An Exploration into the Effect of Mindfulness and Meditation on the Ageing of the Brain

To What Extent Does Mindfulness and Meditation Slow Down the Ageing Process of the Brain with Particular Reference to Alzheimer's Disease?

Psychology

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Table of Contents

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Introduction

Dementia is a term used for the typically age associated illness causing memory loss, disorientation and a range of other symptoms. Alzheimer's Disease falls into the category of dementia, and is named after a German psychiatrist and neurologist in the 1900's. While performing an autopsy on a deceased patient, he discovered the distinct 'clumps of protein [and] twisted bundles of fibre" (Orlando, 2019) now commonly known to be the attributes of a brain with Alzheimer's Disease. MRI studies have shown that grey matter concentration decreases with age from the age of 40 onwards. This loss of grey matter is associated with increased risk of developing dementia.

Since 2017, dementia has been the leading cause of deaths in the UK, overtaking: heart disease, strokes and lung cancer (Alzheimer's society, 2020). This trend is likely to continue for two reasons: firstly, dementia is predominantly age related in an ageing population, and secondly, there is currently no curative medical treatment.
However, non-pharmacological activities such as literacy and meditation have shown promise at delaying onset of age-related brain changes and therefore may possibly also slow the onset of dementia. (Wells, 2019)

There is evidence to suggest that the areas of the brain which are trained through the skill of meditation, are similar to those first affected in Alzheimer's Disease. However, unlike Alzheimer's disease, meditation increases the volume of the grey matter and

cortical thickness. This could indicate that meditation is a potentially protective factor against the disease.

This paper will discuss the evidence supporting the use of meditation in age related brain disorders, and compare it to other protective factors such as: level of literacy, religious practices and biological interventions.

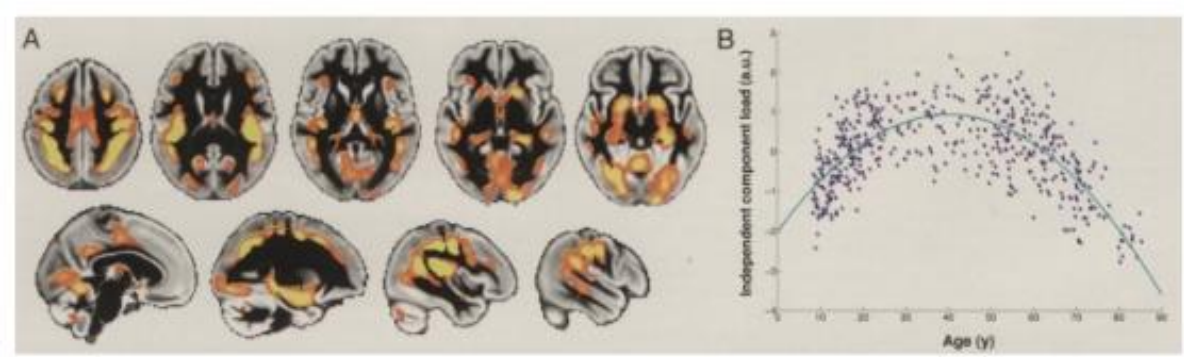
Areas of the Brain Affected by Age

Although the ageing process of the brain is not homogenous, a decrease in grey matter concentration, cortical thickness and brain activity are just some of the most common ways the brain ages with time. These changes often cause the last few years of someone's life to be filled with memory loss, confusion and ultimately lead to death in the form of dementia. This paper will explore the ways meditation could potentially show promise of becoming the modern treatment for the brains of our ageing population.

The Link between Age and Grey Matter Concentration

When looking at areas of grey matter and its link to the ageing process, Douaud et al in 2014, found that there was a strong correlation between age and concentration of grey matter. 484 healthy participants were compared by their age and their grey matter density and they found that between the age of 40-50, the concentration of grey matter in the brain starts rapidly decreasing.

Figure 1: Structural brain images using independent component analysis (Douaud et al, 2014)



Network of gray matter regions showing the inverted-U relationship with age. (*A*) Spatial network corresponding to the second age-related independent component IC4 (orange) overlaid on the gray matter average across all 484 healthy participants (thresholded for better visualization at $Z > 4$). Left is right. (*B*) Second age-related independent component IC4 load for each of the 484 participants plotted against age (quadratic fit is in turquoise; $P = 6 \times 10^{-73}$) (*SI Materials and Methods*). a.u., arbitrary unit. (Douaud et al, 2014)

The graph in Figure 1 clearly shows the rise of increasing grey matter concentration into one's late 30's. This mirrors the healthy developmental process of the brain. However, into the mid 40's, the grey matter concentration starts decreasing as the natural ageing process begins. This decrease of grey matter is linked to heightened vulnerability of ageing related mental disorders including Alzheimer's disease. It is plausible that individuals who have an increased grey matter concentration relative to age matched controls, may be less susceptible to developing age related illnesses.

The evidence presented, suggest that there is a link between age related loss of grey matter and the development of dementia. Interestingly, there may be an association between the practice of meditation and increase in grey matter concentration. Therefore, this paper explores the link between those who meditate throughout their lifetime and whether it may delay the onset of the age-related brain changes and possibly reducing the risk of developing Alzheimer's.

What is Meditation?

The use of meditation has been documented since 1500 BCE in India as a use for "training the mind," (Mead, 2020). It is used to clear the mind of distracting thoughts and destress the body by entering a deep relaxation focusing on breath or the understanding of our body which is known as mindfulness. Through research we now know that while practicing the act of meditation or mindfulness, the brain goes through a series of steps to reach the ultimate goal of deep relaxation. The evident process of meditation is a four-step cycle according to Ricard et al in 2014:

- The primary aspect of the cycle happens when first attempting to meditate and distraction occurs. This triggers an increased activity in the default-mode network (DMN). This network is involved with the recalling of memories and especially autobiographic episodic memories causing increased activity in specific areas in the cortex and inferior parietal lobe.
- The second phase is the acknowledging of the distraction and this is seen on fMRI scans as activating regions of the salience network. This network helps us to decide on an emotional level what is in our best interest and allows us to be self-aware.
- The third phase in the meditation cycle is when the distraction is identified and the brain begins to regain attention by disregarding any distracting stimuli.
- Finally, the last stage of the cycle is when the dorsolateral prefrontal cortex maintains a constant state of focus and the meditator retains focus on a single object or action (like breathing.)

Can Meditation Change the Cortical Thickness in the Brain?

In 2005 Lazar et al conducted a study on the changes meditation has on cortical thickness. A Magnetic Resonance Imaging (MRI) scan was taken of 20 participants who were experienced in the practice of meditation and 20 matched controls. In this particular study, the experienced participants were recruited from local meditation communities and had an average of 6 hours a week of meditation which they had been practicing for an average of 9 years. The MRI results showed an increased cortical thickness in the practicing meditator's brains in comparison to the control participants. This was predominantly seen in the prefrontal cortex and the right anterior insula.

These results suggest that brain regions associated with attention and sensory processing were thicker after years on practicing meditation. In Lazar et al's report they state that 'a large region of right anterior insula and right middle and superior frontal sulci corresponding approximately to Brodmann's area were significantly thicker in meditators than in the controls'. (Lazar, 2005)

However, further analysis of the right frontal sub region resulted in a significant difference in age and the increased cortical thickness. The control participants had experienced an age-related cortical thinning in the prefrontal cortical area. Whereas the matched meditators had the same cortical thickness of all areas of the brain including the pre frontal area. This mirrored the cortical pattern of younger participants who hasn't had not demonstrated age related changes.

In conclusion, the older participants who had been meditating had a similar brain structure to participants more than a decade younger than them rather than their age matched pair. (Lazar,2005)

This study highlighted how regular meditation may have a possible preserving effect on the brain by increasing cortical thickness. In turn, this may decrease the likelihood of developing typical age-related cortical thinning and the associated illnesses. This study was the first to identify structural evidence to suggest that experience-dependent cortical plasticity is associated with meditation practice. (Lazar, 2005.)

Lazar et al's, 2005 study also found significant changes in the left inferior temporal gyrus. Damage in these areas correlate to the common structural changes during Alzheimer's. However, like this study, Hölzel's 2011 study showed how meditation can increase the grey matter concentration in the left inferior temporal gyrus potentially reducing the natural brain damage associated with ageing.

Whilst we don't have any evidence directly linking meditation and the reduced risk of developing an ageing related clinical disorder, we can hypothesise that through meditation and increasing concentration of grey matter in the brain, we may be able to delay the onset of age-related changes in the brain.

Grey Matter Concentration

i) The Brain of a Vipassana Meditator

In 2008 Hölzel et al studied the MRIs of 20 mindfulness Vipassana meditators using voxel-based morphometry. Vipassana meditation is one of the earliest forms of

Buddhism practice originally from Southeast Asia. All the participants in the study had an average meditation practice of 2 hours a day for 8.6 years. Hölzel et al compared the participant's regional grey matter concentration to a control group of non-meditators in a matched pairs design similar in sex, age, education and handedness.

The meditating participants were found to have a greater grey matter concentration in the right anterior insula in comparison to the control participants. The insula - also known as the cortical hub – is responsible for goal directed thinking and conscious awareness (Borsook, 2016). Likewise, the meditation participants were also found to have a greater grey matter concentration in the left inferior temporal gyrus and right hippocampus. The temporal lobe is responsible for language and auditory processing (Trimmel, 2019) and the hippocampus is critical for learning and memory (Poldrack, 2003). This study explains the manner in which the brain of a meditator structurally differs from those who do not take part in ritual meditation.

However, the limitation of this study is that all the participants were long-term Vipassana meditators, and therefore meditate much more than any average meditator. Secondly, as there was no MRIs before the participants had started the practice of meditation, this may have been a self- selected group which already had high concentrations of grey matter allowing them to meditate for long periods. Although this study gives some evidence of a relationship between the structure of the brain and meditation, it does not answer whether there are other factors such as genetics which influence the concentration of grey matter and their ability to meditate.

ii) Grey Matter Concentration Pre-Post an MBSR Programme

In 2011 Hölzel et al conducted a study on changes in the brain's grey matter concentration in order to identify structural brain changes that may be associated with meditation. An MRI scan was performed on the brain in 16 healthy meditation naïve participants before and after an 8-week mindful-based stress reduction (MBSR) programme. The initial MRIs were taken of the participant's brain before they had an knowledge of meditation or mindfulness for a baseline comparison.

The programme taught the participants how to meditate effectively and allocated them time each day to meditate away from distractions. After the 8-week program the psychologists repeated MRI scans of all the participant's brains again and compared them to their previous MRI's before the programme and the MRI's of 17 control individuals.

The study found that the post MBSR program participants, had an increased grey matter concentration in the left hippocampus. Further brain analysis showed increases in the posterior cingulate, the temporo - parietal junction and the cerebellum in the meditation participants.

The results suggest that the training of MBSR has a correlation to the increased concentration in grey matter in the brain regions involved in learning, memory, emotion and the act of talking. This study is significant because it suggested that 8 weeks of mindfulness or meditation practice is enough to change the structure of the brain.

The study also used participants who were naïve to meditation, providing an indication of how the brain of a typical person would change if taking part in a meditation course. This study is also useful because it highlights that the structural changes seen in the

brains of the Vipassana meditators, correlates to similar changes in the population of naïve meditators in this study.

Although there is merit in the study's results, 16 participants is a small sample size which we can assume is due to the high cost of MRIs. The study is also assumed to be culturally bias since it was conducted with Western participants therefore generalising to a wider population is limited.

Finally, the study only shows that meditators have a higher grey matter concentration in comparison to non-meditators, however the study clearly suggests a correlation but it is harder to prove a causation. To investigate evidence of causation, there would need to be larger, randomised trials controlling for other associated factors such as age, genetics, education and cultural background.

iii) Grey Matter Concentration and the Brain of an Alzheimer's Patient

In 2008, Hölzel et al studied how the meditating participants had an increased grey matter concentration in the left hippocampus. In 2015, Thompson conducted a study looking at the grey matter concentration in Alzheimer's patients. It was found that the areas of the brain which first start corroding in patients are plastic regions such as the grey matter in the hippocampus and other 'plastic' regions. This means that grey matter concentration in Alzheimer's patients was found to be significantly lower than the concentration of healthy older participants.

Combining the findings of Douaud et al's (2014) study, with the knowledge that meditation increases the grey matter concentration and has a strengthening effect on the hippocampus, we can hypothesise that meditating may have a slowing or

preventative effect on the likelihood to develop Alzheimer's disease or other age-related brain defects.

Can Meditation Strengthen Brain Activity and the Immune System?

Clear features of an Alzheimer's patient's MRIs show clusters of immune cells where healthy neurons once thrived. Knowing this, we can hypothesise that a strong immune system may have beneficial effects on fighting disease and therefore reducing the likelihood of developing Alzheimer's disease.

In 2003 Davidson et al conducted a study with 25 healthy employees and monitored them over an 8 – week clinical training programme in mindfulness meditation. The researchers used a randomized, controlled study to examine the effects on the brain electrical activity and immune function pre and post the programme. They measured the brain electrical activity (EEG) of the participants and a control group before the programme, immediately after the programme and 4 months post the programme to evaluate the short and long term effects of the meditation training. In addition, all of the subjects and their matched controls received the influenza vaccine at the end of the programme, subsequently blood samples were taken 3-5 weeks and 8-9 weeks later to measure antibody levels in response to the vaccine.

Davidson's study (2003) showed a significant increase in the left-sided anterior activation of the EEG in the programme participants in comparison to the controls. Left sided anterior activation has been shown to be associated with a more adaptive response to stress. This may be relevant as chronic stress is one of the factors that is associated with an increased incidence of Alzheimer's disease (Wells, 2019).

At the end of the study Davidson et al (2003), found that the meditating participants had a higher concentration of antibodies in their blood than the control group. The

findings of this suggests that meditation not only affects the structure of the brain but may also impact on the function and additionally strengthens our immune system to fight flu and other diseases faster and more effectively. Again this study is very useful because it demonstrates how 8 weeks of meditation was associated with changes in the brain activity and on the immune responses of the participants.

The Accessibility of Meditation?

All of the studies referenced suggest that meditation and other spiritual or religious practices have a positive effect on the brain structure therefore, it was challenging to find any published studies that did not show a beneficial effect which probably reflects a bias to publish positive results. In order to present a balanced perspective, the researcher tried to identify publications highlighting negative or harmful effects of meditation. According to the research found by Newberg (2011) meditation's most common negative effect is frustration as mediation is an acquired skill which some master better than others. Meditation is also a skill which requires mastery and therefore can take years to fully learn and understand.

However, other studies such as Wells (2019) suggest that whilst meditation is an acquired skill, it can be learnt by most people including adults with mild cognitive impairments. This is important because it suggests that with the right teaching it is widely available to the population.

Harmful Effects of Meditation

On the other side of the argument there are cases of people in intense meditation which can cause the feeling of dissociation with people and their surroundings.

In 2017, Cabello et al conducted an online survey to assess the unwanted effects of meditation. There were 342 respondents who all had more than 2 months of meditation experience. 25% of participants reported some unwanted effects including anxiety (such as panic attacks) and pain (including headaches). However only 1.1% responded that the unwanted effects were severe enough to seek help or stop their meditation practice.

In conclusion based on the published evidence available it would appear that the potential benefits of meditation outweigh the harmful effects. It is possible that this reflects a publication bias and studies that which demonstrate the potential harmful effects of meditation have been withheld from publication.

Alternatives to meditation and mindfulness

i) Do Religious Practices Have the Same Effect on the Brain?

Newberg (2011) studied whether religious and spiritual practices - such as prayer or reading scriptures - also had an effect on how rapidly the brain aged. Newberg noted that any willful tasks that required a sustained attention were found to exercise the prefrontal cortex and the anterior cingulate cortex (Newberg, 2011, Ingvar, 1994; Frith et al, 1991; Posner and Petersen, 1990). Other activities such as prayer and reflection and require intense focus of attention result in the similar effect on the brain as meditation. Like meditation, religious practices which need full attention mentally, result in similar increases in cortical thickness and grey matter concentration.

The brain images of someone meditating show a clear increase of thalamic activity which is mediated by the neuro-transmitter glutamate. (Newberg, 2011). Glutamate is an essential neurotransmitter which helps to send messages between nerve cells in the brain. However, an overproduction of glutamate can have detrimental effects on the brain by causing damage to nerve cells. One of the most commonly used drug for treating Alzheimer's is memantine which works by protecting nerve cells from damage by blocking some of the effects of the glutamate. By regulating the production of glutamate meditation and other states of intense focus can reduce the risk of a surge of glutamate which causes the damage to the neurons.

In Newberg's research (2011) they found that glutamate is regulated when in a state of intense focus. This suggests that if someone were to meditated or pray frequently, over time their glutamate levels would be better regulated which would help prevent the formation of an overproduction which can lead to Alzheimer's disease.

Newberg (2011) looking at the practicing of Yoga Nidra meditation, also found that a surge of dopamine occurs in the blood when someone is in an intense attention focus. This demonstrates how powerful meditation and similar practices are in improving mental health but also regulating hormones. Dopamine is a well-known 'feel- good' neurotransmitter however, it has other benefits of boosting attention, learning and emotional responses. One of the symptoms of Dementia and Alzheimer's Disease can be a lack of emotional response. This may suggest that meditating in the early stages of the disease, could help emotional response and understanding to be improved.

Martorana and Koch (2014) studied how much of an effect dopamine levels affected Alzheimer's and found that the lack of regulating dopamine may also lead to Alzheimer's. Newberg's (2011) findings of dopamine being regulated through meditation, prayer or other spiritual practices, could suggest how the hormones

released when in meditation and other forms of intense focus, can potentially lower the chances of Alzheimer's disease.

ii) Can Education Reduce the Risk of Alzheimer's Disease?

In 2009, Ramakrishna discussed the correlation between someone's extent of vocabulary and how it correlated to the likelihood of then being diagnosed with clinical symptoms of Alzheimer's. Ramakrishna discusses the famous nun study done by David Snowdon which compared hand-written autobiographies of 93 nuns from the years 1931 to 1939.

Decades later, the neurologist separated the nun's autobiographies on whether they had later on in life been clinically diagnosed with symptoms of Alzheimer's and those who had showed no signs of Alzheimer's. By assessing the 'monosyllabic, multisyllabic and rarely used words in the autobiographies' (Ramakrishna, 2009) Snowdon found a correlation between the nuns who had used a wider, richer range of vocabulary in their 20's and those who had shown no signs of Alzheimer's in their later life.

This fascinating study gives us reason to believe that an advanced level of literacy and potentially high levels of education in general, could lead to the delaying the onset of this ageing disorder or preventing it entirely. The theory hypothesizes that since the brain develops most in the first couple of decades, it's capacity can be increased through plasticity of the brain associated with education and learning. This process is described as '[preserving] its cognitive capacity' (Ramakrishna, 2009).

However, the limitation of this study is that since all the participants were nuns, perhaps the reduced risk of Alzheimer's in some participants was due to their religious practices which have also been suggested to increase cortical thickness. The variation of the nun's genetics may also play a large role in the likelihood of Alzheimer's disease

and the ability to learn high levels of language. Perhaps some participants had a genetic predisposition allowing them to remember more complex language with an associated lower risk of developing Alzheimer's Disease.

iii) Biological Preventions

Laura Helmuth published an article discussing the possibility that taking painkillers for years prior to symptoms could reduce the risk of developing Alzheimer's disease. Although no clinical trials have been conducted, some scientists have suggested that the painkillers could work by '[preventing] hyperactive immune cells from targeting nearby neurons and destroying them' (Helmuth, 2002).

Knowing that Alzheimer's distinctive feature on an MRI is the crowd of immune cells clustered where healthy neurons once were, the theory behind this suggestion sounds reasonable but evidence would need to be identified to support this theory.

Currently, there are a range of drugs which are used to slow down the symptoms of Alzheimer's however, there is no cure for the disease. This means that once Alzheimer's disease starts affecting someone, the disease continues to worsen until death.

Conclusion

Overall, the effect that meditation has on the brain's structure, neurotransmitter efficiency, immune system and hormone regulations, all seem to have a positive impact on slowing down the ageing process of the brain. Multiple studies have been conducted and show evidence as to how a meditator's brain differs from a non-meditators brain and the results correlate to the changes which occur during Alzheimer's disease. Not only may meditation improve the brain's function in terms of

memory, emotional responses, language but also the body is found to boost the immune response when practicing meditation which is also a risk in the later years of someone's life.

But why use meditation? Unlike the other possible preventative measures for the brain - whether it be through education or a lifetime on painkillers - meditation is widely available and free of cost. Although there is no direct link between meditation and the protection of the brain from Alzheimer's Disease, we have seen how the mind of a meditator clearly shows increased grey matter, increased cortical thickness and increased brain activity which all correlate to reducing the likelihood of developing the first signs of Alzheimer's Disease.

However, as mentioned previously meditation is a skill and can take years to fully understand and use effectively. This means that although it is available and completely free of cost, it may be inaccessible for those who have a short concentration span, lack of time or a number of other reasons as to why it wouldn't work for them. In addition, the studies I have discussed either monitor those who have been meditating for years, or those who have been taught and given hours to meditate over an eight-week period. This means that individuals who can meditate for an hour a week or less, were not included in any of the studies.

Overall, there are several examples of the benefits of meditation but it is difficult to quantify how long meditation must be practiced before the beneficial factors are apparent. It is also not clear whether meditation must begin in the first few decades of life while the brain has the more neuroplasticity to demonstrate sustained effect.

Finally, it is also not possible to deduce whether the brain is permanently changed from meditation or whether it must be practiced constantly to maintain the slowing down of the ageing process.

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