

Chapter 2

The Neurophysiological Background

Abstract This chapter begins by providing a schematic review of the neuro-physiological background for the development of a set of capacities e.g. cognitive flexibility, meta awareness and emotional regulation. This includes a brief account of the evidence based scientific studies showing that we *can* change—i.e. that the adult human brain is plastic enough. We have our biological set up, and it is probably a pre-requisite that we are getting to know our limitations as well as our possibilities, in order to perform the changes that are warranted. Then we turn to the question of *how* to bring about such changes. In this chapter we examine the changes that regular mental training in the form of meditation can have on the adult brain and behavior.

Keywords Neuroplasticity • Attention • Mind-wandering • Meditation • Compassion

2.1 Introduction

The combination of the increasing flow of information in society, on the one hand, and our relatively meagre cognitive capacities and emotional repertoire, on the other, effectively stops us from living as good and happy life as we could. Our collective failure to process the information and then make responsible decisions based on our conclusions¹ has disastrous consequences. We harm ourselves, each other and the planet. Although there are several very advanced examples of how

¹Sheena, I. (2011). The art of choosing.

e.g. “big data” could be handled in efficient ways,² in order to facilitate decision-making, it seems as we have a long way to go before such methods could be used seamlessly in everyday life. Evidently, it is not enough to make the right decision on occasion, but also to be able to persist in choosing the necessary new habits which might be connected to ones “valued direction”.³ At the same time one has to adapt to an ever changing environment (as well as ultimately be a co-creator of this environment).

As made clear in Chap. 1 humans would have much to gain from improved decision-making. In other words—the *why* question is answered. To become more skilled in this domain—for example less biased, more able to assess risk and better at epistemic deference—would be beneficial both for the individual and the collective. Concrete examples of cognitive capacities, which plausibly could contribute to responsible decision-making are cognitive flexibility, meta awareness and emotional regulation. These and other candidates will be further explored in the next chapters.

But before we can turn to the *how* (i.e. the main question of this book) we need to provide a schematic introduction of the neurophysiological background for the development of such cognitive capacities. We start with a brief account of the evidence based scientific studies showing that we *can* change (i.e. that the adult human brain is plastic enough) and then we turn to look at some techniques for prompting such change.⁴

2.2 Neuroplasticity

The adult human brain is affected by environmental changes and pressures, physiologic modifications and experiences, which lead to functional and structural reorganization, i.e. *neuroplasticity*. The paradigm of neuroplasticity is

²Manyika, J., Chui, M., Brown, B., Bughin, J., Dobbs, R., Roxburgh, C., ... & McKinsey Global Institute. (2011). Big data: The next frontier for innovation, competition, and productivity. Lampitt, A. (2013). ‘The real story of how Big Data analytics helped Obama win’. *Think big data-infoworld*. Himelfarb S. (2014) Can big data stop wars before they happen? *Foreign Policy*. One of the first and most well-known applications for big data is the flu spotting algorithms developed by Google together with The Centers for Disease Control and Prevention. Ginsberg, J., Mohebbi, M. H., Patel, R. S., Brammer, L., Smolinski, M. S., & Brilliant, L. (2009). Detecting influenza epidemics using search engine query data. *Nature*, 457(7232), 1012–1014. Also in neuroscience extremely large amounts of data from e.g. neuroimaging-behavioral experiments are derived and analyzed in relation to functionality vs locality and connectivity.

³With “valued direction” we here mean the individuals valued direction in life. See also Chap. 1.

⁴Evidently the argument that some changes in the brain (as described here) can—to an extent—be connected to improvement in behavior rests on some assumptions on the possibility of free will and moral responsibility. The larger philosophical discussion on this falls well outside the scope of this volume but for a very interesting account of an agency cultivation model (of how holding someone morally accountable for their actions and the effects of practices matters when it comes to cultivating moral agency) see Vargas, M. (2013). *Building better beings: A theory of moral responsibility*. Oxford University Press.

fundamentally altering a long-held belief that changes in the central nervous system is only possible during critical periods during early development, although some forerunners discussed this possibility decades ago.^{5, 6, 7} It is the mechanism for learning and for growth and development,⁸ but also for effects of severe deprivation.⁹

Over the last decades novel neuroimaging techniques have been used to unravel experience dependent plasticity, and the number of studies is growing continuously. Hence, we have learnt a lot about the mechanisms of plasticity and the relations between brain activity and behaviour.

It seems that formation of new pathways is possible only following initial reinforcement of pre-existent connections. Possible plastic changes are limited by existing connections, which are the result of genetically controlled neural development and are ultimately different across individuals. Reinforcement of existing connections, on the other hand, is the consequence of environmental influences, such as education, training, observing others or an enrichment of the environment.¹⁰

There are different modes in how this reinforcement influences the shape and function of the brain. One example from animal studies is how the outside world impacts on rats, which dates back to the 1940s, when Donald Hebb showed that free range rats (compared with the ones in standard lab cage) after some weeks in

⁵Already in 1783 Bonnet and Vincenzo discovered that dogs and birds that had been trained had an increase of cerebellar “folds”, a finding that at that time did not change the idea that the brain was unchangeable. Doidge, N. (2007). *The brain that changes itself: Stories of personal triumph from the frontiers of brain science*. Penguin.

⁶More than a decade later James (1890) in *The Principles of Psychology* introduced the term plasticity to the neurosciences in reference to the susceptibility of human behaviour to modification: Plasticity [. . .] means the possession of a structure weak enough to yield to an influence, but strong enough not to yield all at once. Each relatively stable phase of equilibrium in such a structure is marked by what we may call a new set of habits. Organic matter, especially nervous tissue, seems endowed with a very extraordinary degree of plasticity of this sort; so that we may without hesitation lay down as our first proposition the following, that the phenomena of habit in living beings are due to the plasticity (William James, 1890, *The Principles of Psychology*, Habit, Chap. 4, p. 68).

⁷Kheirbek, M. A., & Hen, R. (2013). (Radio) active neurogenesis in the human hippocampus. *Cell*, 153(6), 1183–1184.

⁸Pascual-Leone, A., Amedi, A., Fregni, F., & Merabet, L. B. (2005). The plastic human brain cortex. *Annu. Rev. Neurosci.*, 28, 377–401.

⁹Mehta, M. A., Golembo, N. I., Nosarti, C., Colvert, E., Mota, A., Williams, S. C., ... & Sonuga-Barke, E. J. (2009). Amygdala, hippocampal and corpus callosum size following severe early institutional deprivation: the English and Romanian Adoptees study pilot. *Journal of Child Psychology and Psychiatry*, 50(8), 943–951.

¹⁰There is an emerging field of connectivity studies, where complex networks are being conceptualized, parallel to the development of both measurement methods and algorithms for analysis of the huge amounts of data these studies are producing. Sporns, O. (2013). The human connectome: origins and challenges. *Neuroimage*, 80, 53–61.

his home had superior problem solving abilities, such as maze running.¹¹ The term “environmental enrichment” was later used to describe this phenomenon, which seems to be of special importance and powerful when the environment is stimulating, novel and spurs exploration. It seems also that it is of importance that the exercise is voluntary: to generate neuronal changes the animal must decide to enter e.g. the exercise wheel and run in it.¹² In humans it is harder to perform ethically sound studies where only one group will receive the stimulation of enriched environments. However, increasing evidence from observational studies point to that greater involvement in intellectual and social activities is linked to a slower cognitive decline, in elderly populations,¹³ but also aerobic exercises has been shown to be of benefit for brain volume in aging humans.¹⁴

Maguire et al. demonstrated that experience shapes the human brain in a study of London taxi drivers. The drivers’ detailed knowledge of London’s street plan was reflected in enlarged posterior hippocampi (an area of importance for memory storage) and the size of the hippocampi correlated with the number of years spent driving taxi.¹⁵ In a longitudinal study investigating juggling training over a three-month period, an increase of grey matter in the visual motion areas was shown.¹⁶ Wollet and Maguire again studied taxi drivers, but this time they captured data at the beginning and at the end of the drivers 3–4 years training. Increased posterior hippocampi were only observed in trainees who qualified the tests, but not in trainees who failed.¹⁷

Musical training induces cortical plasticity and increases functional connectivity between areas in the brain.¹⁸ The learning of more abstract information has also

¹¹Pickren, W., & Rutherford, A. (2010). A history of modern psychology in context. Hoboken, NJ: Wiley.

¹²Van Praag, H., Kempermann, G., & Gage, F.H. (1999). Running increases cell proliferation and neurogenesis in the adult mouse dentate gyrus. *Nature Neuroscience*, 2(3), 266–270.

¹³Nyberg, L., Lövdén, M., Riklund, K., Lindenberger, U., & Bäckman, L. (2012). Memory aging and brain maintenance. *Trends in Cognitive Sciences*, 16(5), 292–305.

¹⁴Colcombe, S. J., Erickson, K. I., Scalf, P. E., Kim, J. S., Prakash, R., McAuley, E., ... & Kramer, A. F. (2006). Aerobic exercise training increases brain volume in aging humans. *The Journals of Gerontology Series A: Biological Sciences and Medical Sciences*, 61(11), 1166–1170.

¹⁵Maguire, E. A., Gadian, D. G., Johnsrude, I. S., Good, C. D., Ashburner, J., Frackowiak, R. S., & Frith, C. D. (2000). Navigation-related structural change in the hippocampi of taxi drivers. *Proceedings of the National Academy of Sciences*, 97(8), 4398–4403.

¹⁶Draganski, B., Gaser, C., Busch, V., Schuierer, G., Bogdahn, U., & May, A. (2004). Neuroplasticity: changes in grey matter induced by training. *Nature*, 427(6972), 311–312.

¹⁷Woollett, K., & Maguire, E. A. (2011). Acquiring “the Knowledge” of London’s layout drives structural brain changes. *Current biology*, 21(24), 2109–2114.

¹⁸Lappe, C., Herholz, S. C., Trainor, L. J., & Pantev, C. (2008). Cortical plasticity induced by short-term unimodal and multimodal musical training. *The Journal of Neuroscience*, 28(39), 9632–9639. Pinho, A. L., de Manzano, Ö., Fransson, P., Eriksson, H., & Ullén, F. (2014). Connecting to Create: Expertise in Musical Improvisation Is Associated with Increased Functional Connectivity between Premotor and Prefrontal Areas. *The Journal of Neuroscience*, 34(18), 6156–6163.

been shown to be associated in neuroplasticity. After intensive studying for an exam, increases in grey matter volume was shown in several regions in medical students, and three months of language learning resulted in increased cortical thickness in frontal and temporal regions, as well as an increase in hippocampal volumes.¹⁹ However, there are also negative studies that did not show any structural changes in grey matter after training. One explanation of these negative results is related to the type of interventions.

Mental simulation of movements activates some of the same central neural structures required for the performance of the actual movements.²⁰ In doing so, mental practice alone may be sufficient to promote the plastic modulation of neural circuits placing the subjects at an advantage for faster skill learning with minimal physical practice, presumably by making the reinforcement of existing connections easier and perhaps speeding up the process of subsequent sprouting and consolidating of memories. Pascual Leone in a seminal experiment with piano playing, showed that *mental* practice resulted in a similar reorganization of the cortical motor outputs to the one observed in the group of subjects that physically practiced the movements.²¹

Recent neuroimaging studies have shown that mental images are accompanied by processes which, in some respects, are similar to those involved in the initial perception of *sensory* events, and in recalling those images from autobiographical memory.²² One example is that visual mental imagery can activate areas in early visual cortex e.g. when making comparative judgments of imagined shape.²³

2.3 Attention

The capacity to focus one's attention was defined by William James as "the sudden taking possession by the mind, in clear and vivid form, of one of what seems simultaneously possible objects or trains of thought".

Goleman (2013) describes the two main varieties of distractions of our attention: sensory and emotional, where the sensory can be seen as "an endless wave of

¹⁹Mårtensson, J., Eriksson, J., Bodammer, N. C., Lindgren, M., Johansson, M., Nyberg, L., & Lövdén, M. (2012). Growth of language-related brain areas after foreign language learning. *Neuroimage*, 63(1), 240–244.

²⁰Decety J, Ingvar DH. 1990. Brain structures participating in mental simulation of motor behavior: a neuropsychological interpretation. *Acta Psychol. (Amst.)* 73:13–34.

²¹Pascual-Leone, A., Nguyet, D., Cohen, L. G., Brasil-Neto, J. P., Cammarota, A., & Hallett, M. (1995). Modulation of muscle responses evoked by transcranial magnetic stimulation during the acquisition of new fine motor skills. *Journal of neurophysiology*, 74(3), 1037–1045.

²²Holmes, E. A., & Mathews, A. (2010). Mental imagery in emotion and emotional disorders. *Clinical psychology review*, 30(3), 349–362.

²³Kosslyn, S. M., Ganis, G., & Thompson, W. L. (2001). Neural foundations of imagery. *Nature Reviews Neuroscience*, 2(9), 635–642.

incoming stimuli your brain weeds out from the continuous wash of background sounds, shapes and colours, tastes, smells and sensations etc.”. He describes the emotional loaded signals as a much more daunting, and harder to divert from, especially if it comes from close relationship turmoil. This signalling is also an example of what neuroscientists call “bottom-up” processes—information from the peripheral nervous system processed by lower brain areas, and often never reaching the level of conscious experience (some researchers do also include e.g. pharmaceutical products affecting the body unconsciously, although expectations when ingesting a medicine is known to be very powerful, and demonstrated in many experiments on placebo).

The opposite would be top-down processes, a voluntarily act of task/goal directed behaviour, and the quote above from James (1890) also indicates that there is a voluntary part of the attentional process.

It is also interesting to note that the brain cannot distinguish real stimuli or threats from the one we only think of.²⁴ This results in that our inner thought processes will feed fruitless ruminating processes in obsessive loops, unless we come up with tentative solutions and then can let those distressing thoughts go. The ability to inhibit emotions and stay on target is connected to better performance, and operates in the prefrontal lobes.²⁵

The ability to prevent distraction depends on the current level of attentional control activity in frontal cortex,²⁶ and also on a suppressive mechanism that reduces the salience of potentially distracting factors. This has popularly been called an “anti-distraction mode” in our brain, and means that focusing on a chosen object is not only about intentionally paying attention to it, but also suppressing as many distractions in the background as possible.

2.4 Mind-Wandering

Mind-wandering (sometimes referred to as task-unrelated thought) is described as the experience of thoughts not remaining on a single topic for a long period of time, and tends to occur during driving, reading and other activities where vigilance may

²⁴Gilbert, P., Baldwin, M. W., Irons, C., Baccus, J. R., & Palmer, M. (2006). Self-Criticism and Self-Warmth. An Imagery Study Exploring their Relation to Depression. *Journal of Cognitive Psychotherapy*.

²⁵Begley, S., & Davidson, R. (2012). *The emotional life of your brain*. Hachette UK.

²⁶Gaspar, J. M., & McDonald, J. J. (2014). Suppression of salient objects prevents distraction in visual search. *The Journal of Neuroscience*, 34(16), 5658–5666.

be low. It is connected to what William James called the train of thought and the stream of consciousness.²⁷

The phenomenon of when the mind starts “wandering” is related to some negative outcomes, such as worsening in comprehension when students are tested.²⁸ At a first glance also our emotions seem to be negative during mind-wandering, according to the “Track your happiness” study, where several thousands of volunteers answered a plethora of question delivered at random times at their smart-phones.²⁹ Ruminating over the past while mind-wandering is linked to negative mood. When studying mind-wandering during functional imaging (fMRI) the behavioural activity of the mind is mirrored by an activity in the “default mode network³⁰” engaging the medial prefrontal cortex, but when being in an executive mode, other areas are activated (e.g. anterior cingulate cortex and dorsolateral prefrontal cortex).

However, it seems as if also this kind of almost “in-attention” can be very useful. Although the prefrontal cortex may be used during this mind-wandering in a, for our awareness unfocused way, it sometimes results in a surprising problem solving outcome. Especially if one has an interesting musing, that is related to a positive emotion during mind-wandering.³¹

²⁷“Consciousness, then, does not appear to itself chopped up in bits. Such words as ‘chain’ or ‘train’ do not describe it fitly as it presents itself in the first instance. It is nothing jointed; it flows. A ‘river’ or a ‘stream’ are the metaphors by which it is most naturally described. *In talking of it hereafter let us call it the stream of thought, of consciousness, or of subjective life.*” James, William (1890), *The Principles of Psychology*. p. 239.

²⁸Smallwood, J., Fishman, D. J., & Schooler, J. W. (2007). Counting the cost of an absent mind: Mind wandering as an underrecognized influence on educational performance. *Psychonomic Bulletin & Review*, 14(2), 230–236.

²⁹Killingsworth and Gilbert, (2010) A Wandering Mind Is an Unhappy Mind. *Science*. Vol. 330 no. 6006 p. 932.

³⁰“The DMN is a large-scale brain network defined by the temporal correlation between two core regions on the medial surface of the cortex, known as the posterior cingulate and medial prefrontal cortex. These regions form the core of the DMN and interact with subnetworks. Meta-analyses have shown that the core of this system tends to be engaged in self-referential processes, the medial temporal subsystem is engaged by episodic processes, and the dorsal medial subsystem is engaged by social processes. Together, these forms of thought are similar to the content of the self-generated thoughts that often occur during mind wandering, providing important evidence for the involvement of these regions in the mental content that occurs during mind wandering.” Smallwood, J., & Schooler, J. W. (2015). The science of mind wandering: empirically navigating the stream of consciousness. *Annual review of psychology*, 66, 487–518.

³¹Franklin, M. S., Mrazek, M. D., Anderson, C. L., Smallwood, J., Kingstone, A., & Schooler, J. W. (2013). The silver lining of a mind in the clouds: interesting musings are associated with positive mood while mind-wandering. *Frontiers in psychology*, 4.

2.5 Emotional Regulation

Attention is also of major importance for emotional self-regulation,³² and this is underlined in several scientific disciplines, where emotional regulation is described as critical to general wellbeing.^{33, 34}

If one is able to notice one owns emotion, and also to some extent influence the emotional self-regulating process, that can potentially facilitate decision making processes.³⁵ This regulation habit can however also go astray. We as a species characteristically make efforts to control emotion, and if we experience emotions being too unpleasant, we will use strategies in order to avoid them, a behaviour which has been described as “experiential avoidance”. Avoiding the experience of tough and anxiety-related thoughts and feelings, and the associated diminished range of choices and behaviours, has in turn been shown to be associated to a significant number of problems, such as increased social withdrawal and impaired ability to handle stress.³⁶ So, the ability to both identifying emotions and notice the tendency to avoid the unpleasant ones provides a useful base for a successful emotional regulation.

Emotional regulation starts early. For an everyday example consider how infants already at 3–6 months of age can be soothed from distress induced by the presentation of novel objects.³⁷ Such external cues to re-orienting are one of the ways parents/caregivers support their child to develop self-regulation. This also has a neural basis in the network that is involved in orienting to sensory events, which is accompanied by the alerting network, involved in achieving and maintaining the alert state.

³²Frank, D. W., Dewitt, M., Hudgens-Haney, M., Schaeffer, D. J., Ball, B. H., Schwarz, N. F., ... & Sabatinelli, D. (2014). Emotion regulation: Quantitative meta-analysis of functional activation and deactivation. *Neuroscience & Biobehavioral Reviews*, 45, 202–211.

³³Bandura, A., Caprara, G. V., Barbaranelli, C., Gerbino, M., Pastorelli, C. (2003). “Role of Affective Self-Regulatory Efficacy in Diverse Spheres of Psychosocial Functioning”. *Child Development* 74 (3): 769–82.

³⁴Emotions are defined as broadly integrative systems ordering feeling, thought and action, and representing the output of information processing assessing the meaning or affective significance of events for the person. LeDoux, J. E. (1989). Cognitive-emotional interactions in the brain. *Cognition & Emotion*, 3(4), 267–289.

³⁵Gross, J. J. (2002). “Emotion regulation: Affective, cognitive, and social consequences”. *Psychophysiology* 39 (3): 281–91. Miclea, M, Miu, A. (2010). “Emotion Regulation and Decision Making Under Risk and Uncertainty”. *Emotion* 10 (2): 257–65.

³⁶Hayes, Steven C.; Wilson, Kelly G.; Gifford, Elizabeth V.; Follette, Victoria M.; Strosahl, Kirk (1996). “Experiential avoidance and behavioral disorders: A functional dimensional approach to diagnosis and treatment”. *Journal of Consulting and Clinical Psychology* 64 (6): 1152–68. See also Chap. 1, p 4, for a description of experiential avoidance.

³⁷Harman, C., Rothbart, M. K., & Posner, M. I. (1997). Distress and attention interactions in early infancy. *Motivation and Emotion*, 21(1), 27–44.

A shift in control from the brain's orienting network to the executive network (which functions to monitor and resolve conflicts between other brain networks) happens when the child is between 3 and 4 years old.³⁸ The shift contains the evolving abilities to ignore distractions, inhibit responses and impulses, and the ability to plan. With increasing self-awareness, both metacognitive (thinking about thinking) and meta-emotion (noticing, and understanding the stream of feeling and impulses³⁹) skills can be developed. Those together can be described as self-management, where executive attention enables us to focus on to one thing and ignore others.⁴⁰ The strategic allocation of attention has also been shown to be of importance when testing self-restraint against instant gratification. In a series of seminal studies referred to as the “Marshmallow Test”, Mischel et al.⁴¹ invited four-year-olds to study their ability to resist the lure of a marshmallow, and could show that the ones who could delay the gratification of eating a marshmallow, as a reward got an extra marshmallow after 15 min had higher scores on measures of executive control, especially the reallocation of attention. At follow up, during several decades, it has been elucidated that these abilities link to development over the life course and predict many outcomes (e.g. SAT scores, social and cognitive competence, educational attainment and drug use) (Mischel 2014). In their forties, there were also differences in neuronal processing when impulse control was tested during fMRI studies, with a greater involvement of higher cortical areas in the “delayer”.

So, what happens in the human brain when we are able to delay gratification? What seems to be needed is an ability to voluntarily disengage from the object which should be “avoided”, then let our focus prevail elsewhere and resist to gravitate back to the desired object, and remember the reward or goal that awaits in the future.⁴² Some amount of self-awareness and meta-skills seem also to facilitate this process.

³⁸Rothbart, M. K., Sheese, B. E., Rueda, M. R., & Posner, M. I. (2011). Developing Mechanisms of Self-Regulation in Early Life. *Emotion Review*, 3(2), 207–213.

³⁹The opposite would be *alexithymia*, the inability to identify and describe emotions in the self. FeldmanHall, O., Dalgleish, T., & Mobbs, D. (2013). Alexithymia decreases altruism in real social decisions. *Cortex*, 49(3), 899–904.

⁴⁰Executive control varies between individuals, and a heritability has been shown. Fan, J., Wu, Y., Fossella, J. A., & Posner, M. I. (2001). Assessing the heritability of attentional networks. *BMC neuroscience*, 2(1), 14.

⁴¹Mischel, W., Shoda, Y., & Rodriguez, M. L. (1989). Delay of gratification in children. *Science*, 244, 933–938. In the follow up study 59 subjects underwent a behavioral study, and a brain imaging study on a sub-group from the behavioral study (N = 27) was performed: Casey, B. J., Somerville, L. H., Gotlib, I. H., Ayduk, O., Franklin, N. T., Askren, M. K., ... & Shoda, Y. (2011). Behavioral and neural correlates of delay of gratification 40 years later. *Proceedings of the National Academy of Sciences*, 108(36), 14998–15003.

⁴²See also section on Focused Attention Meditation below.

2.6 Mental Training—Meditation

At long last, it is time to examine the changes that regular mental training in the form of e.g. meditation can have on the adult brain and behavior. In nearly all major religions and also in several philosophical traditions, different forms of meditation have been a core part of their practice (Zajonc 2009).

One way of defining meditation is the cultivation of basic human qualities, such as a more stable and clear mind, emotional balance, cognitive flexibility and a sense of compassion—qualities that can remain more or less latent, but also could be developed by regular practice.⁴³

We will discuss three examples of practices where meditation is a core component. In this process we have chosen to restrict our references regarding biological effects of the practices to the structural and functional neuroimaging studies, which now enhance our understanding of the neural processes associated with meditation.⁴⁴ We would also highlight that “traditional Buddhist formulations describe meditation as a state of relaxed alertness that must guard against both excessive hyperarousal (restlessness) and excessive hypoarousal (drowsiness, sleep). The impression is that modern applications of meditation have emphasized the hypoarousing and relaxing effects without as much emphasis on the arousing or alertness-promoting effects. However, there are findings that suggest that the course of meditative progress exhibits a nonlinear multiphasic trajectory, such that early phases that are more effortful may produce more fatigue and sleep propensity, while later stages produce greater wakefulness as a result of neuroplastic changes and more efficient processing” (Britton et al. 2014).

2.6.1 Focused Attention Meditation

The development of attention skills is one of the central components of many meditation traditions such as mindfulness meditation practice.⁴⁵ The aim of training of attention skills is e.g. to enhance the capability to sustain non-judgmental awareness of one’s thinking patterns, emotions, and sensory perceptions, and to

⁴³A common way to start meditating is by assuming a comfortable physical posture. A “self-priming” of the mind is often recommended, such as instilling a wish for an increased self-knowledge in order to develop the skills mentioned above. Stabelizing of the mind, which often is unfocused and disturbed by a never-ending inner chatter, is a major objective. Debarnot, U., Sperduti, M., Di Rienzo, F., & Guillot, A. (2014). Experts bodies, experts minds: how physical and mental training shape the brain. *Frontiers in human neuroscience*, 8. Ricard, M., Lutz, A., & Davidson, R. J. (2014). Mind of the Meditator. *Scientific American*, 311(5), 38–45.

⁴⁴Marchand, W. R. (2014). Neural mechanisms of mindfulness and meditation: Evidence from neuroimaging studies. *World journal of radiology*, 6(7), 471.

⁴⁵Slagter, H. A., Davidson, R. J., and Lutz, A. (2011). Mental training as a tool in the neuroscientific study of brain and cognitive plasticity. *Front. Hum. Neurosci.* 5:17.

centre it in the present moment, while developing the capacity to be vigilant to both inner and external distractions.⁴⁶ Malinowski et al. have developed a model of how the training of attention skills is thought to underpin emotional and cognitive flexibility, bringing about the ability to maintain non-judging awareness of one's own thoughts, feelings, and experiences in more general terms. They also imply how performance increases described above are reflected as changes in neural activity and underlying neural architecture. Hasenkamp et al. describes four cognitive cycle intervals relevant for meditation: mind wandering, awareness of the wandering of one's mind, varying of attention, and prolonged attention.⁴⁷ As one practices the flexible shifting of attention, for instance, from attention to the breath to attention to sounds, cognitive flexibility is also increased (for more on cognitive flexibility see Chap. 4). When attaining sharp focus, key circuitry in the prefrontal lobes gets into a synchronized state, "phase-locking".⁴⁸

This is especially interesting as metacognitive abilities develop during childhood and adolescence as the prefrontal cortex matures and executive functions develop. An increase of meta-skills due to meditation has been described, and it could be hypothesized that the number of possible metacognitive levels is related to e.g. the working memory capacity and effectiveness of the central executive.⁴⁹

The study of performance during an fMRI adapted stress task, which requires impulse and attention control showed that meditation improves efficiency, perhaps by enhancing the ability to sustain attention and control impulses.⁵⁰ Also working memory functioning (which is impaired by e.g. stress) has been shown to be positively affected by meditation practices.⁵¹

⁴⁶We are aware of that selecting just one single capacity, attention, of course will lead to a simplified description of a rather complex process, but we do it for pedagogical reasons. For example, as focused attention and open monitoring conceptually can be separated, even simple forms of mindfulness training will entail both components. Malinowski, P. (2013). Neural mechanisms of attentional control in mindfulness meditation. *Frontiers in neuroscience*, 7.

⁴⁷Hasenkamp, W., Wilson-Mendenhall, C. D., Duncan, E., & Barsalou, L. W. (2012). Mind wandering and attention during focused meditation: a fine-grained temporal analysis of fluctuating cognitive states. *Neuroimage*, 59(1), 750–760.

⁴⁸Slagter, H. A., Lutz, A., Greischar, L. L., Nieuwenhuis, S., & Davidson, R. J. (2009). Theta phase synchrony and conscious target perception: impact of intensive mental training. *Journal of Cognitive Neuroscience*, 21(8), 1536–1549.

⁴⁹Brefczynski-Lewis, J. A., Lutz, A., Schaefer, H. S., Levinson, D. B., & Davidson, R. J. (2007). Neural correlates of attentional expertise in long-term meditation practitioners. *Proceedings of the national Academy of Sciences*, 104(27), 11483–11488. Jankowski T, Holas P. Metacognitive model of mindfulness. *Conscious Cogn*. 2014 Jul 16; 28C: 64–80.

⁵⁰Kozasa, E. H., Sato, J. R., Lacerda, S. S., Barreiros, M. A., Radvany, J., Russell, T. A., ... & Amaro, E. (2012). Meditation training increases brain efficiency in an attention task. *Neuroimage*, 59(1), 745–749.

⁵¹Working memory is the system that is responsible for the transient holding and processing of new and already stored information, an important process for reasoning, comprehension, learning and memory updating. Jha, A. P., Stanley, E. A., Kiyonaga, A., Wong, L., & Gelfand, L. (2010). Examining the protective effects of mindfulness training on working memory capacity and affective experience. *Emotion*, 10(1), 54.

2.6.2 Open Monitoring, E.G. in Mindfulness Training

Mindfulness has been described as a state of consciousness, experiencing the present moment, both external stimuli and a meta-awareness of one's internal thoughts and emotions without judging or trying to change the present. "The awareness that emerges through paying attention on purpose, in the present moment, and nonjudgmentally to the unfolding of experience moment by moment".⁵² Mindfulness has its roots in eastern traditions and Buddhist practices but was adapted to a secular context free of religious components, and it may be developed during meditation and experienced during one's daily life.⁵³ The program *mindfulness based stress reduction* (MBSR) was developed by Jon Kabat-Zinn decades ago and was introduced in psychology and medicine as a coping resource for anxiety, stress and chronic pain.

Under stress, our capacity to see the perspective of others (theory of mind), to keep a sharp focus of the bigger picture (central coherence), and to be flexible and organize information and behaviour (executive functioning) is hampered.⁵⁴ In mindfulness training, participants become aware of signs of stress in their body, and by taking, for instance, a 3-min breathing space, a mini-meditation in which one gets out of automatic pilot and into the present moment,⁵⁵ stress may reduce and the perspective may be widened. In an ambitious study Catherine Kerr et al. studied the diaries of participants of a MBSR program, and discovered (after an initial resistance towards the experiences displayed by the training) the emergence of an observing mind, after about 5–6 weeks of practice.⁵⁶ In the eastern traditions meta-experiences has been described as the core component of the phenomenon called "the beginner's mind".⁵⁷

⁵²Kabat-Zinn, J. (2003). Mindfulness-based interventions in context: past, present, and future. *Clinical psychology: Science and practice*, 10(2), 144–156.

⁵³Williams, J. M. G. (2008). Mindfulness, depression and modes of mind. *Cognitive Therapy and Research*, 32(6), 721–733.

⁵⁴Brosschot J.F. (2010) Markers of chronic stress: Prolonged physiological activation and (un) conscious perseverative cognition. *Neuroscience and Biobehavioral Reviews* 35: 46–50. Liston C., McEwen B.S., Casey B.J. (2009) Psychosocial stress reversibly disrupts prefrontal processing and attentional control. *Proc Natl Acad Sci USA* 106: 912–917.

⁵⁵Segal ZV, Williams JM, Teasdale JD (2012) *Mindfulness-based cognitive therapy for depression: a new approach to preventing relapse*. The Guilford Press.

⁵⁶Kerr, C. E., Josyula, K., & Littenberg, R. (2011). Developing an observing attitude: an analysis of meditation diaries in an MBSR clinical trial. *Clinical Psychology & Psychotherapy*, 18(1), 80–93.

⁵⁷Suzuki, S. (2010). *Zen mind, beginner's mind*. Shambhala Publications.

2.6.3 Compassion

The capacity to notice suffering and act compassionate in the broad sense (to others and oneself).⁵⁸

Emotional regulation, which is disrupted in most mental disorders, has been shown to improve after mindfulness training.⁵⁹ Some clinicians argue that it is wise to actually start meditation practice with compassion training,⁶⁰ in order to increase the functioning of the “self-soothing” system and thereby enable the meditator to face difficult experiences which might come with the increase of focused attention abilities.

Recent behavioural and neurophysiological research vindicates that having one’s emotions resonate empathetically with the feelings of another person, and of compassion really differ. Compassion (and altruistic love) is associated with positive emotions, and to merely empathetically resonate with others (or one owns memories of) suffering can initiate processes of emotional exhaustion or burnout, in fact, a kind of empathy fatigue, or an emotional shut down.⁶¹ An example of how such experiments are performed is a series of studies from Tania Singers group at Max Planck Institute in Leipzig (Klimecki et al. 2014).

About 60 volunteers were divided into two groups. One group meditated on love and compassion, and the others were instructed to cultivate feelings of empathy for others. After a week of compassion meditation, participants had more positive feelings while looking at video clips with suffering people. The other group who had solely cultivated empathy, experienced emotions that resonated with the sufferings of the subjects shown in the video clips, but these shared emotions also resulted in negative feelings and thoughts, and the empathy cultivation group exhibited significant more distress.

The compassion practice entailed noticing suffering in others (and one-self) and a cultivating of attitudes and feelings of loving kindness and compassion toward other people, whether they are close relatives, strangers or enemies, as well as to receive compassion from others, and for one self.

⁵⁸This definition also differentiates compassion from empathy, which refers to the vicarious experience of another’s emotions. Lazarus R. (1991). *Emotion and adaptation* Oxford University Press. However, we acknowledge that research on compassion is complex, not least due to the different scientific understandings of the topic. For an excellent overview, see Goetz, J. L., Keltner, D., & Simon-Thomas, E. (2010). Compassion: an evolutionary analysis and empirical review. *Psychological bulletin*, 136(3), 351.

⁵⁹Hofmann, S. G., Sawyer, A. T., Witt, A. A., & Oh, D. (2010). The effect of mindfulness-based therapy on anxiety and depression: A meta-analytic review. *Journal of consulting and clinical psychology*, 78(2), 169.

⁶⁰Gilbert, P. (2010). *Compassion focused therapy: Distinctive features*. New York, NY: Routledge.

⁶¹Bellini, L. M., Baime, M., & Shea, J. A. (2002). Variation of mood and empathy during internship. *Jama*, 287(23), 3143–3146.

Research suggests that a specialized affect regulation system (or systems) underpins feelings of reassurance, safeness and well-being. It is believed to have evolved with attachment systems and, in particular, the ability to register and respond with calming and a sense of well-being to being cared for.⁶² This affect regulation system is poorly accessible in people with high shame and self-criticism, in whom the ‘threat’ affect regulation system dominates orientation to their inner and outer worlds. When psychology professor Paul Gilbert noticed that his patients had a lot of shame, self-criticism and self-attacking he responded by developing a therapy that draws on evolutionary, social, developmental and Buddhist psychology, and neuroscience, which is called Compassion focused therapy.⁶³ The aim is to help people develop and work with experiences of inner warmth, safeness and soothing, via compassion and self-compassion. It should be noted that this type of self-compassion is distinctly different from e.g. self-esteem, or pity.^{64, 65} The skill we want to highlight here is a robust, trainable and stable capacity, which in its most pure form is not particularly vulnerable to external circumstance (e.g. other people’s opinion, trends in society, social pressure etc.). It has to do with identity and self-awareness. It is in-ward looking—I am both capable and willing to accept what type of person I am (my potential and my limitations) but it is also outward looking as it also relates and regulates how I am interconnected with other beings. This idea fits well with some interpretations of virtue ethics on which virtue ethics contains a distinctly forward looking element. Very briefly the idea is as follows; because I know who I am I can also contemplate my personal development (in relation to my environment) i.e. what type of person I aspire to be and how to get there.⁶⁶

⁶²Gilbert, P. (2009). Introducing compassion-focused therapy. *Advances in Psychiatric Treatment* 15: 199–208.

⁶³“Compassion focused therapy (CFT) is rooted in a functional analysis of basic social motivational systems. During human evolution a range of cognitive competencies for reasoning, reflection, anticipating, imagining, mentalizing evolved, as well as a socially contextualized sense of self. These new competencies can cause major difficulties in the organization of (older) motivation and emotional systems. Our evolved brain is therefore potentially problematic because of its basic ‘design,’ being easily triggered into destructive behaviours and mental health problems. CFT highlights the importance of developing people’s capacity to (mindfully) access, tolerate, and direct affiliative motives and emotions, for themselves and others, and cultivate inner compassion as a way for organizing ourselves in prosocial and mentally healthy ways”. Gilbert, P. (2010). *Compassion focused therapy: Distinctive features*. New York, NY: Routledge. Gilbert, P., Clark, M., Hempel, S., Miles, J.N.V. & Irons, C. (2004) Criticising and reassuring oneself: An exploration of forms, styles and reasons in female students. *British Journal of Clinical Psychology*, 43, 31–50.

⁶⁴Neff, K. D., & Vonk, R. (2009). Self-compassion versus global self-esteem: Two different ways of relating to oneself. *Journal of personality*, 77(1), 23–50.

⁶⁵Smeets, E., Neff, K., Alberts, H., & Peters, M. (2014). Meeting Suffering With Kindness: Effects of a Brief Self-Compassion Intervention for Female College Students. *Journal of clinical psychology*, 70(9), 794–807.

⁶⁶This will be expanded on in Chap. 5 but the reader should note already here that this line of argument does not imply that the virtues are instrumental to the good life. Rather, there is a little means and a lot of ends in all the virtues.

2.7 Some Challenges with Meditation Practice and Research

So far we have presented a rather bright picture of the possibilities with meditation practices. Evidently, there are also many problems attaching both to practice and how to measure results in a scientific way. Below follows a discussion on some key challenges with meditation practice and meditation research.

2.7.1 *Small Groups*

In applied meditation research, participants are often randomized to either a meditation training group or a “wait-list” control group in which there is no training. Both groups undergo comparable testing before and after the period of time taken for the meditation training condition. It is of importance to remember that the studies we cite are based on group statistics: even when there is a strong positive outcome in favor of the meditation group, not every single individual in the meditation group experiences a positive response. The differences between groups are often not that large.

2.7.2 *Not so Blind*

Furthermore, participants can never be truly blind to the condition in which they have been randomized. Those in the training condition are likely to be biased toward different *expectations* e.g. the potential benefit (or lack thereof).⁶⁷ In addition, they might (often subconsciously) be motivated to seek to please the teacher. It is not possible to disentangle such bias from the specific effects of the meditation practice itself and, unfortunately, many of the available experimental studies of meditation in applied settings have employed this kind of research design. That said, alternative designs are of course possible. One good example is studies where participants are randomly assigned to a meditation training condition versus another training condition, such as physical exercise, didactic instruction, or simple muscle relaxation training. Meditation and other active training condition can be carefully equated for such things as amount of training, amount of home practice, credibility and enthusiasm of instructors. These kinds of randomized

⁶⁷This was described by Landsberger already in 1950. The Hawthorne effect is a phenomenon in which individuals improve an aspect of their behavior in response to their awareness of being observed. Henry A. Landsberger. (1958). *Hawthorne Revisited*, Ithaca. McCarney R, Warner J, Iliffe S, van Haselen R, Griffin M, Fisher P; Warner; Iliffe; Van Haselen; Griffin; Fisher (2007). “The Hawthorne Effect: a randomised, controlled trial”. *BMC Med Res Methodol* 7: 30.

active control research designs are being increasingly employed and yielding critically important new data.⁶⁸

2.7.3 *Decreased Well-Being*

It is also important to remember that it is highly unlikely that someone who signed up for a meditation class and joined all of these various studies cited above would actually demonstrate all of the benefits seen across all of the different meditation groups being studied. Just in terms of the law of averages, we would actually expect that some people in the meditation group not to benefit from meditation and others might even experience a temporarily increase in anxiety, or have their performance decreased by the practice.

Negative side-effects of meditation practice are very seldom reported, but there is an increasing awareness of such risks.⁶⁹ There might be some publication bias towards positive effects, as there are several small published studies, which might be biased towards the intervention being tested. The question of opportunity cost (i.e. the time spent in meditation might outcompete other valuable, virtuous activities) is rarely mentioned in the published studies.

2.7.4 *Other Issues*

These are far from the only issues that contemplative science has to deal with. Additional challenges include: How best to assess the subjective experience of meditation practitioners? How to define and measure mindfulness? How to define and measure compassion? How to overcome the inherent biases in self-report measures, and how to best interpret data from modern brain imaging/neurophysiology methods?⁷⁰

On a brighter note, there are, as seen in this chapter well-documented effects of both mindfulness and compassion practices for both healthy subjects struggling

⁶⁸Kazniak A. 2014 Huffington post. www.huffingtonpost.com/al-kazniak/progress-and-challenge-in_b_6083478.html.

⁶⁹Dimidjian, S., & Hollon, S. D. (2010). How would we know if psychotherapy were harmful? *American Psychologist*, 65(1), 21. This study examines examples where psychotherapy has caused serious harm to a patient, and highlights the value of creating standards for defining and identifying when and how harm can occur at different points in psychotherapy. It has inspired research on side effects of meditation, which is now increasingly investigated and e.g. reported in this article: Compson, J. (2014). Meditation, Trauma and Suffering in Silence: Raising Questions about How Meditation is Taught and Practiced in Western Contexts in the Light of a Contemporary Trauma Resiliency Model. *Contemporary Buddhism*, (ahead-of-print), 1–24.

⁷⁰Kerr, C. (2014). Don't believe the hype. Interview in Tricycle, October 01, 2014 www.tricycle.com/blog/don't-believe-hype.

with decisions-making and other “normal” life challenges, as well as in people with more severe symptoms of common public health issues such as anxiety, depression and chronic pain. The fact that these behavioral changes were accompanied by observable changes in brain function and structure (as summarized above) further supports the hypothesis that is defended here.

To sum up this chapter: The function and structure of the adult brain changes in response to e.g. external environmental impacts, and this phenomenon is called neuroplasticity. Central to our cognitive functioning is attention—the challenge to sustain it comes often from both external and internal distractions. Mind-wandering is frequently described as a bad thing, as it disables focused attention, but could be beneficial if one is priming the mind-wandering episode with e.g. interesting musings. Juggling, playing and rehearsing music, driving taxi in a complex city, meditation (e.g. Attention Training Meditation, Open Monitoring and Compassion Training) can be trained and will also produce changes to both the brain and behavior.

In Chap. 3 we will discuss some alternative methods for improving cognitive capacities, such as pharmaceuticals and certain types of technology that can be used to improve our cognitive skills, and what risks that might attach to such practices.

In Chap. 4 we take a closer look at cognitive flexibility. Firstly, we define this core cognitive capacity and explain why it is good to have it to a high degree. Secondly, we examine the link between the meditation techniques promoted in this chapter and increased cognitive flexibility. Thirdly, we point out that high cognitive flexibility does not guarantee responsible moral decision-making. Consequently we need a robust, and action guiding, moral framework which can anchor these capacities and guide vacillating agents. Chapter 4 finishes with a brief discussion of the connection between improved core cognitive capacities and the installing of a set of key epistemic virtues.

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