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# THE NEUROSCIENCE OF MINDFULNESS MEDITATION

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***ABSTRACT: Research over the past two decades broadly supports the claim that mindfulness meditation practiced widely for the reduction of stress and promotion of health — exerts beneficial effects on physical and mental health, and cognitive performance. Recent neuro imaging studies have begun to uncover the brain areas and networks that mediate these positive effects. However, the underlying neural mechanisms remain unclear, and it is apparent that more methodologically rigorous studies are required if we are to gain a full understanding of the neuronal and molecular bases of the changes in the brain that accompany mindfulness meditation.***

***KEYWORDS: Yoga, Mind power, Mindfulness, Meditation.***

## INTRODUCTION

Meditation can be defined as a form of mental training aimed at improving the core psychological capabilities of a person, such as attention and emotional self-regulation. Meditation comprises a family of diverse methods, including meditation on mindfulness, mantra meditation, yoga, tai chi, and chi gong1. Of these activities, over the past two decades, mindfulness meditation has gained the most attention in neuroscience studies, also characterized as non-judgmental attention to present-moment experiences [1]. While meditation research is in its infancy, a number of studies have examined changes in brain activity that are correlated with the practise of, or that accompany, training in meditation mindfulness (at rest and during specific tasks). In beginner and experienced mediators, healthy individuals and patient populations, these studies documented improvements in multiple aspects of mental function [2].

We consider the current state of research on mindfulness meditation in this study. We address the methodological problems facing the field and point to some gaps in current studies. Taking into account some important theoretical aspects, in light of what we agree are the key components of meditation practice, we then address behavioral and neuroscientific findings: attention management, emotion regulation and self-awareness [3]. Within this context, we explain research that, following mindfulness meditation training, has revealed improvements in behavior, brain function and brain structure. We address what has been learned so far from this analysis and

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introduce new research techniques for the field. We concentrate here on meditation methods for mindfulness and have omitted research on other forms of meditation. It is important to remember, however, that other meditation styles can operate through separate neural mechanisms [4].

## CHALLENGES IN MEDITATION RESEARCH

Findings on the impact of meditation on the brain are frequently recorded by the media enthusiastically and used to inform their practice by physicians and educators. Any of the observations have, however, not been replicated yet. Many researchers are themselves enthusiastic mediators. Although their insider insight can be useful for a deep understanding of meditation, these researchers need to make sure they take a critical view of the findings of the analysis. In fact, there is a reasonably strong bias towards the publication of positive or important results in meditation studies [5], as was seen in a meta-analysis. The methodological standard of many research studies on meditation is still relatively poor. Few of the longitudinal studies are actively monitored, and sample sizes are small. Many studies are still not based on elaborate hypotheses, as is common for a young research field, and conclusions are often drawn from post-hoc interpretations. Therefore, these conclusions remain preliminary and studies have to be carefully repeated. There are also some unique methodological problems facing meditation studies.

Cross-sectional versus longitudinal studies. Early meditation studies were mostly cross-sectional studies: that is, they compared data from a group of mediators with data from a control group at one point in time. These studies investigated practitioners with hundreds or thousands of hours of meditation experience (such as Buddhist monks) and compared them with control groups of non-mediators matched on various dimensions [6]. The rationale was that any effects of meditation would be most easily detectable in highly experienced practitioners. A number of cross-sectional studies revealed differences in brain structure and function associated with meditation (see below). Although these differences may constitute training-induced effects, a cross-sectional study design precludes causal attribution: it is possible that there are pre-existing differences in the brains of mediators, which might be linked to their interest in meditation, personality or temperament.

While correlation studies have attempted to figure out if more meditation experience is correlated with greater changes in the structure or function of the brain, such correlations can also not indicate that the changes have been triggered by meditation practise because it is likely that people with these unique brain characteristics can be attracted to longer meditation practise. More recent research has used longitudinal designs that compare data at several points of time from one or more groups and ideally include a control condition (preferably active) and random assignment to conditions [7]. Longitudinal studies are also relatively uncommon in meditation science. Some of these studies have examined the effects of mindfulness training for only a few days, while others have reviewed 1 to 3 months of programmes. Some of these studies have revealed changes in behavior, brain structure and function. A lack of similar changes in the control group suggests that

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meditation has caused the observed changes, especially when other potentially confounding variables are controlled for properly.

Meditators for novices versus meditators for experts. Although long-term meditators have been included in most cross-sectional studies, longitudinal studies are mostly carried out in beginners or naive subjects. Therefore, variations in cross-sectional and longitudinal research outcomes may be due to the various brain regions used during meditation learning versus those used during a learned skill's continued practice. Over a long-term period of practice, it would be important to observe subjects to assess if modifications caused by meditation training remain in the absence of continued practice. Such long-term longitudinal studies would [8], however, jeopardize feasibility constraints, and prospective longitudinal studies are likely to remain limited to relatively short training periods.

Control groups and interventions. It is important to control for variables that may be confounded with meditation training, such as changes in lifestyle and diet that might accompany the meditation practice or the expectancy and intention that meditation beginners bring to their practice. Researchers must carefully determine which variables are integral aspects of the meditation training and which can be controlled for [9]. Some earlier studies only controlled for the length of time that the individual has practiced meditation and the effects of repeated testing, but more recent studies have developed and included active interventions in control groups such as stress management education relaxation training or health enhancement programs that can control for variables such as social interaction with the group and teachers, amount of home exercise, physical exercise and psycho education. Therefore, these studies are better able to extract and delineate the effects specific to meditation. One study investigating short-term meditation training, for example, used a 'sham meditation' condition in which participants thought they were meditating, but did not receive proper instructions for meditation, allowing researchers to control factors such as the teacher's expectation, body posture and attention. Ideally, mechanistic studies need to use interventions that are as efficient as meditation on mindfulness in producing the beneficial effects on target variables, but which allow the unique mechanism underlying the practise of mindfulness to be evaluated [10].

Control conditions in functional imaging. Although all functional neuroimaging studies must use appropriate comparison conditions, this challenge is particularly important when imaging meditative states (BOX 2). The comparison condition should be one in which a state of mindfulness meditation is not present. Many studies use resting comparison conditions, but a problem with this is that experienced practitioners are likely to enter into a state of meditation when at rest. However, other active tasks introduce additional brain activity that renders the comparison difficult to interpret. Using imaging protocols that do not rely on blood-oxygen-level-

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dependent contrasts (BOLD contrasts), such as arterial spin labelling, might be a possible solution for this problem30.

## MINDFULNESS AND ATTENTION

Many meditation traditions emphasize the necessity to cultivate attention regulation early in the practice. A sufficient degree of attention control is required to stay engaged in meditation, and mediators often report improved attention control as an effect of repeated practice. Multiple studies have experimentally investigated such effects.

Attention is often divided into three different components: alerting (preparedness to prepare for an impending stimulus that involves tonic effects resulting from spending time on a task (vigilance) and phasic effects resulting from brain changes induced by warning signals or targets); orientation; and monitoring of conflicts (monitoring and resolution of conflict between computations in different neural areas, also referred to as executive attention). Combinations of these three components refer to other distinctions between types of attention. Sustained attention, for example, refers to the sense of vigilance during long-term tasks and may involve both tonic alerting and orientation, while either orientation or executive function may be involved in selective attention.

With the attention network test, performance in these three basic domains can be measured (ANT). This test uses an arrow pointing left or right as a target. The target is surrounded by flankers, and the subtraction of reaction times from reaction times to incongruent stimuli to congruent stimuli (that is, those indicated by the arrow on the side of the screen) produces a measure of time to resolve conflicts. The use of signs that indicate when or where the target will occur enables alerting and orienting to be assessed. These measures are used to quantify efficiency in each of the three networks that support the individual components of attention. Alerting involves the brain's noradrenaline system, which originates in the locus coeruleus. Orienting involves frontal and parietal areas, including the frontal eye fields and inferior and superior parietal lobe. The executive network involved in conflict resolution involves the ACC, anterior insula and basal ganglia.

## CONCLUSION

In the past two decades, interest in the psychological and neuroscientific investigation of mindfulness meditation has grown markedly. Studies suffer from poor methodological standards and present speculative post-hoc interpretations, as is generally usual in a new area of study. Therefore, knowledge of the mechanisms that underlie meditation's effects is still in its infancy. There is, however, emerging evidence that meditation on mindfulness could cause neuroplastic changes in the structure and function of brain regions involved in focus, emotion and self-awareness control. Further research needs to use longitudinal, randomized and actively controlled research designs and larger sample sizes to advance the understanding of the mechanisms of mindfulness meditation in regard to the interactions of complex brain networks, and needs to

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connect neuroscientific findings with behavioral data. If supported by rigorous research studies, the practice of mindfulness meditation might be promising for the treatment of clinical disorders and might facilitate the cultivation of a healthy mind and increased well-being.

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