Mindfulness and yoga meditation as influences on learning and well-being

Meditation interventions positively influence attentional control, emotion regulation, awareness and self-awareness in children, adolescents and adults. School interventions are being increasingly used to facilitate academic engagement and school success.

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Executive Summary

- Teaching and learning in schools have strong academic components, but also social and emotional factors. Social and emotional factors can facilitate or impede children's academic engagement, commitment and ultimate school success, and are crucial for well-being.
- Both attention- and activity-based meditation interventions such as mindfulness and yoga, respectively, have been suggested to positively influence attentional control, emotion regulation, awareness and self-awareness, cognitive functions that are at the core of both academic learning and well-being, by changing brain morphometry and function.
- Meditation techniques have also been suggested to be effective in managing classroom behaviour problems and improving students' ability to focus attention, as well as in decreasing stress and anxiety and improving self-confidence, social and emotional confidence, and well-being.
- Meditation interventions may induce changes in brain morphometry and function in several areas such as the cerebral cortex, subcortical grey and white matter, brain stem and cerebellum, whose functionality correlates with reported benefits in children, adolescents and adults.
- Findings on the effects of meditation on the brain are often reported enthusiastically by the media and practitioners but, although interventions in children, adolescents and young adults hold promise, particularly in relation to improving cognitive performance and resilience to stress, the diversity of study samples and controls, variety in implementation methodologies and exercises, and the wide range of instruments used to quantify the results make it very difficult to draw very specific conclusions and thus they have to be carefully interpreted.
- As empirical evidence shows a link between teachers' well-being and students' outcomes, meditation interventions for educators have been proposed as a form of professional development to better manage the demands of teaching and to decrease stress and burnout.

Social and emotional education for academic learning and well-being: a possible role for meditation

Teaching and learning in schools have strong academic, social and emotional components[1]. Emotions can facilitate or impede children's academic engagement, commitment and ultimate school success. Because interpersonal relationships and emotional states affect how and what is learnt, the 4th United Nations Sustainable Developmental Goal (Quality Education)[2] empowers educational systems and schools to address these aspects of the educational process for the benefit of all students. Unfortunately, many students become less connected to school as they progress from elementary to middle and on to high school, and this lack of connection negatively affects their academic performance and behaviour[3], among other factors. There is broad consensus among educators, policy makers and the public that educational systems should produce students who are not only proficient in core academic subjects but as citizens are also able to work well with others from diverse backgrounds, in socially and emotionally skilled ways, and behave responsibly and respectfully[2,4]. In other words, schools have an important role to play by fostering not only children's cognitive development but also their social and emotional development.

It has been suggested that school-based efforts to promote students' social and emotional learning (usually abbreviated as SEL) can contribute to children's success in school and through life[5-8]. Several meta-analyses have revealed that SEL interventions effectively enhance positive youth development[5,6]. In most of the experiments reported, participants in SEL interventions fare significantly better than controls in social-emotional skills, attitude and indicators of well-being, regardless of students' ethnicity, socioeconomic background or school location. Interestingly, research also indicates that effective mastery of social-emotional competencies is associated with better academic performance. Conversely, the failure to achieve competence in these areas is associated with a variety of personal, social and academic difficulties[5,6].

Similarly, research over recent decades suggests that both attention-based meditation such as mindfulness and activity-based meditation systems such as yoga, tai-chi and chi gong, among others, which are widely practiced for the reduction of stress and promotion of health, exert beneficial effects on sociality and emotionality, as well as on cognitive performance[9]. Mindfulness meditation is often defined as the awareness that arises through intentionally attending to one's moment-to-moment experience in a non-judgemental and accepting way[10], although what practitioners do under this label may vary widely. Activity-based meditation systems such as yoga consist of a series of poses, meditation and controlled breathing to

positively affect mental states[11], and again what practitioners do under this label may vary widely. In this regard, meditation is considered a form of mental training that aims to improve an individual's core psychological capacities, such as attentional and emotional self-regulation[12].

Although meditation research is in its infancy, a number of studies have investigated changes in brain morphology and activation associated with the practice of meditation or following training in meditation[e.g.13-18], which may influence behavioural aspects that are crucial for effective learning, such as awareness and self-awareness, attention control and emotion regulation[6,9,19]. Although different kinds of meditation programs and different approaches to teach meditation exhibits particular characteristics, individual studies and meta-analyses have demonstrated brain effects of both attention-based and activity-based meditation practices, in areas involved in reward processing and learning, attention and memory, awareness and sensory integration, self-referential processing, emotional processing and self-control[20]. For example, it has been reported that mindfulness practices act on the brain regions involved in body awareness, attention and the integration of emotion and sensory processing, whereas yoga meditation appears largely to influence those brain areas involved in self-control, social cognition, language, speech, tactile stimulation, sensorimotor integration and motor function[20].

In this brief, effects and potentialities of meditation interventions on social, emotional and academic performance will be discussed in the light of scientific and pedagogical research. The brief will focus mainly on mindfulness (attention-based meditation) and yoga (activity-based meditation). It is not the intention of this brief to explain and discuss particular ways to apply specific programmes or interventions based on meditation in schools, but to discuss scientific evidence supporting their alleged benefits for an integrated education, promoting not only academic learning and excellence but also social and emotional skills, fostering well-being.

Controversies and limitations in meditation research

For thousands of years, ancient Eastern contemplative practices have been used to deepen self-awareness. In recent times, these practices are increasingly being used all over the world, mainly to reduce stress, enhance well-being, improve coping, and increase cognitive skills and neuroplasticity[e.g.6,9,19]. This led, in 2016, to yoga being recognised as an Intangible Cultural Heritage of Humanity by UNESCO[21].

Despite the increasingly wide use of meditation practices in schools (see below), research in this field is somewhat controversial. Findings on the effects of meditation on the brain are often reported enthusiastically by the media and used by educators and practitioners to inform their work. However, some findings have not yet been replicated and many researchers involved in meditation research are themselves practitioners which, it has been suggested, can interfere with the critical overview of the results and interpretations drawn from them[9]. It has even been reported that, as in many other fields, meditation studies show a bias towards the publication of positive or significant results[19]. Moreover, although there are some common themes and similar conclusions emerging from extensive reviews of meditation studies, there still seems to be some lack of consensus on neural networks that can be identified as meditation's main targets of action, and very few have been done in children and adolescents. This could be due to a number of reasons, including the variety of exclusion and inclusion criteria used in reviews and meta-analyses, the kind of meditation practice analysed, the tests and techniques used to identify possible differences with controls and the duration of the interventions[20].

It has been said that most meditation studies are cross-sectional rather than longitudinal[9]. That is, they compare data from a group of experienced meditators with data from a non-meditator control group, at one point in time. The rationale is that any effects of meditation would be most easily detectable in highly experienced practitioners. However, although these differences may constitute training-induced effects, it is possible that there are pre-existing differences in the brains of meditators which might be linked to their interest in meditation or to their personality and temperament[22,23], making it difficult to distinguish between cause and effect.

Longitudinal studies, that compare data from one or more groups at several time points, are still relatively scarce in meditation research[6,9]. Among these studies, some have investigated the effects of meditation training over just a few days or up to 1 to 3 months of interventions. Interestingly, some of these studies have revealed changes in behaviour, brain structure and function as compared with controls, suggesting that meditation may be the cause of the observed changes[e.g.14,18,24-30]. For ethical reasons, however, most studies of meditation interventions in schools lack controls, as children or adolescents that could have been used as controls may not have been afforded the same opportunities as their counterparts involved in the active research (although, of course, there are ways around this, especially for short-duration interventions, as for example wait-list controls in which the intervention is done latter). Thus, although meditation-based

interventions in children, adolescents and young adults hold promise, particularly in relation to improving cognitive performance and resilience to stress, as will be discussed below, the diversity of study samples and controls, the variety in implementation and exercises and the wide range of instruments used make it very difficult to draw very specific conclusions and thus they have to be carefully interpreted[31]. However, despite the controversies, meditation interventions are being increasingly used in schools to reduce students' stress and to enhance emotional, social and academic learning, as well as to increase well-being[e.g.9,14].

School interventions

Many studies have established a causal relationship between a student's academic self-concept, academic interest and academic performance[32], to the point where academic self-concept is considered to be a key element in a student's future success[33,34]. In this regard, it has been said that a high self-concept contributes to scholastic success which, in turn, favours development of a positive self-concept[35,36], in a feedback mode. Other studies have shown that the higher a student's positive self-concept is, the better their motivational conditions such as anxiety, concentration and aptitude for schoolwork are, and the stronger the study and deep-learning strategies they use. This then feeds back into a positive self-concept, favouring a student's use of more cognitive learning strategies, thereby facilitating more profound, elaborate information processing[37].

It has been demonstrated that some of the most negative factors affecting learning and school engagement from early childhood to young adulthood are high levels of stress and anxiety[38,39], which also influence behaviour, leading to a high predisposition towards low mood, depression and anger[40,41], among others. Here, meditation techniques have shown their effectiveness in improving psychological effects of distress in its various forms such as anxiety, worry and emotional discomfort[42-44], depression[45] and poor general wellness[46], as well as in enhancing social skills[47] and improving self-concept[48] (the personal knowledge of who we are, encompassing our thoughts and feelings about ourselves physically, personally, and socially, and also including our knowledge of how we behave, our capabilities, and our individual characteristics).

In the sphere of education, interventions based on meditation techniques such as mindfulness or yoga have been demonstrated to be effective in managing classroom behaviour problems and improving students' ability to focus and sustain attention[4][9]. Several different studies have been performed in either children, adolescents or young adults. To cite some examples, in primary school it has been reported that mindfulness interventions significantly improve children's schoolwork[50], favour emotional regulation and positive behaviours[51] and reduce feelings of helplessness and anger[52]. Similarly, yoga interventions have been shown to modestly increase attention in children displaying Attention Deficit Hyperactivity Disorder-Inattentive Type[53]and thus that it can be used complementary to behavioural interventions (but not as a treatment by itself).

It has also been reported that the use of yoga and relaxation among children with emotional and behavioural difficulties and at risk of exclusion improved self-confidence, social confidence, communication and contributions in class[54]. In this regard, it is worth noting that early interventions help to the prevention of problem behaviours in children during their educational journey[55]. However, other works[56] found no significant differences in the study's primary outcomes regarding self-worth and perceptions of well-being, although conversely, children participating reported less negative behaviour in response to stress and had better behavioural balance than a comparison group, which has led to the suggestion that a possible function of the practice, in this case, of yoga, is to improve children's own perceived well-being[56]. Other significant studies that should be mentioned have shown that in elementary school children meditation may improve executive function skills with a greater improvement in children with poorer initial executive function[57] and improve selective attention but not sustained attention[58], and that in adolescents may produce a decline in negative emotions and somatic complaints, and a rise in the scale of calm, relaxed and self-accepting emotions[59].

At secondary school, it has been reported that mindfulness may improve students' academic performance as well as all self-concept dimensions and well-being and may decrease stress and anxiety states and traits[60-63]. Moreover, it has been reported to affect the hypothalamic-pituitary-adrenal (HPA) axis hormones, including cortisol and adrenaline[63]. The HPA axis integrates physical and psychosocial influences in order to allow an organism to adapt effectively to its environment, use resources and optimize survival[64]. Interestingly, the HPA axis is also involved in the neurobiology of mood disorders and functional illnesses, including anxiety disorder, insomnia, post-traumatic stress disorder, attention deficit hyperactivity disorder, depressive disorders and burnout, among others, all of which impair learning and decrease well-being[65]. This is especially relevant considering that adolescence is often accompanied by an increase in stress and depression[66]. In this regard, students with learning disabilities, defined exclusively by compromised academic performance, often have higher

levels of anxiety, school-related stress and less optimal social skills compared with their typically developing peers[e.g.67,68]. It has also been shown that mindfulness meditation may lessen anxiety, promote social skills and improve academic performance among adolescents with learning disabilities[69]. Similarly, it has been reported that mindfulness-based programmes in pre- and early adolescence may increase optimism, social and emotional competences, and well-being[70].

Other significant studies of adolescents that should be mentioned have detected a decrease in stress[71], significant improvements in coping, self-concept and self-esteem, empathy and social competence[60], a slight decrease of ego-resilience and an increase of well-being[72], following meditation interventions. Interestingly, it has also been shown that students with low self-concept gain the greatest improvement in self-concept, students with high anxiety state benefit from the greatest reduction of anxiety status and students with medium trait anxiety benefit the most regarding trait anxiety[73]. In young adults it has also been shown that university students that practiced mindfulness twice a day raised their academic performance[74], although it cannot be discarded that student who can commit to doing anything consistently for twice a day for some amount of time are more prone to rise academic performance. In summary, evidence suggests that meditation-based interventions are beneficial for children, adolescents and young adults, enhancing self-regulation and coping, emotional and social competences, decreasing stress and anxiety and increasing well-being, aspects that together are crucial for effective learning and education.

Neuroscience behind meditation practices

Several dozen studies have investigated changes in brain morphometry and function related to different meditation practices, mostly made in young adults or adults. These studies vary in regard to the meditation tradition under investigation and the measurement tools used to investigate effects on brain morphometry and functions[e.g.6,9]. Moreover, some studies have also investigated correlations between brain changes and other variables related to behaviour, such as stress reduction[15], emotion regulation[17] or increased well-being[75]. Because these studies vary regarding study design, measurement and type of meditation, it is not surprising that the locations of reported brain changes are diverse and cover multiple regions which include different areas of the cerebral cortex, subcortical grey and white matter, brain stem and cerebellum, suggesting that the effects of meditation might involve large-scale brain networks.

Attention-based meditation (mindfulness)

As reported above, mindfulness meditation is often defined as the awareness that arises through intentionally attending to one's moment-to-moment experience in a non-judgemental and accepting way[10]. First, it is important to distinguish between dispositional (or trait) and intentional mindfulness. Dispositional mindfulness can be defined as the mindfulness an individual typically experiences in daily life[76], as opposed to intentional mindfulness, which requires specific interventions. Dispositional mindfulness, commonly measured via the Five Facet Mindfulness Questionnaire[77,78], has been positively associated with self-reported optimism, life satisfaction, empathy, positive affect, vitality, sense of autonomy and self-esteem[79,80], as well as with the personality traits of agreeableness (i.e., a tendency to be sympathetic and affectionate) and conscientiousness (i.e., a tendency to be thorough and deliberate)[81]. Conversely, it has been reported to be negatively associated with depression, distress, anxiety, rumination and difficulties with emotion regulation[79,80], as well as with neuroticism (i.e., a tendency to be anxious and moody)[81]. Brain imaging research on dispositional mindfulness also suggests that it facilitates emotion regulation[9,82], that it can modulate neural systems associated with arousal[83] and cognitive control of negative emotions[84] and that it may predict lower cortisol responses to acute social stressors[85]. In other words, brain changes due to specific interventions may depend on the original state of an individual, supporting the observation that students with low self-concept show the most improvement in self-concept, students with high anxiety state benefit the most in anxiety status and students with medium trait anxiety benefit the most regarding trait anxiety (see above).

Intentional mindfulness meditation affects brain morphometry and functionality in meditators, with nine brain regions consistently found to have been altered: (1) the frontopolar cortex, which might be related to enhanced meta-awareness following meditation practice; (2) the sensory cortices and (3) insula, areas that have been related to body awareness; (4) the hippocampus, a region of the limbic system that is related to memory processes; (5) the anterior cingulate cortex; (6) the mid-cingulate cortex and (7) orbitofrontal cortex, which are known to be related to self- and emotion regulation; and (8) the superior longitudinal fasciculus and (9) corpus callosum, which are involved in intra- and inter-hemispherical communication[19].

Thus, the above reported data suggest that mindfulness interventions positively influence attentional control, emotion regulation, awareness and self-awareness, by changing brain morphometry and functionality[6,9], cognitive functions that are

at the core of both academic learning and well-being. Regarding attentional control, improved conflict monitoring was reported in several studies[86-90]. The brain region to which the effects of mindfulness training on attention are most consistently linked is the anterior cingulate cortex[25,91], which is known to enable executive attention and control[92,93]by detecting the presence of conflicts emerging from incompatible streams of information processing. Other attention-related brain regions in which functional changes have been observed following mindfulness meditation include the dorsolateral prefrontal cortex, where responses are enhanced during executive processing[94].

It has also been suggested that emotion regulation is positively influenced by mindfulness interventions. It refers to strategies that can influence which emotions arise, when and how these emotions are experienced and expressed, and how long they persist for. Several suggested processes may be involved, such as attentional deployment (i.e., attending to mental processes, including emotions), cognitive change (i.e., altering typical patterns of appraisal regarding one's emotions) and response modulation (i.e., decreasing harmful levels of suppression)[95]. It has been shown that mindful emotion regulation works by strengthening prefrontal cognitive control mechanisms and thus downregulates activity in regions relevant to emotion processing, such as the amygdala[96,97]. Self-reporting studies, neuroimaging and measurement of peripheral physiology have reported various positive effects such as a decreased physiological reactivity and facilitated return to emotional baseline after response to a stressor, decreased self-reported difficulties in emotion regulation[98], reduction in emotional interference by unpleasant stimuli[99], improved positive mood states[18,100]and lowered intensity and frequency of negative affect[101,102].

Finally, with respect to awareness and self-awareness, mindfulness training has been reported to influence the activity and cortical thickness of the insula[103,104]. Given its known role in awareness[105], it has been suggested that this might represent amplified awareness of the present-moment experience. Mindfulness interventions have also been associated with more positive self-representation, higher self-esteem (i.e., a person's overall sense of self-worth or personal value) and higher acceptance of self[106] through the default mode network[107], which is known to be involved in self-referential processing. The default mode network is a large-scale brain network known for being active when a person is not focused on the outside world and the brain is at wakeful rest, such as during daydreaming and mind-wandering, as well as when the individual is thinking about others or about themselves, remembering the past or planning for the future[108]. It includes the medial prefrontal cortex, posterior cingulate cortex, anterior precuneus and inferior parietal lobule[109,110], which have been suggested to support diverse mechanisms by which an individual can project themselves into another perspective[111].

Activity-based meditation (yoga)

Although most of the brain regions described as changing their morphology or enhancing their activity during or after yoga practice are common also to mindfulness meditations, some are suggested to be unique to activity-based meditation. As reported above, yoga consists of a series of poses, meditation and controlled breathing to positively affect mental states[11], thus more actively involving the whole body. It has been said that yoga interventions activate brain areas involved in meta-awareness, i.e., the frontopolar cortex; sensory awareness, i.e., sensory cortex and insula; attention, i.e., the anterior and mid-cingulate; memory, i.e., the hippocampus; and emotion regulation, i.e., orbitofrontal cortex[19].

Most of these regions are involved in self-control, social cognition, language and speech, tactile stimulation, sensorimotor integration and motor function, and they can broadly be thought of as subserving wilful acts and movement, as well as social processes. For example, the dorsolateral prefrontal cortex is well known for its role in cognitive and executive functions, and more specifically, it has been implicated in the evaluation of rewards, working memory, sense of agency and self-control[112-116]. Activation of the dorsolateral prefrontal cortex resulting from activity-based meditation is in line with numerous studies suggesting improvements in mood, depression, anxiety and stress resulting from specific yoga practices[117-119]. The medial prefrontal cortex has been suggested to be uniquely related to active meditation styles. It plays a major role in social cognition[120], most notably in making self/other judgements[121].

Several other key regions that have also been suggested to be uniquely activated during active-type meditative practices are those subserving language, tactile stimulation and movement, such as the superior temporal lobe, an area of the brain that is involved in language, spatial processing and social perceptions[123]; the paracentral lobule, involved in language and speech[124]; and the precentral gyrus, which is involved in articulation, speech, hand movements and tactile stimulation[125,126]. In the same way, effects on the postcentral gyrus and superior parietal lobe are also suggested to be unique to activity-based meditations. The postcentral gyrus is largely involved in sensory and motor functions[127]. The parietal lobe is involved in attention and visual shifts, coordination of visual to motor information and higher-order processes that give rise to positioning of the body[128-131]. It is critical for sensorimotor integration[132] and is closely related to working memory[133,134].

Finally, there is also some evidence suggesting that yoga is associated with endogenous dopamine release in the ventral striatum, a major area of the brain's reward system[135]. Dopamine is a neurotransmitter that is implicated in feelings of pleasure and craving, reward learning, motivation, mood and responses to novel stimuli[136,137], suggesting a link between the physiological and behavioural responses to activity-based meditation interventions affecting mood, stress reduction and motivation.

Taken together, the data reported for attention- and activity-based meditation interventions, with the necessary precaution given the controversies arising (see above for a discussion on the controversies in meditation research), suggest a link to beneficial effects on children, adolescents and young adults in school engagement and learning, acting on attentional control, emotion regulation, awareness and self-awareness.

Meditation intervention for teachers

Teachers play a central role in creating a classroom climate that fosters student learning and social and emotional well-being, and thus teacher stress and burnout are an ongoing challenge in education. Empirical evidence continues to accumulate that speaks to the important connection between teachers' well-being and student outcomes[138,139]. Positive classroom environments, including positive student–teacher relationships, are indeed critical for student well-being and learning outcomes. As for teachers, meditation interventions such as mindfulness and yoga have been proposed as a form of professional development to manage the demands of teaching[140]. There is some research looking at meditation interventions on teachers to reduce stress and burnout. For example, it has been reported that after mindfulness training teachers show greater focused attention and working memory capacity, as well as lower levels of occupational stress and burnout[141]. Similarly, yoga and mindfulness training may significantly benefit educators' positive affect, classroom management, distress tolerance and stress-awakening response, and educators have found meditation interventions feasible and beneficial as a method for managing stress and promoting well-being[142,143].

Conclusions

In summary, despite the heterogeneity of reports published to date and the fact that more research is needed to disambiguate ongoing controversies, current evidence suggests that both attention- and activity-based meditation interventions influence brain morphology and function, and that both may be beneficial for children, adolescents, young adults and teachers. Both are suggested to enhance self-regulation and coping, which are central to the management of psychological symptoms associated with stress, and thus to benefit learning, commitment, academic success and well-being, acting on attentional control, emotion regulation, awareness and self-awareness. However, although findings on the effects of meditation on the brain morphology and function used to be reported enthusiastically by the media and practitioners, interventions in children, adolescents and young adults have to be carefully interpreted due to the diversity of study samples, variety in implementation methodologies and exercises, and the wide range of instruments used to quantify the results. Further research is clearly needed to disambiguate current controversies.

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