietly without thought or emotion. This is a result of a Buddhist concept described extensively in Zen Buddhism and Tibetan Buddhism.

There exists the concept known as "monkey mind" (sometimes referred to "mind-monkey"). The mind is like a monkey, always chattering, restless, and often uncontrollable. The purpose of mindfulness training and meditation is to focus the attention of the monkey mind towards something like the breath. The mind will grow restless and wander but the purpose of meditation is not to stop those thoughts but to bring the monkey mind back into focus. If consciousness were a stream to be perceived in the mind and every thought and emotion were an

object floating down the stream of consciousness, the monkey mind attempts to pick up the objects. Restless, the monkey mind will attempt to pick up every object. Mindfulness is a technique to train the monkey to put those objects back into the stream of consciousness or "non-attachment". None-attachment means not to allow the mind to become attached to any thought or emotion but instead train the mind to accept the thought or emotion and then let go. Once the mind is trained to let go with constant practice and experience, one can train the monkey mind to simply watch the thoughts and emotions flow down the stream of consciousness with acceptance and non-judgement in complete awareness and without attachment. This mindfulness technique is fundamental to most forms of meditation. The goal to have a blank mind or to not think is misinformed. Attempting to do so would result in a paradoxical event and be extremely difficult to accomplish through conscious effort. It is important to have a background and basic understanding of mindfulness and meditation before attempting to understand it within scientific research.

Methodological Issues

As previously mentioned there are methodological issues surrounding the research of meditation over the past several decades. Most of these issues have been discussed in detail within the American Psychologist article titled "Conceptual and Methodological Issues in Research on Mindfulness and Meditation" by Richard Davidson and Alfred Kaszniak. The basis of this paper stem from much of what is written within this article and, in large part, due to the research conducted by researchers like Davidson and Kaszniak over the past several years. Although many of the issues can be found within Davidson and Kaszniak's article, it is important to address some of these issues before delving into further literature review.

First and foremost, keep in mind that most of the present literature review looks at articles and research that was conducted before the article on conceptual and methodological issues. Second, this literature review is not meant to specifically address every methodological issue in the research on meditation even though it addresses some of these issues. Finally, this paper is taking an opposing stance in regard to one of the methodological issues discussed in Davidson and Kaszniak (2015).

The main methodological issue that this review is opposing and looking at more extensively is that on reverse inference. Although there is a caution against use of reverse inference it may still be critical for progressing research on meditation at this stage in its development. Reverse inference, as is stated in Davidson & Kaszniak (2015), refers to the utilization of brain functioning as a representation of psychological functioning and behavior. It is true that there should be some caution when using reverse inference but the main issue to avoid when using reverse inference to avoid is concluding that the brain functioning observed determines the psychological functioning. There are many philosophical debates surrounding the power of the mind and brain and which controls which, if either is in control, which is unlikely. It is most likely that brain functioning affects psychological functioning just as psychological functioning affects brain functioning. Regardless the stance on the matter it is crucial to, at one point or another, observe brain functioning during mindfulness and meditation to determine whether or not it resonates with the psychological and behavioral functioning of the individual. Therefore, using brain imaging techniques to observe mindfulness and meditation, even if it is yet to be quantified by scientific research, is still important. It is at this point that it may be helpful to utilize other fields of study such as religious studies or philosophy on meditation to help further guide and support the research which is not necessarily being done in the fields of

neuroscience and psychology. As this literature review focuses primarily on amending this potentially beneficial component to the study of neurophysiology and meditation it cannot be overlooked.

One other issue with the current research on meditation and that is the absence of double-blind procedures. These procedures cannot be utilized for mindfulness based interventions because the participants will know whether they are in the meditation group or not and so will the examiners. The absence of such procedures hurts their clinical and medical efficacy as an intervention. Most clinical studies use a waitlist control but some have used incentive-based controls. It is argued that the best control would be a comparison treatment that matches the mindfulness intervention in all nonspecific areas. But treatments such as these would be difficult to create and research on treatments such as these have found that nonspecific factors of an intervention can be beneficial to the participant can be altered if the instructor knows that the group is a control. There are a few other important methodological issues within the research on meditation that are also important to address. The first is in regards to meditation duration, the second is in regards to the participant pool and area of collected research.

The first issue of mention is the duration of meditation. It is quite difficult to determine how much training an individual has had in formal meditation practice as well as the practice time of the individuals participating in the study. For more experienced meditators it is difficult to determine what forms of meditation they are practicing as they have likely been trained or are familiar with more than one form of meditation. However, as was stated at the beginning of this review, there are fundamental components to most forms of meditation and although it is important not to lump the forms of meditation together, there are specific aspects should be emphasized. But again, it is impossible to determine whether or not the participants are following

protocol except for self-report. The best direction for the research on meditation to go is for longitudinal studies beginning with participants without any formal training in meditation and observing the changes as they gain experience. Therein lies the continual issue of self-report on outside practice which is difficult, if not impossible at this point to control. Meanwhile, such a study would require and extravagant amount of money to fund and for participant retention.

Second, the issue in regards to the participant pool and the area in which the research is conducted is important to discuss. Long-term meditators are difficult to come by and, as previously discussed, it is unlikely that they have only practiced one form of meditation or received training in only one form. In order to conduct a longitudinal study such as this it might be beneficial to reach out to different monasteries, especially Tibetan Buddhist monasteries that train and retain several hundred students over the course of several years. However, there is also an issue with this as most research collected in the West has not attempted to look into research in monasteries or Eastern parts of the world. Most of the research conducted in such ways are only available in other languages such as Chinese and Japanese which would potentially be difficult to interpret for most Western scientists and might not even meet their desired standards for research methodology. If such research is to be conducted it cannot be done effectively in the Western Hemisphere where such practices are less common and difficult to find experienced practitioners. This is not to mention the potential differences in brain structure and psychological functioning in people who choose to become long-term meditators. This is why current research may have to observe only within subject results unless there are close commonalities between subjects.

Attention

The nature of the current meditation literature is primarily concerned with attention and attention regulation in meditators. Since mindfulness techniques are focused on generating a greater awareness of ones thoughts and emotions, one's ability to attend to a thought precedes their perception of the thought. John Kabat-Zinn defined mindfulness as "paying attention in a particular way: on purpose, in the present moment, and non-judgmentally" (Kabat-Zinn 1994). If a similar definition is used then it is necessary to qualify this literature on attention with the doctrine of practice before examining other aspects of meditation.

Despite the recommendations for researching the neurophysiology of meditation by use of imaging (Davidson & Kaszniak, 2015), a majority of the current research on mindfulness and attention attempts to investigate the underlying brain mechanisms involved in meditation. These underlying brain mechanisms will be important in qualifying whether or not there is at least some objective support to the subjective reports in relation to the doctrine of meditative practice.

Author(s)	Title	Year	Intervention Description	Control Condition(s)	Participants	Measures	Main Results
Klaus B. Baerentsen; Niels V. Hartvig; Hans Stodkilde-Jorgensen; Jens Mammen	Onset of Meditation Explored with fMRI	2001	Zen meditation (7-23 years practice)	N/A	5 healthy LT meditators	fMRI, onset of meditation with blocked on-off design	Decrease in activity visual cortex, PCC; Increase in PFC, ACC, hippocampus
Britta K. Holzel; Ulrich Ott; Hannes Hempel; Andrea Hackl; Katharina Wolf; Rudolf Stark; Dieter Vaitl	Differential engagement of anterior cingulate and adjacent medial frontal cortex in adept meditators and non-meditators	2006	Vipassana meditation (~8 years practice, 2hr daily)	15 healthy controls	15 healthy LT meditators	fMRI, meditation and arithmetic condition	Increased activations in the rostral ACC and the dmPFC bilaterally
Amishi P. Jha; Jason Krompinger; Michael J. Baime	Mindfulness training modifies subsystems of attention	2007	MBSR and Mindfulness Retreat	17 participants with no experience in meditation	17 participants MSBR (8 weeks); 17 participants mindfulness retreat (1 month)	Inspection of alerting, orienting, and conflict monitoring via Attention Network Test (ANT)	Time 1: Retreat group had improved conflict monitoring performance; Time 2: MBSR had improved orienting, Retreat group had altered performance on alerting component with increased in exogenous stimulus detection; Groups did not differ in conflict monitoring at Time 2
J. David Creswell; Baldwin M. Way; Naomi I. Eisenberger; Matthew D. Liberman	Neural Correlates of Dispositional Mindfulness During Affect Labeling	2007	Dispositional Mindfulness determined by Mindful Attention Awareness Scale (MAAS)	Gender labeling control task	27 healthy students (UCLA)	fMRI, affect labeling task (match words to displayed facial expression)	High in mindfulness had increased PFC activity and decreased bilateral amygdala activity during affect labeling, strong negative associations between PFC and right amygdala responses

Author(s)	Title	Year	Intervention Description	Control Condition(s)	Participants	Measures	Main Results
J. A. Brefczynski-Lewis; A. Lutz; H. S. Schaefer; D. B. Levinson; R. J. Davidson	Neural correlates of attentional expertise in long-term meditation practitioner	2007	Tibetan Buddhist Meditation	16 age-matched novice meditators with an interest in meditation but no prior experiences (NMs); To control for motivation 11 incentive novice meditators (INMs)	14 long-term Buddhist practitioners with 10,000-54,000 hours of practice from two similar schools of the Tibetan Buddhist tradition (EMs)	fMRI, meditation and rest in a standard block paradigm; during meditation presented distracting external stimuli (sounds)	EMs had increased activity in frontoparietal regions, cerebellar, temporal, parahippocampal, and posterior occipital cortex; SEE TABLES for ALL activated regions
Yi-Yuan Tang; Yinghua Ma; Junhong Wang; Yaxin Fan; Shigang Feng; Qilin Lu; Qingbao Yu; Danni Sui; Mary K. Rothbart; Ming Fan; Michael I. Posner	Short-term meditation training improves attention and self-regulation	2007	IBMT (integrative body-mind training)	40 Chinese undergrads (Dalian University of Technology); relaxation training	40 Chinese Undergrads (5 days of training 20 min per)	Inspection of alerting, orienting, and conflict monitoring via Attention Network Test (ANT); POMS; cortisol and sIgA measurements; arithmetic	IBMT better on conflict monitoring but no difference on alerting and orienting; IBMT had increased positive moods and decreased negative moods; IBMT had lowered cortisol response to the mental stress; IMBT had increased sIgA
Norman A. S. Farb; Zindel V. Segal; Helen Mayberg; Jim Bean; Deborah McKeon; Zainab Fatima; Adam K. Anderson	Attending to the present: mindfulness meditation reveals distinct neural modes of self-reference	2007	MBSR (8 weeks)	16 healthy controls	20 healthy novice meditators	fMRI, NF (narrative focus) vs. EF (experiential focus)	EF Meditators had a decrease in activity mPFC, left dorsal lateral amygdala; EF Controls had a decrease in activity of vmPFC, PCC; NF for both groups had a increase in activity right superior frontal gyrus, right precentral gyrus, mPFC, left hippocampus, left caudate; EF Controls had increased activity in left vlPFC, left dlPFC, right dlPFC, right ilPFC, right insula, secondary somatosensory cortex
Giuseppe Pagnoni; Mike Cekic; Ying Guo	"Thinking about Not-Thinking": Neural Correlates of Conceptual Processing during Zen Meditation	2008	Zen meditation (at least 3 years practice)	12 healthy controls	12 healthy LT meditators	fMRI, mindfulness of breathing while distracting by words	Meditators had left language areas (angular gyrus and superior frontal gyrus) activated for less time after word distraction

Author(s)	Title	Year	Intervention Description	Control Condition(s)	Participants	Measures	Main Results
Antoine Lutz; Heleen A. Slagter; Nancy B. Rawlings; Andrew D. Francis; Lawrence L. Greischar; Richard J. Davidson	Mental Training Enhances Attentional Stability: Neural and Behavioral Evidence	2009	Vipassana Meditation (3 month retreat meditating 10-12hr/day)	23 healthy controls (interested in meditation); 1hr meditation before each session and 20min daily	17 experienced meditators	Dichotic listening task performance; EEG	Focused attention meditation increased attentional stability, reduced task effort, increased the phase consistency of brain response to sensory inputs
Rudi De Raedt; Saskia Baert; Ineke Demeyer; Ellen Goeleven; An Raes; Adriaan Visser; Michel Wysmans; Erik Jansen; Rik Schacht; Joe R. Van Aalderen; Anne Speckens	Changes in Attentional Processing of Emotional Information Following Mindfulness-Based Cognitive Therapy in People with a History of Depression: Towards an Open Attention for all Emotional Experiences	2011	MBCT (w/o other forms of psychotherapy during course)	26 adults of same inclusion/exclusion criterion tested before and after 8 week period w/o intervention	45 adults	Negative Affective Priming Task (NAP); Mindful Awareness Attention Scale (MAAS); Beck Depression Inventory-II (BDI-II); Mini International Neuropsychiatric Interview (MINI); Hamilton Depression Rating Scale (HDRS)	MBCT group had increased facilitation for sad faces and inhibition for happy faces; MBCT group improved on MAAS and BDI (increased mindfulness and lower depression); Negative correlation between BDI and NAP for negative information (more depressive symptoms=less inhibition of negative information); Positive correlation between NAP and MAAS (more mindful=more inhibition of negative information); Negative correlation between NAP and MAAS (more mindful=less inhibition for positive information);
Micah Allen; Martin Dietz; Karina S. Blair; Martijn van Beek; Geraint Rees; Peter Vestergaard-Poulsen; Antoine Lutz; Andreas Roepstorff	Cognitive-Affective Neural Plasticity following Active-Controlled Mindfulness Intervention	2012	Mindfulness Meditation	31 adults to active control condition	30 adults to 6 weeks mindfulness-meditaiton	fMRI, Error-awareness task (EAT) and affective stroop (AS)	Both groups improved on response inhibition task; MT group had reduced affective Stroop conflict; MT group had greater dorsolateral prefrontal cortex responses during executive processing; MT practice had increased activity in dlACC, mPFC, and right anterior insula during negative valence processing
Giuseppe Pagnoni	Dynamical Properties of BOLD Activity from the Ventral Posteromedial Cortex Associated with Meditation and Attentional Skills	2012	Zen meditation (at least 3 years practice)	12 healthy controls	12 healthy LT meditators	fMRI, mindfulness of breathing while distracting by words; RVIP (test for sustained attention conducted outside the scanner)	vPMC activity differences in meditators and controls; SEE FIGURES

Neuroimaging

A review and analysis of focused attention meditation describes some of the neuroscience regarding attention during meditation. A paper by Lutz and colleagues it is stated that "the ability to focus and sustain attention on an intended object requires skills involved in monitoring the focus of attention and detecting distraction, disengaging attention from the source of distraction, and (re)directing and engaging attention to the intended object." (Lutz et. al 2008) These capacities have been separated into: conflict monitoring, alerting (or selective attention), and orienting (or sustained attention). There are hypothesized neural systems that are associated with each of these capacities. The dorsal anterior cingulate cortex and dorsolateral prefrontal cortex have been associated with conflict monitoring. The temporal-parietal junction, ventro-lateral prefrontal cortex, frontal eye fields, and intraparietal sulcus have been associated with alerting. The right frontal and parietal areas and the thalamus have been associated with orienting. Other fMRI studies reviewed acknowledge other neural systems associated with these three capacities and some of those will be addressed in this review.

Addressed earlier in the methodological issues, some long-term practitioners of meditation may have different characteristics either neurologically or psychologically that separates them from others before meditation training even begins. A study conducted on the neural correlates of dispositional mindfulness (Creswell et. al 2007) investigated those with a disposition to mindfulness and how they performed during affect labeling in which they had to pay attention to facial expressions and select the description that most closely fit that expression. In order to determine their disposition to mindfulness the participants were assessed on the Mindful Attention Awareness Scale (MAAS). This measure evaluates how open or receptive an individual is to experiences of the present moment across several domains. Participants were

then observed under fMRI while undergoing the affect labeling task. The results show prefrontal cortical activation and decreased bilateral amygdala activity for those with a high disposition to mindfulness. The findings suggest that this increased prefrontal cortical regulation of those with dispositional mindfulness helps to reduce negative affect. Such activity may be present in those who also have a disposition towards meditative practices. All other studies reviewed utilize meditation interventions rather than dispositional mindfulness but this study, and studies like it, act as a foreground to studying meditators of any sort.

With a dispositional mindfulness and potential dispositions to long term meditation in mind, neural activity of long-term meditators may be better understood. If the findings by Creswell and colleagues (2007) are accurate, if not precise, meditators should have an increased activity of the PFC when practicing mindfulness. An earlier study looks at this neural activity in long-term Zen meditators (7-23 years of practice) at the onset of meditation using a blocked on-off design where meditation was "on" and relaxation was "off" (Baerentsen et. al 2001). There was reported decrease in activity of the visual cortex and PCC and an increase in activity of the PFC, ACC, and hippocampus during meditation. While inactivity of the visual cortex and activity of the hippocampus are not entirely conclusive, activity (or inactivity) of the other regions may further support doctrine of meditation and neural systems of attention. First and foremost, there is consistency with increased activity in the PFC. Activity in the ACC may suggest that the meditators have a strong regulation of autonomic functions such as heart rate and blood pressure which is supported by other studies on meditation. The ACC is also important for impulse control which may reflect the meditators ability to control distracting thoughts.

The deactivation of the PCC is interesting and not always addressed in great detail in studies on meditation. The PCC is pivotal in the default mode network (DMN) which has

recently sparked some interest in meditation research. The DMN is generally active when an individual is at wakeful rest, not attending to outside stimuli. One might think that the PCC should then be active during meditation since it is so strongly associated with not-thinking. Recall that meditation and mindfulness are not about not-thinking but are instead about attention and controlling attention. The DMN is actually responsible for day dreaming and mind-wandering for those at wakeful rest. Therefore the PCC should be less active if one is trying to prevent mind-wandering or is in control of the monkey mind. The results of this study have implications for the greater body of research on mindfulness and meditation in regards to several domains such as homeostatic functioning, regulation of the autonomic nervous system, etc. However, the study was only conducted on 5 participants which is not enough to make any concrete conclusions.

Other, more recent, studies attempt to make more concrete conclusions for mindfulness and meditation that specifically address attention. These studies utilize a variety of different methods but all of which are focused on observing neural systems with fMRI while applying distracting tasks. The results vary depending on the specificity of the task on certain aspects of attention. Together these studies reveal increased activity in common areas like the ACC and the PFC. In regards to attention monitoring and regulation, the rostral ACC is suggested to reflect a better processing of distracting events (Holzel et. al 2006) and the dorsal ACC is particularly important for response inhibition (Allen et. al 2012) which was shown through the error-awareness task (EAT). Activity of the PFC is also crucial for attention. For example, Farb and colleagues (2007) utilized MBSR to train participants in mindfulness before undergoing a narrative focused assessment and an experiential focused assessment in fMRI. There is a wide range of activity and inactivity of different regions of the PFC and their connections with the

insula, secondary somatosensory cortex, and the inferior parietal lobule. These connections suggest a default mode of self-awareness that are dissociated by meditation. This dissociation is consistent with the fact that mindfulness training allows the practitioner to enter a mode in which thoughts, emotions, and, potentially, physical sensation are accepted in a non-judgmental form. These thoughts and feelings can then be observed as transient events. Such data supports the doctrine of meditation when it is related back to the concept of monkey mind and attention regulation. However, it also has implications for different domains such as emotional regulation, regulation of pain, and the greater understanding of the self.

Attention Performance

While the previous studies described are focused on the neuroimaging and neural activity during meditation, specifically while undergoing different attentional tasks under fMRI, other studies are focused on the performance of participants on these tasks. Two studies utilize the attention network task (ANT) to analyze performance. The ANT assesses their performance on conflict monitoring, alerting, and orienting; the three capacities previously discussed. Conflict monitoring is evaluated as the participant presses two keys that indicate the direction of an arrow that is surrounded by either congruent, incongruent, or neutral flankers. Alerting is evaluated based on the participant's reaction time with a warning signal. Lastly, orienting is evaluated based on the participant's reaction time with cues that indicate where the target will occur.

One study sent participants to MBSR training or a mindfulness retreat to test their performance on the ANT compared with controls (Jha et. al 2007). The MBSR group had an increase in conflict monitoring and the mindfulness retreat group had improvements on the alerting component with an increased ability to detect exogenous stimuli. The MBSR group also

had better orienting when compared to the control group. These results suggest that participants trained in meditation have improved voluntary attentional selection. Other results suggest that those with prior meditative experience had greater conflict monitoring before further mindfulness training, and also had significant results after further training. Greater experience correlated with reduced alerting scores implying that without target onset warning, attention was at a more readied state. To relate back to the purpose of mindfulness and the doctrine of meditation, these results are to be expected since mindfulness and meditation training should allow the practitioner to be more aware without attachment to any specific stimuli and thus able to respond and attend to stimuli voluntarily. This level of awareness and state of readiness also allows the mind to become more malleable, adaptive to changes in attention, and able to voluntarily direct and redirect that attention.

Another other study utilized a different intervention. As opposed to a specific mindfulness intervention like MBSR or a retreat they utilized integrative body-mind training (IBMT) (Tang et. al 2007). Participants that underwent IBMT were compared to a relaxation training control on the ANT as well as other measures like the Profile of Mood States (POMS), cortisol measurement, and sIgA measurement. IBMT participants had improved conflict monitoring but no change in alerting or orienting. This particular study was interested in more than just attention, but instead was focused on the influence of meditation across several domains. Results show a decrease in anxiety, depression, anger, and fatigue, and an increase in vigor vigor on the POMS, a significant decrease in stress-related cortisol, and an increase in sIgA which suggests a greater immunoreactivity. A study such as this supports the doctrine of meditation in that a similar mindfulness exercise also enhances one's ability to monitor the focus of attention and recognize discursive thoughts. At the same time it also makes further

implications and supporting claims to other domains in which meditation is being used for research: emotional regulation, stress management, and immunoreactivity.

These studies on attention performance not only support the doctrine of meditation but also support or provide supplemental information for identifying neural systems and developing future studies. All of these articles discussed and all the different forms of approach to the neuroscience of meditation are interwoven to develop a scientific understanding of meditation as a whole.

Conclusion

Recent research on the neuroscience of meditation in regards to attention appear to support the doctrine of meditation through mindfulness techniques in the context that it has been described. This is not to suggest that there aren't methodological flaws to any particular study or the field of research as a whole, but the results are becoming consistent. The studies are also supporting one another, for example, neural systems of attention during meditation that have been identified are correlating with the performance on attention tasks and in the presence of distracting stimuli. All the results suggest that mindfulness and meditation are enabling the practitioner to become more aware of their thoughts and feelings which allows them to accept such thoughts and feelings in a non-judgmental fashion. This awareness and form of perception allows the practitioner to better focus their attention voluntarily and not be clouded by discursive thoughts which enhances their mindfulness. Due to this they have better conflict monitoring, alerting, and orienting which is supported by the scientific findings and is then related to different neural systems that are implicated in such attentional networks of monitoring and regulation.

There are several directions in which future research could go and there are extensive studies on meditation in different domains like immune functioning, emotional regulation, and pain tolerance as well as others. Regardless of which domain of meditation is being researched, reviews such as these are helpful in bringing related studies together and putting them back into the context in which they originally arose. In regards to meditation, this original context is the religious doctrine in which these techniques were developed. Even though there are some discrepancies in this field of research scientifically, the findings seem to support that doctrine in its original context which is at least a step forward to better understanding meditation and its benefits.

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