

学習と脳 —睡眠，運動，栄養の役割—

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Learning and the Brain — The Role of Sleep, Exercise and Nutrition

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Abstract

教育やティーチングのコースには、一般的に多様なティーチングに関する理論、方法論、アプローチが含まれるが、実際に生徒がどのように習得をしているかという知見は含まれていない。比較的最近になり、証拠に基づいた神経画像及び脳マッピングの研究を通して先進の脳研究が、教育や言語学習に適用できるであろうことを示している。現在の心、脳、および教育に関する科学研究は直接的な実用方法を示してはいないが、教育者の実際に教室で適用するための神経科学に基づいた生徒の学習に対する理解を深めてくれる。学習での注意力、記憶といった、学習の極めて重要な要素の理解を深め、より効果的にティーチングで実践する手段を与えてくれる。学習の生物学的な観点を含む多様な分野や知識に数多くの研究が集中してきた；ニューロン新生、可塑性、運動、睡眠及び栄養における心と身体の関係性（トクハマ-エスピノサ，2011）。運動、肉体的活動と動きは、神経伝達物質ドーパミンを多量に放出させることに加え、多かれ少なかれ脳に非常に多くのプラスの影響を与える、ということは数多くの証拠が示している（レイティ，2008；ウィリス，2010；メディナ，2008）。十分な睡眠が、学習の非常に重要な構成要素であることは認知されてきた。また良い栄養バランスも健康な脳機能、そしてよりよい学習をサポートする。

これ以前にも、過去20年で数多くの研究と技術の進歩により、脳に関する発見が数多くなされた。また脳に関する誤った考えが“脳機能の迷信”として一掃されてきた。本論文はまずニューロン新生と可塑性という重要な概念にとって代わられた、これまで信じられてきた脳の処理機能の2つの誤解に関して要点を述べ、その後睡眠、運動、栄養の重要性について述べる。

Key words : brain, mind, body, memory, learning, neuroscience, exercise, nutrition, sleep

キーワード：脳，心，身体，記憶，学習，神経科学，運動，栄養，睡眠

1) 共通・教職科目群

Neurogenesis

For many years it was commonly believed that brain cells or neurons were fixed during early childhood and did not regenerate or died off. This misconception has been overturned since the late 1990's with the new belief that neurons actually continue to grow throughout the lifespan (Sousa, 2010; Tokuhamas-Espinosa, 2011). Neurogenesis occurs at approximately monthly cycles where about half the cells die and the remaining half survive by attaching to existing ones, while the final quarter create new links (Tokuhamas-Espinosa, 2011). Implications of this relate to the importance of long-term memory, hence learning. Both the growth and survival of new neurons can be enhanced by physical activity, good nutrition and lifestyle choices such as maintaining low levels of stress and weakened by prolonged sleep loss deprivation (Sousa, 2011).

Plasticity

Brain plasticity also known as neuroplasticity refers to brain changes throughout the lifespan whereby life itself, as a result of environmental input, changes the brain (Sousa, 2010; Tokuhamas-Espinosa, 2011). It was previously thought that the brain was fixed or hard-wired mostly at a young age, rather than being highly malleable or able to re-wire. This former belief was based on the misconception that particular brain areas had highly specific functions that only those areas could fulfill. This re-wiring is in fact the essence of learning, where senses, feelings and thoughts you attain constantly change the physical make-up of the brain, meaning that

neurons that fire together “wire together” (Tokuhamas-Espinosa, 2011). This change to neural networks creates stronger, more efficient networks in long-term memory such as through repeated practice and review. This is obviously evident in sport and music, where “practice makes permanent” (Willis, 2010).

The Mind-body Connection: Sleep, Exercise & Nutrition.

Sleep

In today's modern society people often lead busy lives and all too often neglect the importance sleep. Sleep is typically associated with allowing the body to rest, and has been discovered to be vitally important for the brain regarding learning and memory.

Contrary to common belief, most learning occurs during sleep when we encode or store information and skills from short-term memory to long-term memory, known as memory consolidation. During sleep, we replay various learning experiences and thoughts from that day when the brain is not being impacted by large amounts of sensory input as when awake. For example, when learning new skills in a sport, the brain controls muscle movement but the memory of the new skill has not been stored until several hours after practice, which mostly occurs in deep sleep. Therefore, by getting enough sleep you can remember the new skills more strongly in addition to; growing new neurons, having better energy, focus and split-second decision-making.

Various stages and cycles of sleep occur which are characterized by rapid eye movement- REM-which is also associated with dreaming and non-rapid eye movement-NREM. During a typical teenager

and adult 8 to 9 hour sleep time, five REM cycles occur. It is in this REM stage of sleep that most encoding of information and skills takes place, so if you reduce your sleep time by one or two hours, you may lose one or two of the most important REM “learning” cycles (Sousa, 2011).

Sleep deprivation also reduces the ability to pay attention and impacts memory, both critical for learning. Students may also become more irritable, agitated and less able to perform tasks requiring high-order brain functions and simple memory tasks.

In addition, spacing out study throughout the day is more beneficial than reducing sleep time for study. According to renowned sleep expert Stickgold, students need sleep prior to tests and after learning new material, while a nap during lengthy study may also be beneficial (Zadina, 2014).

Exercise, Movement and Dopamine

Exercise participation, as one of many lifestyle choices has significant bearing on overall physical and mental health, especially considering increasingly sedentary lifestyles in modern society. The positive link between physical movement and learning is supported by neuroscience (Madigan, 2014). Moreover, the role of exercise and movement in various learning contexts is often falsely overlooked despite the ease of implementation.

Extensive research has been undertaken in various contexts and age groups including: exercise and fitness programs before school; and measuring the positive relationship between fitness and activity levels in relation to improved academic performance and standardized testing. Overall results indicate that fit bodies correlate with better brains.

Movement, physical activity and exercise modify the learning state, enhancing the ability to retain or retrieve memory and the physical activity advantage for students may typically last for about thirty, to sixty minutes (Madigan, 2014). A study by neuroscientist Winter, indicated that long and short-term memory was improved by only three minutes of aerobic activity (Zadina, 2014). Also, Harvard researcher Ratey claims that exercise enables the release of a growth effect known as brain-derived neurotropic factor (BDNF) which keeps existing neurons healthy and facilitates greater neural connectivity (Ratey, 2008). Essentially, movement provides greater blood circulation and oxygenation, which in turn improves attention spans and memory.

Movement also provides the means for greater release of the pervasive neurotransmitter dopamine, which enhances communication between different parts of the brain, assists focus, responds to positive experiences, including the mere anticipation of pleasure or reward. Conversely, low dopamine has numerous negative implications, including reduced attention. In relation to the classroom context, dopamine is increased by positive interaction with peers, choice, humor and achievement, thus enabling students to experience greater pleasure, creativity, motivation, curiosity, persistence and perseverance (Willis, 2010). Integrating movement and learning with novel student-centered activities and active-learning approaches through various neural pathways, enables a greater likelihood of knowledge to be stored in long-term memory.

Nutrition

Current lifestyle preferences often include less than ideal food choices that detract from the brain's potential. The brain needs energy to function optimally, with food as the primary source to supply the necessary proteins, carbohydrates, vitamins and minerals. Despite being only 2-3% of body weight, the brain uses 20% of the body's fuel (Zadina, 2014). As such, prolonged periods of concentration and attention can be as exhausting as from physical activity. Essentially, the quality of the nutrition impacts the structure of the brain and consequently impacts classroom performance (Tokuhama-Espinosa, 2011).

Brain cells need oxygen and glucose- a particular type of sugar, to function optimally, so food choices and suitable hydration have a direct bearing on learning effectiveness (Materna, 2014). For example, high-sugar foods provide a quick energy boost but cause a more detrimental slump, which negatively impacts learning. Alternatively fruit, like apples and raisins provide an excellent source of glucose. Furthermore, glucose supply is also depleted when people skip breakfast (not *breaking the fast*) which can increase irritability, moodiness and reduce alertness and concentration levels in classrooms.

Healthy choices should be considered for both main meals and snacks throughout the day, such as consuming an even balance of nutrients with protein, complex carbohydrates and unsaturated fat. More specifically, the amino acids tyrosine and tryptopan are important to consider. Tyrosine is employed by the brain to manufacture dopamine and norepinephrine,

which enables the brain to think quickly and alertly, react fast and retrieve long-term memory. If tryptopan accesses the brain first and dominates, the serotonin produced will impair concentration, induce sleepiness and begin the process of slowing mental productivity. By eating protein-based foods high in tyrosine such as meat, nuts, cheese or yoghurt rather than high carbohydrate snacks and sweetened drinks, learners can support their natural production of dopamine and norepinephrine for optimal learning (Materna, 2014).

Particular vitamins, minerals and fat are also important considerations. B-complex vitamins contained in fish, chicken, pork and eggs, soybeans, oats, leafy green vegetables are also recommended, in addition to Vitamin C-based foods such as citrus fruits. Vitamin C also uses protein to produce the necessary neurotransmitters to enhance memory (Materna, 2014). The minerals; boron-found in apples and raisins; copper- available in fruit, vegetables and seafood; and iron-found in meat are also noteworthy. Considering brain cells mostly consist of fat, optimal sources of fat are required. Polyunsaturated fats such as, safflower, sunflower and soybean oils seem to be beneficial for thinking (Materna, 2014).

Adequate hydration is perhaps one of the simplest considerations for the brain. A feeling of thirst already indicates that the body and brain are dehydrated and a two percent decrease can impact brain performance, such as reducing processing capacity. Regular water intake is also necessary to enable efficient neural signals through the brain and for overall healthy brain activity (Sousa, 2011). Water is the most effective beverage for the brain, which

essentially enables the lungs to remain adequately moist to support the circulation of nutrients and oxygen to the bloodstream and brain. As a result, learners are able to process information more efficiently (Materna, 2014).

Conclusion

Many broad-ranging factors come into play when beginning to understand the complexity of the learning brain and ongoing neuroscience research is continually unraveling many unknowns, which in turn, can better inform teaching practices. The scope of this paper has been restricted to the biological aspects of learning, merely a fraction of the abundance of interrelated pertinent information linked to mind, brain and education science. The implications and importance of sleep, exercise and nutrition for learning act as awareness raising themes for both teachers and students alike. Additional and varied approaches can be to provide students with content-based topics and activities that serve a lifelong purpose, which may ultimately result in positive long-lasting implications for their bodies and brains. In addition, teachers as “brain changers” are able to better support students’ learning through more effective teaching practices in tandem with new applicable findings from neuroscience.

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