

## 7 Keeping Your Brain Fit through Learning

**A**s humans, our brains are wired for learning, and learning new things has a great impact on our brain health and wellbeing, and can also benefit society. At its core, learning is the process of acquiring new knowledge, skills, and experiences, which, in turn, shapes the individual and collective human experience. In terms of mental health, learning plays a pivotal role in promoting resilience and emotional wellbeing. Continuous learning fosters cognitive flexibility, problem-solving abilities, and adaptability, all of which are not only useful at work, but are also vital in managing stress, anxiety, and depression. Furthermore, it empowers us to develop a sense of competence, self-confidence, self-efficacy, and mastery over challenges and situations, which further enhances self-esteem and overall mental wellbeing. Learning is vital for our capacity for critical thinking, creativity, and innovation. It enables us to make informed decisions, comprehend complex ideas, and engage in lifelong development. Furthermore, learning is a cornerstone of society, driving progress, innovation, economic development, and cultural evolution. It equips us with the tools to navigate an ever-changing world, bridging generational gaps, and contributing to social cohesion. In essence, learning is the cornerstone of mental health, cognitive enhancement, and societal

advancement. Importantly, lifelong learning can also build up cognitive reserve, which is beneficial in all stages of life.

## **Brain Plasticity and Development**

Brain plasticity, also known as neuroplasticity, is the remarkable ability of the brain to adapt, reorganise, and change throughout our lives. It is a fundamental characteristic of the brain that allows it to respond to learning, experiences, and environmental influences. There are two main types of brain plasticity, namely structural and functional. Structural plasticity involves physical changes in the brain's anatomy, such as the formation of new neural connections, growth of dendrites, like a tree branch where neurons receive information, or even the creation of entirely new neurons in certain regions. This type of plasticity is prominent during early childhood, but continues to a lesser extent throughout life (213). Functional plasticity, on the other hand, involves the brain redistributing functions across different regions to compensate for injury or changes in demand. For example, if one area of the brain is damaged, another region may take on its functions, allowing individuals to recover from injuries or adapt to new skills and challenges (213). Brain plasticity underscores the brain's capacity to recover from injuries, adapt to new circumstances, and learn throughout life. It has significant implications for rehabilitation, education, and lifelong learning, and therapies designed to enhance cognitive function. Understanding and harnessing the potential of brain plasticity can lead to improved treatments for various neurological and psychiatric conditions (214).

Our brain development is a lifelong process, but it is also characterised by special periods of development (118, 122, 215, 216). As an infant, our brains are highly plastic, allowing for rapid growth and adjustment in response to environmental stimuli. As we grow as children, new neural connections are formed, and existing ones are refined through learning and experience. Early childhood is a critical period for language development, motor skills, and social cognition, with the brain undergoing significant changes in these domains (118, 217). Adolescence is another special developmental period and is characterised by increased synaptic pruning, which is the brain's way of making the connections more efficient. Like pruning of trees or bushes, we actually lose some neurons, but this makes the others more efficient. The reason this may happen is to accelerate the speed of the exchange of information in the regions of the brain that we use a lot and remove unused connections. The brain's reward and emotional processing systems continue to mature during adolescence, impacting decision-making and risk assessment. It's also a time when individuals further develop their identity and solidify cognitive skills (216). Throughout adulthood, our brains continue to evolve. Lifelong learning and mental stimulation are essential for maintaining cognitive health. The brain's plasticity allows for ongoing adaptations, such as learning new languages or acquiring new skills. However, as we age, there is a natural decline in certain cognitive functions, such as processing speed and working memory (218, 219). Within the workplace, this decline can frequently be compensated for by work experience, which is often pattern recognition for problem-solving or 'look ahead' planning.

For example, an experienced worker may have run into a similar problem before and have an efficient approach for solving it. It may also be that experienced workers can better anticipate problems that might occur in the future, having had some of them happen previously. This highlights how important it is to continue learning even as we age. If you are lucky enough to have a stimulating job where you are learning new things on a regular basis, then this will provide a level of continued learning. If you are retired, it makes it even more important to stay cognitively active by stimulating your brain through, for example, hobbies such as reading books, and through engaging in new learning, including learning a new language. One easy way to access free and interesting educational content around literature is The Queen's Reading Room (<https://thequeensreadingroom.co.uk/>). In summary, brain development is a lifelong process that encompasses childhood, adolescence, and adulthood. It's a journey marked by adaptability, learning, and growth, underscoring the significance of providing a stimulating and enriching environment at all stages of life to support healthy cognitive development.

### **‘Use It or Lose It’**

Our early publication already suggested the concept of ‘use it or lose it’ (128). This is the idea that if we do not use our brains and keep them active throughout life, they will deteriorate and lose functionality. This is similar to physical health, where muscles will deteriorate if not used. To keep your brain functioning at its best, you need to drive the neural

networks through cognitive activities, including learning and thinking. It has since been shown in several studies that learning new things drives neural networks and activates brain areas. When we use those brain areas, by learning something, the volume of those areas becomes larger. This was demonstrated in a now classic study by Eleanor Maguire and colleagues (36), where they showed in black-cab taxi drivers that the more time spent as drivers, thereby learning and remembering the location of places and streets in London, the greater the size of their posterior hippocampus. As mentioned previously, the hippocampus is a critical area for learning and spatial memory and awareness, which is remembering the locations of places around you. Work from Torkel Klingberg's laboratory (220) showed that healthy participants who took part in 14 hours of working memory training over 5 weeks had increased activation in the middle frontal gyrus and superior and inferior parietal cortices after training. The training included a visual and spatial memory task where people had to remember the location of circles within a 4×4 grid. In addition, the training included remembering a series of numbers and letters. This suggested that training-induced plasticity in the neural systems that are involved in working memory had taken place. A later study extended these findings and showed that there were also changes in the dopamine receptor system following working memory training (221). Another study showed that learning a new skill, for example juggling, was associated with both white matter (222) and grey matter changes in the brain (223). White matter contains relatively few cell bodies and consists mostly of long-range axons. These axons are covered

in myelin, and this gives it the whitish colour after which it is named. From this study, it is clear that learning a new skill, like juggling, actually changes our brain structure, as well as how it works. It is now well established that learning, both physical and cognitive skills, can lead to neuroplasticity and changes in the brain structure and function (224). So, to keep the brain fit, we have to exercise it through learning.

Another important aspect of learning is that it can build cognitive reserve. As mentioned in the introduction, cognitive reserve refers to the brain's ability to resist damage and maintain normal cognitive function, despite experiencing physical changes or damage in the brain (2). It can be thought of as a reservoir of cognitive capacity that can help individuals adapt to brain injuries, ageing, or neurodegenerative diseases like Alzheimer's. Cognitive reserve is a concept that helps explain why some people with significant brain damage, such as plaques and tangles associated with Alzheimer's disease (225), may exhibit fewer or milder cognitive symptoms than others with similar or lower levels of brain damage. One study showed that cognitive reserve may help in the outcome from head injury (226), specifically, that patients with higher cognitive reserve were less likely to develop depression following a traumatic brain injury. It has been suggested that cognitive reserve may impact on neuropsychiatric disorders in three ways: by affecting the risk for developing the disorder; in the expression of symptoms within disorders; and in patients' functional outcome (2). Cognitive reserve has also been suggested to be protective against age-related cognitive decline (227, 228) and dementia (229). These studies suggest that cognitive reserve may give

us a better ability to compensate by using other areas of the brain if some regions become damaged. This also allows us to be more flexible and use alternative ways for problem-solving or coping with the environment, be it at work or at home (227). Importantly, cognitive reserve is not fixed, but continues to evolve across the lifespan. Therefore, lifelong learning is crucial not only to keep your brain fit and healthy, but also to help in times of stress and promote a healthy ageing process.

### **Enhancing Cognitive Reserve**

Education, in addition to intelligence level, contributes to cognitive reserve. One of the most effective ways to enhance cognitive reserve is through learning. This can include learning new skills and participating in cognitively engaging tasks, but also includes education in school, higher education, and lifelong learning. We have recently discovered that early in the life course a simple activity, such as reading for pleasure, can have significant impacts on mental health, cognition, and brain function later in life (230). Our results showed that children who engaged in reading for pleasure at an early age had increased total cortical brain volume, including in key regions supporting cognition, such as the frontal lobe, anterior cingulate, and hippocampal regions. Early reading for pleasure was also associated with better mental health, better cognition, and school achievements in adolescence. These cognitive benefits seemed to extend into later in life. Previous studies have also shown that brain plasticity occurs in adults learning a new language. Specifically,

there were increased volumes in the hippocampus, frontal gyri, and temporal gyrus (231). Changes in the brain have also been demonstrated in the auditory cortex of musicians (232). These findings show that there are changes in different brain areas depending on what you are learning. This shows that you can learn a number of different skills to keep your brain active throughout life.

Engagement in cognitively demanding tasks may be particularly beneficial for cognitive function (233). Cognitive training, which is repeatedly engaging in a cognitive task, can be considered a form of learning that can be done over the life course. Studies have shown that cognitive training has benefits in maintaining cognitive health in the long term, and also has a beneficial effect on quality of life (234). This study included three different training groups for memory, reasoning, and processing speed. The memory training consisted of remembering words, the reasoning training focused on problem-solving, and the processing speed training involved processing increasingly more information faster. One large study of 4,715 participants demonstrated that 15 minutes of cognitive training 5 days per week over 10 weeks significantly improved performance on tests of processing speed, short-term memory, working memory, problem-solving, and fluid reasoning (235). Interestingly, a follow-up study specifically examined whether the improved cognitive performance was associated with age (236). They showed that there were no significant differences in the cognitive improvements between participants aged 18–49 and those aged 50–80. These findings demonstrated that participating in cognitively engaging tasks was beneficial for cognition



throughout the life course. In contrast, tasks of low cognitive stimulation, such as watching uninformative TV, have been associated with an increased risk of cognitive impairment (237). This may, in part, also be due to the fact that higher educational attainment, that is more years in education, is associated with greater participation in various lifestyle activities, for example, exercise and cognitively demanding tasks (238).

One of the main problems with cognitive training is that people may report it as not being very engaging or motivational. Studies have shown the importance of motivation for learning (239, 240). Therefore, it is important to take part in stimulating activities that you enjoy. One way in which we have tried to overcome this problem is by gamifying cognitive training. Barbara has specifically worked with participants, scientists, and a games developer to develop fun, engaging games that are evidence-based to enhance the cognitive and neural networks, but that are also fun and motivational. For example, two games, 'Wizard' and 'Decoder', were invented and have since been technology transferred to the gaming app PEAK Brain Training. These game training apps are now widely available on mobile phones and tablets, through the Apple App Store or Google Play through PopReach. These cognitively engaging games are a fun and enjoyable way to play while learning in a similar way to more traditional forms of cognitive training. 'Wizard' was designed to have wizards battling each other, and by completing the levels in the game, participants could win coins to gain better potions or spells within the game. Playing the 'Wizard' game for 8 hours over 1 month has been shown to significantly improve performance on tests of episodic

memory, a form of everyday memory like remembering where you left your keys, in patients with schizophrenia (241) and stroke (242). Improving such a key memory function in these patients improves their functioning in daily life and also enhances their quality of life. Importantly, the game also improved measures of daily living and patients reported high enjoyment and motivation during the training duration (241). A similar game, called 'GameShow', was designed for amnesic mild cognitive impairment, which is the early stage of Alzheimer's disease, and showed improved episodic memory, apathy, and general function (243). The 'Decoder' game was designed to train attention or concentration and requires players to respond to a sequence of numbers in order to decode messages in a spy theme. In healthy volunteers, playing 'Decoder' for 8 hours over 1 month significantly improved sustained attention (244). Again, participants reported high levels of engagement and enjoyment over the training period. Meta-analyses of gamified training have shown that it is beneficial for cognitive performance in older adults, specifically for processing speed, memory, and executive function (245, 246). While scientific studies have frequently focused on the benefits of traditional cognitive training, there are often many people who stop engaging with this form of training. Gamified versions of these tasks are much more fun and engaging and there is recent evidence that these do have similar benefits for cognitive function. Ultimately, it is important for you to find the things that you enjoy, be it downloading and trying these games, or completing the daily crossword, Sudoku, or maybe learning to play a musical instrument. These are all

great ways to keep your brain active and continue learning throughout your life.

### **The Importance of Lifelong Learning**

Although this chapter has focused on cognition, cognitive health and mental health are closely intertwined, with one significantly influencing the other. Those with better cognition have better wellbeing (8). When cognitive abilities are strong, we can better adapt to life's challenges, for example developing the skills needed for a new job, thereby reducing stress and anxiety. Engaging in activities that enhance cognitive health, such as reading and learning new skills, can stimulate the brain and improve overall mental wellbeing. Conversely, a decline in cognitive function can lead to feelings of frustration and insecurity, which may exacerbate mental health issues. By prioritising cognitive health through lifestyle choices and brain-stimulating activities, we can ultimately boost our mental health and resilience.

In the same way that you exercise different parts of your body, engaging in different types of learning can activate different areas in the brain. It is important to want to broaden your mind and consistently seek to learn new things. This will likely mean not only making the most of learning during school, university, and work, but also being motivated to learn outside these contexts. The best way to do this is to find things that you enjoy or are motivated to learn. Continual learning can, of course, make you more aware of the world around you; it promotes creativity and innovation, which may help us to come up with concepts or technologies

which might help with global challenges, such as climate change or healthier food production. Learning also makes you grow as an individual and can make life more interesting for you as you begin to learn about topics that interest you, or motivate you to take up a new hobby, including sports, music, art, or theatre. Hobbies can be very good for us: they can help us de-stress and relax, often by focusing intensively on a single activity, thus preventing stressful or distressing thoughts from coming into the mind. Many hobbies, in addition to being enjoyable, fulfil several positive lifestyle factors, including learning new things, socialising, and exercise. For those who are retired, hobbies can also provide structure to the day and purpose or new goals to attain, which may have previously been provided by work. Of the countries that were surveyed, it has been found that people in Denmark are the keenest on hobbies, with about 96% engaging in them. In England, about 78% of people and in the USA about 56% of people engage in hobbies. The lowest levels of hobby participation were reported in Italy, with 54%, in Spain, with 51%, and in China, with 38% of people engaging in hobbies (247). With so many people around the world enjoying and getting benefits from hobbies, if you don't have a hobby, perhaps ask yourself whether you might want to start a new one. Having a hobby that you are passionate about and looking forward to doing increases your wellbeing. Some people take up hobbies to help relax themselves and to focus on something interesting, thereby reducing stress. It is important to note that some countries where the greatest number of people engage in hobbies, such as Denmark, also rank very high on comparative country lists of wellbeing and happiness (248).

A survey of 24,176 respondents in England, aged 18–64 years of age, reported that the top three hobbies engaged in were reading, cooking and baking, and travelling, with over 35% of people participating in those. Twenty-nine percent of people listed video gaming and 26% of people listed sports and fitness and gardening as their hobbies (247). Not all hobbies are the same in terms of boosting your brain health and well-being. You should select a hobby that interests you and which you enjoy, but try to find one that pushes you to continue to learn new things and is not highly repetitive. The more the hobby activity makes you learn and pushes your thinking, the better it is for you.

### **Cognitively Enhancing Ourselves by Boosting Learning!**

In summary, learning plays a pivotal role in bolstering cognitive reserve. Engaging in continuous learning throughout life, whether through formal education or personal pursuits, helps to build cognitive reserve. This reserve acts as a buffer against cognitive decline and neurological disorders. When we challenge our brains with new information, skills, and experiences, we create a rich network of neural connections that can compensate for age-related changes or brain damage. This increased neural complexity enhances cognitive resilience, delaying the onset of cognitive impairment. Thus, the importance of learning for cognitive reserve cannot be overstated, highlighting the lifelong value of education and mental stimulation in preserving brain health and cognitive function.

### Dos

- Keep on learning throughout your life. It is important to keep our brains active and healthier for longer. This may be through crossword puzzles, learning to play a musical instrument, or reading engaging books.
- Learning affects our brains and allows us to build new neurons and connections within the brain. This process also helps us to build cognitive reserve, which is protective against cognitive decline later in life.
- Try to motivate yourself to broaden your mind and consistently seek to learn new things. In the same way that we would exercise different parts of the body, we should activate different parts of our brain.