

Our inner world enriched by arts facilitates learning, memory and creative thinking

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I should like to thank President Katalin Novák for the opportunity to share my views with such a distinguished audience. I will focus on the importance of developing our inner world – which consists of our motivations, emotions, and cultural heritage – for better learning capacity and creativity.

One of the most important challenges of family life is education, particularly for children, but lifelong learning is also becoming more and more important in an aging society with demographic crisis. I would like to demonstrate the learning benefits of an active inner world, if enriched and developed by enhancing emotional richness, motivation, moral standards, positive thinking, and by a better transfer of cultural heritage from generation to generation. Recent results in neurobiology have important implications for the mechanisms of learning, memory, and creative thinking, clearly demonstrating that nerve pathways in the brain that carry information about motivation and emotions generate brain waves that are fundamental to learning and memory. To convince you about the scientific evidence-based validity of this important conclusion I have to summarize briefly the very basics of the neuronal machinery that produces memory traces and brain waves. I will try to be very simple, but in such a short time, and without slides, it will be challenging. This is the reason why I chose to write down the presentation.

Memory traces are stored in our brain cortex, an over 1 square meter large, 3-4 mm thick gray matter that is folded up in such a way that it can be squeezed into our skull. The size of the cortex is proportionate to the cognitive abilities, for example, monkeys have less than 1 square decimeter. This part of our brain has over 100 billion nerve cells, or neurons, which are heavily interconnected with each other. One such nerve cell is connected to 10 to a 100 thousand others via their numerous,

extensive branching processes, like branches of a tree. These complex networks of the cortex are responsible for our highest brain functions, such as conscious perception, learning and memory, the control of movement; it is the site of emotional and motivational impact, original thoughts, and creativity. The human cortex is unique in being conscious of its own existence, it can position the „Self“ in the material world, and in the network of other brains, which may be called society.

The storage capacity of a network that consists of 100 billion elements, each of which can talk to 10 to 100 thousand others, is basically unlimited. This is especially true if we consider that these connections between nerve cells are not of constant strength, but can be strengthened in a use-dependent manner. A strengthened contact between nerve cells can be considered as a basic unit a memory. Of course, memory is not stored in one single connection between two nerve cells. There are no grandmother neurons, which if activated, will let us remember our grandmother. When a memory trace is formed, those nerve cells that participate in the perception process – they can be hundreds of millions – should strengthen their connections with each other, and thereby they form networks within which connections are potentiated. These potentiated “mini networks” can be considered as a memory trace, or an engram. The most interesting question from the point of learning efficacy is how these connections get potentiated, and how that process can be enhanced. Considerable evidence supports the notion that if a connected pair of neurons fire synchronously with a precision of a couple of milliseconds, the synapse between them will be strengthened. Thus, there has to be a mechanism which can synchronize the activity of millions of neurons that participate in the encoding of a particular percept in a particular moment. This mechanism is known to involve a group of pacemaker neurons located in a brain area outside the cortex called the septum. These cells not only synchronize neuronal activity, but they do it rhythmically, generating brain waves. Thus, there is an ancient brain structure, the septum, which is able to synchronize neuronal activity throughout the cortex.

We found a total of three brain areas which operate with the same strategy, that is synchronizing cortical neurons via generating brain waves, thereby

consolidating memory traces. **The most important conclusions can be drawn when we explore the common features of these three areas** (you can relax now, this was the end of my neurobiological arguments):

- First, they consist of only a few hundred thousand neurons, yet they can efficiently control and synchronize the activity of the entire brain cortex containing billions of neurons.
- Second, and most importantly, they carry information about **motivation, emotions**, and the physiological state of the individual.
- Motivations and emotions – as determined by thousands of years of human cultural heritage – together comprise our **INNER WORLD**.

This explains the well-known observation of all of us that we vividly remember events that happened decades ago if intense emotions are attached to them. It can be a very tragic or a very happy event, we will never forget it. However, if something happened yesterday that was emotionally neutral, we forget it by next day. According to current theory, our brain has the capacity to store almost everything that ever happened to us. Yet we hardly remember a fraction of it. Thus, the bottleneck is not the storage, but the recall. Our inner world puts a handle on the information packages, which allows us to grab, and drag them into our conscious thinking processes.

It follows from the above that the most important educational/self-educational tasks from the point of creativity is first of all to secure the time and conditions for the brain to couple INNER WORLD impulses to information packages deriving from the external world during the learning process. These impulses will make storage and retrieving more efficient via enhanced synchrony brought about by brain waves.

Second, and just as importantly, the INNER WOLRD has to be continuously enriched and developed: by enhancing emotional richness, motivation, moral standards, and by a better transfer of cultural heritage from generation to generation.

What is happening today instead: The demand and conditions to involve the inner world are in danger due to the explosion of information and communication technologies.

1) No time is left for the association of inner world impulses to outer world information packages:

(When our kids sit down to the computer searching for some important information, they have motivation and an **emotional attitude** towards the subject they want to learn. However, while searching they find something more interesting, check it out, and plan to return to the original search later. But instead, they find another interesting subject, and so on. This is why it is called surfing on the Internet. If we ask them an hour later why they sat down to the computer, what the search was about, they won't remember... Thus, during surfing, motivation as well as the emotional attitude is gradually lost. The temporary memory stores will be saturated with useless information that have no emotional attribute, no handle on it, and no original idea will emerge from these memory traces. This superficial information gathering results in decreasing creativity. Since emotions are usually also switched off, or contribute very little, it may lead to emotional emptiness.

2) The flood of information exerts an adaptational pressure on the human brain, like any environmental change in biology. If the environment of a species changes, the species, or one of its organs has to adapt. Natural selection will favor those genetic variants that cope better with the new environment, and these variants will prevail. The larger the environmental change, the greater the adaptational pressure. Information can be considered as a kind of "environment" for our brains, since this is the organ that is responsible for the perception, storage and usage of information. Thus, information explosion results in a huge adaptational pressure on the human brain. If we cannot deal with that, and don't develop a coping strategy, then our brain will do it by itself, which may not be an optimal

solution. Our brain wants to defend itself from this flood of information by all means, for example by rolling down the shades by alcohol or drugs. Or some may believe that they are able to digest all that information, but this is impossible for most of us. This results in frustration, chronic stress, and ultimately, depression. Thus, there is a massive spreading of drugs, alcoholism, neurological and psychiatric disorders. According to WHO, in health-economic terms, the most devastating diseases of the coming decades will be depression, anxiety, and their somatic consequences. Now you know at least one of the reasons why.

Another consequence of the adaptational pressure is that passing on cultural heritage to the next generations is becoming poorer in quality and efficiency. An example from biological evolution is the eelworm. It is a simple creature, living in spring water, the temperature of which can occasionally change, when another stream joins in supporting the spring. This is a radical environmental change for this worm, which responds to it by increasing mutation rate. That is the frequency of incorrect DNA copying. Although these mutations are random, because of the greater numbers, there is a greater chance that a new genetic variant will be born that can better accommodate to the new environment. While this is true, it also results in the birth of freaks of nature, since mutations occur by chance. Information may be considered as part of the environment of our brains. Information explosion is thus a major environmental change for our brains, which decreases the faithfulness of passing on memes, not genes. This explains why passing on cultural heritage to the next generations is becoming poorer in quality and efficiency. And also, why societal evolution will produce monsters, freaks of nature like terrorism, religious sects, loneliness and selfishness.

3) Communication by Internet (Facebook) is very efficient. It has lots of advantages, but also serious disadvantages if it replaces personal contacts. If the child rushes home after school to communicate with many friends via the Internet, instead of going out together to do sports, or to study circles, or other social activities. It may result in sensory deprivation if

we do not use most of the sensory organs in the communication. Emotions, again, are largely switched off, leading to emotional emptiness.

During Covid, we learned to work from home and do even our shopping from home. This may result in social isolation. Humans are social animals in a genetically determined manner, as also pointed out by Professor Peterson yesterday. Detached from their natural social environment, there is a danger of cognitive and physical decline, which can lead even to personality distortion! And, worst of all, **Internet addiction!**

Scientists first used this term as a joke, but by now it is considered a clinically defined illness, which has 3 major phases. The most serious is obsession, when a person has a compulsive need to spend a great deal of time on the Internet, has recurrent thoughts of its use, and has serious depressive symptoms in the absence of the Internet. The second is neglect, when other areas of life (such as social relationships, work, or health) are allowed to suffer. The lightest phase – in which most of us in this room surely suffer – is the loss of control, when we cannot keep the time that we originally allocated to Internet use.

In a recent MRI-based study, Janszky and his co-workers investigated the brains of Internet addicts of different severity, and they found rather shocking changes. The prefrontal cortex, the area responsible for providing emotional context to any events that we want to memorize, was shrinking. Thus, the practice of switching off emotions during Internet surfing seems to have materialized. It has, indeed, resulted in a change of brain structure. The other important change was the enlargement of the nucleus accumbens, which is the reward center of the brain. If the neurotransmitter dopamine is released in this area, we feel pleasure and satisfaction. The growth of this brain region suggests an extensive pleasure seeking of these people by Internet use. Importantly, this change is similar to that observed in drug addicts.

One may ask the question: why did brain evolution invent such a reward system? It did so because dopamine is released by:

- Activities serving the survival of the species, like eating, drinking, and sexual activity.
- In humans, results achieved by serious energy investment, for example professional activities, like a PhD defense, or sport success, also evokes DA release in this brain region.
- Humans learned how to misuse this, and discovered that drugs of abuse like heroin, cocaine, cannabis, alcohol, nicotine, and amphetamines also release DA in the nucleus accumbens. They also learned how much easier it is to smoke cannabis than to defend a PhD.
- Unfortunately, DA is also released by problematic Internet use. And this explains the growth of the nucleus accumbens in Internet addicts.
- **The good news is that DA is also released by catharsis, and artistic experience. Thus, there is an unlimited, cheap, and healthy source of pleasure, reward and satisfaction. No need for drug abuse or pathological Internet use!**

Let us return to the **two most important educational/self-educational tasks from the point of creativity**. The second task I mentioned was that the inner world has to be enriched and developed since it is useless to secure its involvement if it is poor, disbelieving, and lacks credibility.

This enrichment is the easiest, and most enjoyable to achieve by arts, by cathartic experiences.

In addition to arts and cathartic experiences, inner world enrichment can be further amplified by active participation in the process of artistic creation, as well as by education in moral and ethical issues and by the establishment and maintenance of small communities.

The activity that combines all four is creative activity in small communities. Just to name a few: singing in a choir, playing in chamber orchestra, dramatics, poetry, dance, folkdance, film clubs, visual art camps, team sports.

Throughout my school years, I was fortunate enough to sing in two choirs, play the clarinet and the sax in two jazz bands and occasionally in a symphonic orchestra. I am convinced that if I ever had any creative thoughts in my research career, it was largely due to the contribution of my inner world enriched by music. Whether the mechanism of this involves the entrainment of synchrony via cortical oscillations – which depend on nerve pathways carrying information about motivation and emotions –, I am not sure about this. Nevertheless, I believe every word of the famous Hungarian composer, Zoltán Kodály, who said:

*“The mission of music is a better understanding, revival and expansion of our **inner world**. And where we reach the barriers of knowledge, music goes beyond these limits, into another world, which cannot be known, only guessed or presumed.”*

Our mission as scientists is to use the most developed, state-of-the-art technologies of our age to push the barriers of knowledge as far out as possible. Then we bump into new barriers again. Unless we can look beyond the barriers, we will never find the next best hypothesis, or the most suitable approach to explore the unknown.

Throughout anyone’s career, our inner world enriched by arts can serve as the major guide of our instincts that allows us to flash a glance behind the limits of knowledge, and to come up with decisions that turn out to be realistic, creative and useful. Furthermore, listening to our inner world, to the voice of our soul, will also enable us to employ our creativity, our desires, and the power of our cooperative spirit at the service of our smaller and larger communities.

Thank you for your attention.