NEUROSCIENCE CAN HELP TO BUILD PERSONAL EFFECTIVENESS

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Abstract. The objective of this article is to present how personality is reflected in the brain structure, how the brain is changed by experience and some methods taken from neuroscience and psychology about how people can learn and re-learn, in the benefit of their personal effectiveness. Today is accepted that most of the changes in personality take place between 20 and 40 years old. Studies from neuroscience revealed that personality has biological bases in the brain, reflects the architecture of the brain and changes in personality should mean changes in the brain. Any brain is capable of change, usually through learning; constant learning is a key process for personal effectiveness. In this paper are presented some scientifically proved learning methods, the critical time windows which facilitate effective re-learning, and techniques which are able to put the brain into a learning-mode, thus contributing to personal growth.

Keywords: personality, learning, critical periods, metaplasticity.

Introduction

Personal effectiveness means making use of all the personal resources at person disposal – talents, skills, energy and time – to enable the achievement of both work and life goals.The way person manage theirselves impacts directly on their Personal effectiveness. Being self-aware, making the most of person's strengths, learning new skills and techniques and developing behavioural flexibility are all key to improving the personal performance. Some tried to find personality patterns for Personal effectiveness. But what if somebody doesn't match with one of these patterns? He/she is doomed to not be efficient?

This article is a theoretical review having the objective to present the status of what is currently known in neuroscience regarding how the brain is changed by experience and how people can control this process in the benefit of their personal effectiveness. It starts presenting the personality traits associated with personal growth and personal change, challenging the ideea that personality is fixed in adult people. Afterwards is presented the role neuroscience has in establishing the brain correlates of personality and also of economical behavior. Going deeply inside the biology of learning it is presented the concept of epigenetics – the science which explain how genes and environment interacts contributing to changes in the brain. In the Solutions and Recommendations section is presented the concept of affective relearning and are presented several techniques scientifically tested which facilitate

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learning. Also, in the Future research directions section was presented the concept of meta-plasticity and its relevance in promoting learning.

Background

One of the main topics in personal effectiveness studies is what inner factors represent triggers and moderators of personal growth and personal change? Studies measuring personal growth by asking people about their continued development and realization of their potential, found that those who scored higher in a so called "creative lifestyle" were significantly more likely to score high also in personal growth. It is interesting that creative lifestyle is not significantly correlated with general life satisfaction but instead is associated with intrinsic motivation – a love of creating for the sake of creating. People who reported being more motivated by specific goal, such as to develop a final product, tends to score lower in overall creative capacity and higher in stress and extrinsic motivation (Kaufman, 2015).

A recent study presenting an integrative model of creativity that includes personality traits and cognitive processes, identified three "super-factors" of personality that predict creativity: Plasticity, Divergence, and Convergence (Furst, Ghisletta & Lubart, 2014). According to the authors Plasticity consists of the personality traits of *Openness to Experience, Inspiration and High Energy.* Openness involves active imagination, aesthetic sensitivity, attentiveness to inner feelings, preference for variety, and intellectual curiosity. Inspiration involves creativity and problem solving oriented rather on insight, while High Energy refers to enthusiasm and drive. The authors noticed that *the common factor here seems to be the drive for exploration*. Divergence consists of Non-conformity, people high in this trait being very independent. Finally, Convergence consists of Conscientiousness, Precision, Persistence, and Critical Sense. Correlations made in those reviews found that Plasticity is strongly related to Convergence. People who are open to experiences, energetic, and exploratory tends to also have high levels of persistence and precision. Others proposed that the common factor here seems to be *high energy* (Kaufman, 2014). It is no surprise that studies also found that the trait Openness to Experience impacts the ability to make significant changes in life. People older than 30 years old – an age when Openness to Experience starts to decrease – find themselves unable or unwilling to make fundamental changes in their life (Westerhoff, 2008).

Openness to Experience and Extroversion – personality traits responsible with exploratory behavior and interest towards interpersonal relationships – are also some of the most important factors influencing career success. Why? Because they moderate people's social network, influencing the predisposition to have an open or closed social network. Most people spend their careers in closed networks of people who already know each other. They stay in the same industry, the same political party or the same cultural background. In a closed network it is easier to get things done because they have built up trust they know all the unspoken rules, and all the shorthand terms. But according to some studies, *being in an open network* instead of a closed one offers unique challenges and opportunities and is one of the best predictor of career success (Simmons, 2015). Having an open network offers huge opportunity for several reasons. First, it provides a more accurate view of the world because is possible to pull information from diverse clusters. People with open networks are better forecasters than people with closed networks. Second, an open network provides also the ability to control the timing of information sharing people having the chance to be the first to introduce information to another cluster of their network. Finally, people with an open network can create value by serving as an intermediary and connecting people and organizations who would not normally run into each other. By being a connector between groups offers them the opportunity to have more breakthrough ideas, to create atypical combinations. Studies made on academic literature have shown that top performing studies had references that were 90% conventional and 10% atypical, pulling information from other fields (Simmons, 2015).

Personality and intelligence are traditionally considered distinct areas of mind. However, research over the past 30 years suggests that intelligence is a personality trait. Studies in neuroscience have shown that many personality traits involve cognitive processes and abilities (DeYoung, Grazioplene & Peterson, 2012) and recent studies have found that IQ correlates with several personality traits such as intellectual involvement, creativity, speed of mental processing, intellectual competence, insight, ingenuity, imagination and reasoning depth (Kaufman, 2014).

The conclusion that can be drawn based on these personality studies is that instead of trying to make a clear distinction between personality traits and other cognitive capacities, people rather should focus on the possible relationships between traits like Exploration, High energy, Extroversion and Creative lifestyle on one hand and the capacity to implement changes in their lives, the career success and personal growth, on the other.

Personality is Not Fixed, is a Lifelong Evolving Phenomenon

One fundamental problem raised very often is about the ability of adult people to really change themselves? However it is defined, people generally say that personality should contain any significant behavior that helps distinguish one person from another and that is *constant* over time and in different contexts. Therefore, the most likely personality definition would be: patterns of characteristic *stable* behavior, ways of thinking and emotionality which determine a person's unique way of adapting to the environment. Back in the '70s and '80s was generally believed that personality traits once consolidated at the end of adolescence, remain stable from 21 years old until senescence. But how stable are these patterns, actually?

In the '90s this perception about personality began to change. Hence, studies found that some personality traits such as Assertiveness and Self Confidence tend to increase between 27 and 43 years old, mainly as a result of carrier success. At the beginning of 2000's several studies revealed that between 21 and 60 years old the scores on Conscientiousness, Emotional Stability and Agreeability increase while the score on Neuroticism decreases. Today is accepted that most of the changes in personality take place between 20 and 40 years old (see for a review Rodriguez, 2013). Most of the studies show a curvilinear trajectory, Extroversion and Agreeability increasing until 40 year old and decreasing after 60 years old, while Conscientiousness having a stable growth during the entire aging process. Openness to Novelty, Agreeability and Extraversion are the best predictors of life satisfaction, but also of well-being, health and life expectancy, especially when these traits increase throughout life as a result of person's capacity to learn how to manage critical situations or whether they were positively influenced by job satisfaction and interpersonal relationships. Interestingly, events such as divorce seem to increase Extroversion and Openness to Novelty in women just like re-marriage decreases Neuroticism in men (Rodriguez, 2013). Openness to Experience and Openness to Novelty are strongly related concepts, most of the specialists considering these two as being relatively the same thing.

Among all personality traits, Openness to Experience is the one which starts decreasing earliest in life. Studies made in the 1970s by Costa and McCrae – the authors of the Big Five model of personality – found that people tend to be open to new experiences during their teens and early 20s but after this the fascination with novelty decreases, regardless of cultural background, pointing towards a possible biological explanation (Costa & McCrae,1992). More recent studies such the one made in 2003 by researchers from the University of Oregon on more than 130.000 participants confirm the results, adding that men begin adulthood more open to experiences than women but during their 30s this trait decreases at a faster rate than women (Westerhoff, 2008). This is rather sad because Openness to Experience describes the general tendency to be exploratory, curious, to have artistic and aesthetic interests.

In conclusion questioning whether people can change is not a real dilemma anymore. However is fundamental to know how to help people to change themselves for better personal effectiveness.

Personality Reflects the Architecture of the Brain

For many years a controversy exists in psychology – naming if personality is something inherited or shaped by experience. And if we accept that both factors are responsible for building personality, which one is the most important. Recent studies found that up to half of the variability in the personality traits is heritable suggesting that these traits have biological bases in the brain (Kanai & Rees, 2011). We can say that personality reflects the architecture of our brain. But not all the people are aware of it and also most of them do not know that changes in personality should mean changes in the brain.

Resting-state functional connectivity (RSFC) is an imagistic technique that can detect intrinsic activation patterns without relying on any specific task and was used in early 2000 to investigate brain networks. In 2011, Adelstein and his colleagues used RSFC to investigate the neural correlates of the Big Five personality domains. Based on seed regions placed within two cognitive and affective 'hubs' in the brain—the anterior cingulate (part of the medial prefrontal cortex) and precuneus (part of the medial parietal lobe) — each domain of personality predicted RSFC with a unique pattern of brain regions. Openness to Experience, Neuroticism and Extraversion, the most widely studied of the five constructs, predicted connectivity between seed regions and the dorsomedial prefrontal cortex and limbic and paralimbic regions, respectively. Hence, they found that Neuroticism correlates with the resting state connectivity in the dorsomedial prefrontal cortex subsystem known to be involved in self-referential processing and emotional regulation, while Extraversion correlates with the connectivity in the lateral paralimbic structures implicated in motivation and reward. Also, Openness to Experience correlates with connectivity in the so called brain's Default Mode Network, known to be involved in integration of information concerning both the self and the environment (Cirneci, 2011). Functional connections identified as having a significant relationship with Openness to Experience were also located in the dorsolateral prefrontal cortex, a region associated with working memory, intelligence, creativity and the intellect facet of Openness to Experience. These patterns corresponded with functional subdivisions responsible for cognitive and affective processing such as motivation, empathy and future-oriented thinking. Conscientiousness correlates with connectivity in the medial temporal lobe subsystem involved in future-oriented episodic judgment and planning. Finally, Agreeableness correlates with connectivity in the brain areas known to be involved in social and emotional attention (Adelstein, Shehzad, Mennes, De Young, et al, 2011). These results suggest that although a fundamental core functional architecture is preserved across individuals, variable connections outside of that core encompass the inter-individual differences in personality that motivate diverse responses. Hence, inter-individual differences in personality are reflected in the particularities of neural connections between brain areas.

Various studies found biological bases of other personality traits. Conformity – the act of changing one's behavior to match the responses of others – was found to be based on brain mechanisms that comply with principles of reinforcing learning (these principles constitute the biological base of instrumental learning, which means learning the value of actions). Conflict with group opinion triggers a neural response in the anterior cingulate cortex and the ventral striatum similar to the "prediction error" signal known to be involved in the reinforcement learning of actions and the amplitude of the conflict-related neural signal predicts subsequent conforming behavioral adjustments (Klucharev, Hytonen, Rijpkema, Smidts & Fernandez, 2009).

Michael Cohen and his colleagues discovered that nervous tracts connecting limbic structures such as amygdala and hippocampus with ventral striatum predicts individual differences in Novelty Seeking while tracts connecting prefrontal cortex and striatum predict individual differences in Reward Dependence. Novelty Seeking (concept closely related to Openness to Experience, as I mentioned earlier) is characterized by impulsivity, exploratory drive and excitability while Reward Dependence (concept closely related to Extroversion) is characterized by enhanced learning from reward signals, persistence in repeating actions associated with rewards, high sociability and reliance on social approval (Cohen, Schoene-Bakar, Elger & Weber, 2009). Impulsivity measured alone and characterized by the tendency to prefer receiving small, immediate rewards over large, delayed rewards was found to correlates with white matter integrity in frontal and temporal lobe white matter tracts (Kanai & Rees, 2011).

The author cannot helps to notice that some of the above mentioned findings are related with economic behavior. Further are presented other examples, even more deeply connected with business, such as studies that relate business style to genes.

Whether to sample other options or maintain the current strategy for maximizing reward is known as the *exploration/exploitation dilemma*. Researchers in many disciplines have been searching for the optimal solution to this dilemma giving rise to a multidisciplinary framework that applies equally to humans, animals, and organizations. For instance, this framework can be used to explain the most efficient resource allocation for a start-up company. Michael Frank and his colleagues have discovered that two genes controlling the dopamine function in the striatum, DARPP-32 and DRD2, are associated with exploitation while a gene controlling dopamine in the prefrontal cortex, COMT, is associated with exploration (Frank, Doll, Oas-Terpstra & Moreno, 2009). Other dopamine gene was found to be related to financial risk taking. Hence, a study made by Kellogg School of Management from Northwestern University found that people with DRD4-7R variant of the gene which encodes the dopamine D4 receptor take 25% more risk (than people whithout this variant) while those with the 5-HTTLPR s/s variant of the gene which encode the transporter of serotonin take 28% less risk (than people without this variant) (Kuhnen & Chiao, 2009). Risk taking was also found to be modulated by some hormones such as cortisol and testosterone. One study made by University of Cambridge discovered that a trader's morning testosterone level predicts his day's profitability, higher testosterone contributing to economic return while cortisol level being increased by risk (i.e. the volatility of the market)(Coates & Herbert, 2008). All these chemicals influenced activity in some brain areas such as nucleus accumbens and insula. One study made by Stanford Graduate School of Business using fMRI found that nucleus accumbens activation preceded risky choices as well as risk-seeking mistakes, while anterior insula activation preceded riskless choices as well as risk-aversion mistakes. By *mistakes* the authors mean suboptimal choices in a financial decision-making task (Kuhnen & Knutson, 2005).

As it was mentioned earlier, most people are not aware that changes in personality should mean changes in the brain. And here is another example of controversy: the conventional belief in neuroscience and common culture has long been that adult brain is pretty much hardwired. But in the last 15 years there's been a shift in that thinking, many studies revealing that people have the ability to change the structure of their brain adding new synapses and new neurons during almost all their adult life. These changes appear not only through behavior, just thinking could change the brain structure and function, as you will see in one example bellow. Any brain is capable of change, usually through learning and constant learning is a key process for personal effectiveness. Although people can see the results of learning in their performance and knowledge, these are actually the behavioral reflections of the changes which take place in the brain during the learning process.

In one of her books, Sharon Begley provides some astonishing examples of what is capable our *plastic brain*. One of the most extreme is the experiment showing that in people who have lost their vision at an early age the visual cortex can process sound and in some cases somatosensory feelings when they „read" Braille. This brain area started to process semantics and grammar – things very different from what nature wired it up to do. In another example she presented an experiment done at Harvard Medical School where volunteers sit in front of a piano keyboard five days a week for several hours a day and play a five-finger little exercise while another group of volunteers sit at the keyboard but only think about playing the same exercise. After five days the scientists found that even in the so-called virtual piano players – those who only imagined themselves touching the keys – the region of the brain that controls the right fingers had expanded just as much as in the brains of the people who physically played (Begley, 2007).

Related to genes vs enviroment controversy presented above is also the following: traditionally people consider themselves as a mixture between genes and culture. And culture is aquired through learning. But the reality is more complex. Learning is a process which actually changes the genes in the brain – process called *epigenesis*. Epigenesis refers to the DNA changes induced by external stimuli that generate stable behavioral patterns. Mechanisms that produce such changes are DNA methylation and histone modification (histones are components of chromatin), each of which alters how genes are expressed without altering the underlying DNA sequence. In this way, one simple environmental stimulus can turn on or off specific genes, and this modification may be transmitted to the descendants, affecting the genes of the species because in the center of epigenetic processes lays the idea that genes have a memory. An increasing number of studies have demonstrated the existence of a complex epigenetic mechanism that regulates brain's gene activity without altering the genetic code. This mechanism has long-lasting altering effects on the functioning of mature neurons. Genome-wide epigenetic markers appear during memory consolidation, or what we call learning (Sweatt, 2009). Although the term epigenetics was coined nearly seventy years ago, its critical function in memory processing by the adult brain has only recently been appreciated. The hypothesis that epigenetic mechanisms regulate memory and behavior was documented by evidence that supports a role for epigenetic mechanisms in regulation of synaptic plasticity, in the formation, consolidation and storage of memory (Sultan & Day, 2011). In addition to learning, epigenetic mechanisms are involved in stress. There are solid evidence that chronic stress induced epigenetic alterations in some brain areas such as hippocampus (Fuchikami, Morinobu, Segawa, Okamoto, et al., 2011) and even that these alterations can be transmitted to the descendants (Dietz, La Plant, Watts, Hodes, et al., 2011)! In a classic experiment, Meaney and Szyf (2005) discovered that DNA expression is far more malleable than previously suspected. So malleable, in fact, that behavior alone could cause it to change. They took two groups of rats, one raised by attentive, nurturing mothers and the other raised by inattentive, stressed, neglecting mothers. In the group of rat pups raised by neglecting mothers, they found that the DNA in the hippocampus was highly methylated. Methylation tightens DNA and makes it harder to read and replicate in the cell. Due to their DNA tightening, those rats were unable to form as many glucocorticoid receptors in the hippocampus, which reduce stress. In the group of rat pups raised by nurturing mothers, they foud no methylation of DNA, and hence proper formation of glucocorticoid receptors in the hippocampus. As would be expected, these rats were much calmer and themselves more sociable and nurturing.

All these are very relevant, because if people want to optimize their performance and finally to change themselves they should target these epigenetic mechanisms. Although it is not yet entirely clear to what extent we can control our DNA through behavioral factors, we can consider that even something as simple as thoughts or beliefs could impact our genetic code.

Solutions and recommendations

As it was previously stated, learning new skills and techniques and developing behavioural flexibility are all key to improving our personal performance. Above was also presented some personal strenghts at the personality level and innate talents which give people an advantage when coping with challenges. Here is obviously a problem because not everybody possess these personal strengths and innate talents. But is not a lost war for those people who do not have this natural advantage. Studies proved that it is possible to change themselves, to optimize their performance.They just have to learn.

The shocking truth is that people do not know how to learn. Most students use re-reading and highlighting, yet these techniques do not boost performance, and they distract students from more productive strategies. Underlining, highlighting and re-reading the material are simple and quick – but it does little to improve performance. In fact, it may actually hurt performance on some higher-level tasks. In head-to-head comparisons, re-reading fares poorly against more active strategies. But which are these?

According to a review study made by Dunlosky and his colleagues there are two clear winners: self-testing and distributed practice. How it works? Unlike a test that evaluates knowledge, practice tests are done by students on their own, outside the class. Methods might include using flash cards to test recall or answering the sample questions at the end of a textbook chapter. Although most students prefer to take as few tests as possible, hundreds of experiments show that *self-testing* improves learning and retention. This technique seems to trigger a mental search of long-term memory that activates related information, forming multiple memory pathways that make the information easier to access. Regarding the second technique, *distributed practice*, this is how it works. Students often "mass" their study. But distributed learning over time is much more effective. Longer intervals are generally more effective. Generally speaking, 30-day delay improves performance more than lags of just one day. In more details, to remember something for one week, learning episodes should be 12 to 24 hours apart; to remember something for five years, the material should be spaced 6 to 12 months apart. Although it may not seems like it, the brain actually do retain information even during these long intervals, and you quickly re-learn what you have forgotten. Long delays between study periods are ideal to retain fundamental concepts that form the basis for advanced knowledge (Dunlosky, Rawson, Marsh, Nathan & Willingham, 2015).

The techniques presented above seem to be the most practical. Along with them, there are a few with moderate utility. *Elaborative interrogation* requires to put yourself in the position to ask “Why?”. “Why does it make sense that ….?” or “Why is this true?”. This is effective especially if you already know something about the subject. Another technique is *self-explanation*. In this case, students generate explanations of what they learn, reviewing their mental processing with questions such as “What new information does this data provide for me?”. Similar with elaborative interrogation, self-explanation may help integrate new information with prior knowledge. It helps in solving math problems, logical reasoning puzzles and learning from narrative texts. At the bottom of the list is *interleaved practice*. In this technique students alternate a variety of types of information or problems, instead of study in blocks, finishing one topic before moving on to the next. It improves performance on algebra problems and is effective to train medical students to put correct the diagnostic. But this technique is useful mainly for those who are already reasonably competent (Dunlosky, Rawson, Marsh, Nathan & Willingham, 2015).

In order to adapt to an ever changing world, organisms need to alter their behavior according to these changes. As was stated in the Introduction, developing behavioural flexibility is one of the keys to improving personal performance. Further will be presented the mechanisms responsible with affective re-learning, also kown as affective shifting, which represent critical factors of behavioral flexibility. Affective shifting represents the ability to adapt through associative learning to the situation in which an initial rewarding stimulus loses its rewarding value, respectively an initially dangerous stimulus loses its negative valence – process termed *extinction*. Importantly, in the extinction process, the new association does not erase the old one. But rather, the novel memory inhibits the old one, thus making extinction a new form of learning (Gottfried & Dolan, 2004; Quirk & Mueller, 2008). So, healing a phobia (in this case healing is based on extinction) is not a process of erasing a bad memory, is a process of new learning. An additional situation describes the scenario in which stimulus reward value is transformed into punishment or vice versa – process termed *reversal learning*. In both cases – extinction and reversal learning – it is required the re-writing of the old memory with new information, process called memory updating. So, healing a phobia (in this case healing is based on extinction) is not a process of erasing a bad memory, rather is a process of new learning.

It is fundamental to say that memory updating occurs only when the brain enters an “encoding mode”, and the new information is presented on top of this substrate. Studies demonstrated that re-exposure (*in vivo* or by mental imagery) to the context where (or when) original memory was created is critical for updating old memories (Hupbach, Hardt, Gomez & Nadel, 2008). It seems that new memories cannot be formed without recalling an old memory which can organize and provide significance to the current perceptive information (Sara, 2000). Interestingly, solely the old memory is subject to change, and thus the new combined memory entails that new information is engraved into the old structure (Hupbach, Hardt, Gomez & Nadel, 2008).

There are highly specific recepies for reactivating old memories where timing is a critical factor. The recall of an old memory places this memory into an unstable state in which new information can be incorporated into an old memory. And is critical when we add the new info into the old one, because there is a specific time window for this. Extinction trainings performed within the time window between 10 minutes and 2 hours subsequent to recalling the conditioned stimulus, are known to be efficient in modifying the conditioning, with a verified efficacy of up to 180 days (Clem & Huganir, 2010). The new updated memory suffers a process of reconsolidation, which also takes some time. Extinction training proved to be efficient when the conditioned aversive stimulus was associated with omission of aversive stimulation (that induces extinction) in the time interval underlying the reconsolidation process (Monfils, Cowansage, Klann & LeDoux, 2009). The *reconsolidation effect* has been demonstrated in humans in almost all type of learning such as procedural learning, affective conditioning, instrumental learning, semantic and episodic memories (Hupbach, Gomez, Hardt & Nadel, 2007).

However, the effect of the novel information is not immediately discernable. But rather, it is visible 2 days after learning (Hupbach, Gomez, Hardt & Nadel, 2007). During the past years, some sort of neuroscience dogma has become evident. This refers to the fact that episodic memory transfer from the hippocampus to the neocortex is a long process which takes months to unfold. Nevertheless, it has been more recently discovered that this process can be much faster if there is an already existing "mental schema" containing pieces of information related to the ones being learnt. This similarity between the new and the old information favors assimilation by acting upon the encoding and consolidation processes which materialize in the hippocampus and medial prefrontal cortex. Consequently, the new information will become hippocampus-independent in 2 days, and thus transferred to the neocortex (Yehuda, Joels & Morris, 2010; van Kesteren, Rijpkema, Ruiter, & Fernandez, 2010).

Generally speaking, new information in order to be permanently saved requires the transfer and incorporation within the long-term memories, process called *systemic consolidation*. This process seems to depend on sleep and the emergence of new neurons. As noted above, studies in neuroscience have shown that memories become permanent if they are saved in the most advanced areas of the brain called the neocortex. Here, memories come to be related to other old memories but only if we remember them more often. In this way they become a narrative content, a story that is dependent on language and less dependent on the sensory modality they were originally (Yassa & Reagh, 2013). This process could take weeks or even months. Meanwhile, these temporary memories are stored in a part of the brain called the hippocampus, which is a kind of extension of the visual area of the brain (Baxter, 2009). And the transfer of them from hippocampus to neocortex takes place during a specific phase of sleep, called *slow wave sleep* (Diekelmann & Born, 2010; Holz, Piosczyk, Fiege, Spielhalder, et al, 2012). That is why dreams are so "visual" and, in general, sensory, containing a strange mixture of sensations combined as in a puzzle. It is a totally different feeling when you remember something after many years – long term memory is a construct made using mainly the language and very poor in sensations. The transfer of the memories from hippocampus to neocortex during sleep depends on the emergence of new neurons (Kitamura & Inokuchi, 2014). Although the process is very pronounced in childhood, it is known that the hippocampus is one of the few areas of the human brain where new neurons arise also during adult life, but at a lower rate (Kokovay, Shen & Temple, 2008). This process is called adult neurogenesis and seems to have the role of "clean up" the hippocampus, freeing the place to store new memories. If adult neurogenesis is diminished or blocked in some way, the hippocampus remains stuck with old memories, unable to learn new things (Frankland, Kohler & Josselyn, 2013). This happens amid mental illnesses such as depression or dementia, in which adult neurogenesis is affected.

It becomes obvious that in order to learn new things, people must do activities that give rise to new neurons. The generation of new neurons is known to be stimulated by physical exercise, exploring new environments, spatial learning and interaction with unfamiliar people (Aimone, Wiles & Gage, 2009). In one of our studies using fMRI we found that successfully managing an unfamiliar and ambiguous situation positively correlates with activation of hippocampus and other surrounding structures from both hemispheres in healthy adult people (Cirneci, Preoteasa, Constantinescu, Marian & Tarța-Arsene, 2013). A lifestyle full of routines and habits inhibits adult neurogenesis and makes people more likely to be stressed when they are facing changes in life (Aimone, Wiles & Gage, 2009). We can say that working out the hippocampus makes people enjoy the benefits of new neurons for the benefit of their personal effectiveness.

Future research directions

As says David Sweatt, a professor of neurobiology at University of Alabama at Birmingham, evolution has been efficient in setting of molecular mechanisms that cells use to trigger persisting changes and it uses those mechanisms in development of an organism. Then in the adult nervous system it has coopted some of those same mechanisms to trigger experience-dependent, persisting change in the function of neurons (Sweatt, 2009). It is critical to emphasize that learning is a form of development and is based on the growth of the brain cells.

A great number of studies have demonstrated the existence of temporal periods during postnatal life, known as *critical periods*. During these periods, neuronal circuits exhibit heightened sensitivity to the acquisition of informative and adaptive signals from the environment (Hensch, 2004). Different areas of the brain that serve major functions (vision, hearing, movement or language) exhibit these critical periods, which are activated and regulated by distinct mechanisms (Baroncelli, Braschi, Spolidoro, Begenisic, et al., 2010). A *critical period* represents the time interval when the surrounding stimuli are critical for the normal development of a certain circuit in the brain – such as development of vision or native language. Conversely, a *sensitive period* is a time window when experiences exert the greatest impact on a certain brain circuit – such as learning a foreign language (Hensch & Bilimoria, 2012). Interestingly, in the case of language acquisition, any foreign language learnt under the age of 11 overlaps with the cerebral correlates of one's native language, in the same region of the Broca area, but any foreign language acquired after this age localizes in a different brain region. In the visual cortex, the critical period ends around the age of 5 in humans (Hensch, 2004). Such critical periods are evident in other regions of the brain as well. Not all brain regions present the same course of development. Research has established a maturation pattern on the frontal-occipital axis, as well as hierarchical levels of processing for certain neuronal pathways. Generally, a property processed at a superior level (i.e. problem solving) involves a longer critical period, as opposed to a property undergoing processing at a lower level (i.e. vision) (Hensch, 2004). Once a critical period is ended, sensitivity to experiences related to it reduces. After this interval, the capacity of the brain to be modified by experience, reduces significantly as a consequence of certain mechanisms.

Critical periods are specific to childhood and early adolescence. Nevertheless, recent studies from neuroscience found that is possible to open this type of windows along with their advantages even in adult. How? The trigger and length of a critical period does not depend solely on age, but especially on experiences. If the adequate cognitive activity does not overlaps with the responsible brain circuit, this circuit will be maintained on hold until the input becomes available. In contrast, enriched environment extends plasticity of the brain (Hensch, 2004). *Enriched environment* is a stimulation technique used on animals which provides a combination of multi-sensory stimulation, physical activity, social interactions and stimulation of exploratory behavior. Exposure to enriched environment determines the return of plasticity in the brain. Moreover, enriched environment exerts profound effects on the brain, leading to improvements in cognitive functions (particularly, learning and memory) and positively affecting emotional reactivity and stress response. In addition, it increases cortical thickness and weight, dendritic branching (particularly in the hippocampus and occipital lobe), neurogenesis and newborn neuronal integration within the already existing neuronal networks, as well as expression of 41 genes participating in learning and memory, synaptic plasticity, neurogenesis, vasculogenesis, cellular growth, excitability, synaptic transmission, neurotrophic factors and finally, in the dopaminergic, serotonergic and noradrenergic systems. Furthermore, enriched environment was found to stimulate anti-oxidative mechanisms, effect which may be identified owing to a decrease in the concentration of pro-inflammatory and pro-oxidative mediators (Baroncelli, Braschi, Spolidoro, Begenisic, et al., 2010). In another paper, the author of this article suggests that some contextual learning tasks, which are based on hippocampus, could trigger DNA repair mechanisms in that particular brain area, and can be used as a model for developing possible treatments for DNA lesions induced by oxidative stress (Cirneci & Silaghi-Dumitrescu, 2013).

Studies found that enriched environment favors maturation of the visual system even in the absence of visual experiences! Housing pregnant mice females during their last trimester of pregnancy in such an environment, determines more rapid development of the visual system of their cubs. What is more, running in a wheel in the case of pregnant females increases precursor neuronal cells in the hippocampus of the cub. This enhancement is two times more potent than normal. Furthermore, pregnant mother swimming increases the short-term memory abilities of the future cubs (Baroncelli, Braschi, Spolidoro, Begenisic, et al., 2010).

A critical period can be induced in humans during adult life through non-invasive techniques such as enriched environment exposure, incremental training and action video games, thus enhancing plasticity and facilitating learning at this age (Hensch & Bilimoria, 2012). People undergoing training based on action video games exhibit improvement in terms of visual acuity, which does not occur in individuals playing video games without action. This finding suggests the importance of attention in the efficiency of these trainings. Attention seems to be essential for generating plasticity in the visual cortex (Baroncelli, Braschi, Spolidoro, Begenisic, et al., 2010). Also, animal studies have found that learning capacity of adult owls can be improved by modifying training protocols targeting gradual changes in sensory experience (incremental training), and this procedure can be adapted for human (Hensch & Bilimoria, 2012).

In addition to the above topic, it seems there is a way to prepair the brain for future learning. *Metaplasticity* refers to the regulation of synaptic plasticity or to “plasticity of synaptic plasticity”. It represents a modification in the physiological and biochemical state of neurons or synapses, which influences their ability to generate synaptic plasticity. Metaplasticity mechanisms set the synapses and neuronal networks to a “learning mode”. This concept refers to a major form of adaptation that helps maintain synaptic efficacy in a dynamic framework, as well as neuronal networks in a learning-adequate state. The persistence of effects associated with metaplasticity may last from a few minutes to many days (Abraham, 2008).

Studies revealed that 2-3 weeks of physical exercise or enriched-environment exposure lowers the plasticity threshold (Abraham, 2008). Jociane de Carvalho Myskiw and her colleagues have demonstrated that rat exposure to an open field 1 to 2 hours prior to extinction training (as it was already mentioned, extinction is a re-learning process used to overcome phobias and addiction) significantly increases the success of extinction. However, this does not occur if exposure takes place for less than one hour or for three hours before. This may be explained by protein synthesis occurring in the hippocampus during novelty exposure. These proteins are subsequently captured by the synapses responsible with stabilizing extinction and transforming it into a long-term memory – process called tag-and-capture. Effects similar to open field exposure are generated by many hippocampus based tasks such as contextual aversive conditioning, novel object recognition task, inhibitory avoidance task and spatial learning in a water maze (de Carvalho Myskiw, Benetti & Izquierdo, 2013). So, the activity in one set of synapses can consecutively affect the plasticity at nearby synapses. How? Synthesized proteins resulting from learning-activated transcription of some genes can promote new memory formation in a novel task, as long as the neurons participating in the two learning tasks overlap.

From all these experiments a conclusion emerges – neuroscience is able to provide not only explanations but also practical advices which can make a difference. One critical aspect is to adapt for human the experimental methods used in animal studies. If this happens, in the future people could beneficiate by the results and have the key to develop new streghts and even change their personality.

Conclusion

Questioning whether people can change is not a real dilemma anymore.Today is accepted that most of the changes in personality take place between 20 and 40 years old. Moreover, studies found relationships between personality traits like Openness to Experience and also creative lifestyle on one hand and the capacity to implement changes in their lives, on the other. People who score higher in creative lifestyle are significantly more likely to score high in personal growth. In addition, creative lifestyle is associated with intrinsic motivation – a love of creating for the sake of creating. The personality trait Openness to Experience was also found to impacts the ability to make significant changes in life. Although there is evidence that some personal strenghts at the personality level give people an advantage when coping with challenges, this is not a lost war for those who do not have these natural strenghts.

Recent studies from neuroscience found that up to half of the variability in the personality traits is heritable suggesting that these traits have biological bases in the brain and personality reflects the architecture of our brain. But although this means our personality is hardwire in the brain circuits, this does not mean it is something fixed. In the last 15 years many studies revealed that people have the ability to change the structure of their brain adding new synapses and new neurons during almost all their adult life. Any brain is capable of change, usually through learning and constant learning is a key process for personal effectiveness. Learning new skills and techniques and developing behavioural flexibility are all key to improving the personal performance.

A fascinating discovery presented inside this article is that learning is a process which actually changes the genes in the brain – process called epigenesis. An increasing number of studies have demonstrated the existence of a complex epigenetic mechanism that regulates brain's gene activity without altering the genetic code. Epigenetic mechanisms regulate memory and behavior and there are strong evidence that supports a role for epigenetic mechanisms in regulation of synaptic plasticity, in the formation, consolidation and storage of memory. If people want to optimize their performance and to change themselves they should target these epigenetic mechanisms.

In order to adapt to an ever changing world, organisms need to alter their behavior according to these changes. This article contributions's novelty consists in presenting the brain's mechanisms responsible with re-learning – reversal learning and extinction – but emphasizing that there are highly specific recipes for reactivating old memories where timing is a critical factor. It is very important to know that the recall of an old memory places this memory into an unstable state in which new information can be incorporated and is critical when we add the new info into the old one, because there is a specific time window for this. This is very relevant given the findings that this procedure proved its eficacy in almost all type of human learning such as procedural learning, affective conditioning, instrumental learning, semantic and episodic memories.

Also one of this article contributions's novelty is the finding that an information in order to become a long term memory should be related to other old memories and this happens only if we remember them more often. In this way they become a narrative content, a story that is dependent on language (and neocortical areas of the brain) and independent of their initial sensory encoding. In addition, this process seems to depend on sleep and the emergence of new neurons and this is why activities which stimulate adult neurogenesis – such as physical exercise, exploring new environments, spatial learning and interaction with unfamiliar people – are important factors in facilitating learning. These findings corroborate with data from studies that found a superior efficacy of some learning techniques such as self-testing and distributed practice which seem to trigger a mental search of long-term memory that activates related information, forming multiple memory pathways that make the information easier to be accessed. And this is something helpful to keep in mind when we wish to learn something.

Finally, inside this article were presented the critical periods during which the neuronal circuits present a heightened sensitivity to the acquisition of informative signals from the environment. Although critical periods or windows are specific to childhood and early adolescence, one new and relevant finding presented in this paper is that is possible to open these windows even in adult. Studies made on animals found that exposure to enriched environment determines the return of plasticity in the brain. Enriched environment exerts profound effects on the brain, leading to improvements in cognitive functions (particularly, learning and memory) and positively affecting emotional reactivity and stress response. A critical period seems to be possible to be induced in humans during adult life through non-invasive techniques such as enriched environment exposure, incremental training and action video games. Related to critical periods is the concept of metaplasticity. Metaplasticity set the synapses and neuronal networks to a "learning mode". Physical exercise, but also enriched environment and some hippocampus based learning tasks are known to induce metaplasticity in animals, so it looks promising to adapt some of these methods for human too.

The advances made by neuroscience in the last decade put it in the position of a mature science, with a huge scientific data base able to explain most part of the human behavior and performance. What makes it even more interesting is the knowledge about how behavior can be changed and performance can be optimized. Should be the mission of various specialists to choose and adapt all the relevant data for the benefit of human species.

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