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Creativity, The Brain, and The Classroom

Creativity can be defined as the generation of original and imaginative ideas by perceiving the world in new ways and making connections between seemingly unrelated concepts, then turning these ideas into a reality (Kampylis and Berki, 2014). Distinct from, but vital to this process is imagination, which can be understood as the ability of our brains to produce images and other sensory experiences that we've never encountered before- at least not in their entirety. This often feels effortless because we are so used to doing it, but creating these imagined images requires an extremely complex process that involves the perfect coordination of the approximately 100-billion neurons inside our brain (Vyshedskiy, & Dunn, 2015). In simple terms, imagination is our brain's ability to create new and unique images and ideas by combining and assembling familiar concepts and sensory experiences in new ways (Vyshedskiy & Dunn, 2015).

Hebbian Theory suggests that our brains must orchestrate thousands and thousands of electrical signals to arrive at precise destinations at exactly the right times (Hebb, 1949; as cited in Vyshedskiy & Dunn, 2015). Each time we look at an object, thousands of neurons fire in our posterior cortex (i.e. a region towards the back to the brain). They are encoding all of the characteristics of the object that we perceive. The simultaneous firing of these clusters of neurons causes the connections between them to strengthen, and this links them together into what neuroscientists call "neuronal ensembles" (Quiroga, Kreiman, Koch & Fried, 2008). For example, if we see a koala bear for the first time, and then try to recall it later, the entire neuronal ensemble that was created when we saw the koala will be activated. A different neuronal ensemble will be activated when we think about a kite, for example. Everything we have ever perceived is encoded in this way- neurons wired together through synchronized firing (Quiroga, Kreiman, Koch & Fried, 2008).

This explains why and how we are often able to visualize an image we are familiar with vividly in our mind, but it does not explain how we can synthesize images and thoughts about things we have never seen or experienced before. Mental synthesis theory strives to explain how this is possible. It suggests that if the neuronal ensembles associated with two unrelated concepts are activated at the same time, then we are able to perceive those two concepts as a single image or thought. Research suggests that the pre-frontal cortex (PFC) is responsible for coordinating this (Vyshedskiy & Dunn, 2015). The PFC is located at the very front of the frontal lobe, and is involved in a large range of high-level functions such as focusing our attention, anticipating outcomes, planning for the future, and coordinating complex ideas (Fuster, 2000). Neurons in the PFC are connected to the posterior cortex by string-like filaments called neural fibers or dendritic branches. Synthesis theory proposes that the PFC neurons send electrical signals down these connecting fibers to multiple ensembles located in the posterior cortex, activating them simultaneously (Vyshedskiy & Dunn, 2015). When the neuronal ensembles are activated in unison, we experience a merged version of the two unrelated concepts as if we have actually seen it. We imagine it (Vyshedskiy & Dunn, 2015). For example, if our neuronal ensemble for the koala bear is activated in unison with the one for a kite, we might be able to imagine a koala flying a kite.

In order for this process to happen, electrical signals must arrive at both neuronal ensembles at the same time. Some neurons are much further away from the PFC than others, and so it would seem that if the signals travel down both fibers at the same time, they would arrive out of sync. The length of the neural fibers can't be changed, but our brains are equipped to change the conduction velocity of the electrical signal (Stadelmann, Timmler, Barrantes-Freer &

Simons, 2019). Neural fibers are coated with layers of a fatty substance called myelin. The myelin acts as an insulator, which speeds up the electrical signals travelling through the neural fiber. Neural fibers can have up to one hundred layers of myelin wrapped around them, and can conduct signals more than 100 times faster than some fibers with fewer myelin layers (Stadelmann et. al, 2019). Research suggests that it is this difference in myelination that facilitates the identical arrival times of signals from the PFC to multiple neuronal ensembles, and ultimately our abilities for mental synthesis (Stadelmann et. al, 2019).

When we are first born we experience an enormous volume of new things. We continue to have novel experiences at a very high rate throughout our childhood, but typically, the longer we are exposed to the world, the more this decelerates. Our brains are already equipped with the basic structures and some neural networks when we are born, but have very few neural connections in comparison to the number that exist in our adult brains, and none of these initial connections are myelinated (Tau & Peterson, 2010). Myelination begins slowly when we are around 3 months old, and it accelerates rapidly through childhood as we have more experiences, and make new connections that are in turn reinforced (Tau & Peterson, 2010). Research supports that the generation of neural fibers- those thread-like extensions connecting one neuron to many others- and the myelination of these fibers, happens more frequently and at a much faster rate when we are infants and throughout childhood than is does when we are adults. In fact, we have the most connections in our brain that that we will ever have around the age of two. This may explain why children so often have especially vivid imaginations.

As we approach adulthood, a process called neural pruning begins. This involves the systematic death of the neurons that build the neural fibers which form connections in our brains that we never or rarely use (Tau & Peterson, 2010). These neglected connections become severed, and those that are used become stronger and grow thicker with myelin. By the time we reach adulthood, we have significantly fewer connections within our brain, but many of the remaining ones are much stronger and faster, allowing us to retrieve and connect specific information more quickly (Tau & Peterson, 2010). This pruning of neural connections leads to the trade-off of the potential of our brains to do many different things, for the ability to conserve time and energy when we do the things and operate in the ways we most often do. This is often referred to as a transition between brain plasticity and brain efficiency that occurs as we evolve into adults (Tau & Peterson, 2010).

Understanding this transition should alert us to the importance of facilitating creativity and fostering curiosity in our children. Teachers are arguably the people with the greatest amount of direct contact and influence over the greatest number of children in our society, and this is why the conversation about the impact of classrooms and schooling on children's creativity is so important. Our experiences and environment dictate which neural circuits get more use, so we know that environmental exposures can have a profound effect on brain development (Vyshedskiy & Dunn, 2015). Children spend a large portion of their lives at school, so the impact of these spaces- and what goes on inside them- on children's brain development is significant.

Traditional classrooms facilitate a very narrow and specific style of learning, and focus on teaching students facts rather than teaching them how to think. This archaic philosophy manifests itself in too many modern classrooms in several different ways: favoring of teaching strategies that encourage memorization and regurgitation of information; over emphasis on extrinsic rewards and consequences such as grades, prizes, and detention; teaching through only highly structured, repetitive, and independent activities; greater valuing of subjects that depict the world in an oversimplified way- black and white, right and wrong- than those that yield more complex, less satisfying, and less measurable answers. These practices not only fail to encourage creative and diverse thinking in children, they stifle it.

When children are rewarded for thinking within rigid parameters, the majority of them become conditioned very quickly to think only within those limits, losing the opportunity to imagine, innovate, and create (Ruhl, 2014). Ultimately this leads to the loss of diversity of neural connections in their brains that enables creative thinking. Children who do not, or cannot, conform to society's narrow and exclusive definition of intelligence are quickly labeled as incompetent or dumb. Their minds are not valued, they understand that, and this asphyxiates their confidence and motivation to think creatively. They too end up with sparse neural networks, ill-equipped for the future. Of course, this is an over simplified representation of the effects of the traditional classroom environment on young minds, and many teachers are using methods and creating environments conducive to and encouraging of creative thinking. It would be paradoxical to suggest a systematic identification of and the standardization of creativity-positive classrooms and teaching-practices, largely because of how different all the individuals inside a classroom and their needs are. However, it is useful and necessary for educators to discuss the effect of different environments and practices on students' creativity, and that we try to understand what strategies and mind-sets can build creativity-nurturing classrooms, and what that might look like for each of us individually.

Joe Ruhl, an experienced high school Biology teacher from Indiana shares his personal insights on fostering creativity in his classroom in a Ted talk called "Teaching methods for Inspiring Students of the Future" (Ruhl, 2014). He describes making a shift from a "teacher centered classroom" to a "student centered classroom", describing his new role in the classroom as more of an eager assistant on the side lines of his students' learning than an instructor. He believes that student-choice is central to a "student centered classroom" (Ruhl, 2014). He designs his classes so that students can choose from a long "menu" of activities each day. He tries to design these activities to meet the needs of the diverse learning styles and preferences of his students, and carefully crafts them in such a way that students are not forced to do all of (or even most of) the activities on the menu in order to come away from each unit having achieved all the desired learning outcomes. He believes this allows his students to feel a sense of autonomy over their learning, and to discover which mediums support and develop their way of thinking (Ruhl, 2014). Ruhl focuses on creating an environment that values and develops collaboration, effective communication, critical thinking, caring, and creativity in his classroom. He refers to these elements (along with choice) as "the 6 Cs" that are necessary to create a student-centered classroom (Ruhl, 2014). Ruhl describes and shares images of a typical day in his classroom, and it looks very different than what I believe most of us imagine when we try to picture a normal high-school class. Students are all over the room using a large range of different resources. Some are working in small groups, some are working in larger groups, some of them are working alone, and they are all doing something different. Some are sitting, some are standing, some are lying down, some are moving around (Ruhl, 2014). An ideal model for how a creativity-positive classroom should look and operate does not exist, but the individualization and autonomy promoting practices that Ruhl describes in his classroom might be fundamental to encouraging creative thinking.

The popular flexible seating movement challenges the traditional model of a classroom (i.e. 20 to 30 desks facing an arbitrary "front of the room", each paired with an identical chair- or some variation on this model). The idea is very simple: incorporate a variety of seating (or standing, or lying, or moving) options in your classroom, and allow students to choose which they would like to use while learning (Schilling & Schwartz, 2004). A growing body of research supports that having flexible seating in the classroom can have a surprisingly positive impact on learning, moral, and creativity (Merritt, 2014). Flexible seating promotes collaboration and builds community, since traditional desk set ups can be isolating and don’t encourage cooperation. The choice and control flexible seating allows students to have is empowering and can contribute to students’ sense of autonomy (Merritt, 2014). The freedom to move, and to some degree control the level of sensory stimulation they experience, that flexible seating allows students encourages them to explore what conditions help them focus and think creatively. This can help develop self-regulation skills (Schilling & Schwartz, 2004). The prioritization of their comfort that flexible seating represents shows students that they are cared about in the classroom and that they matter (Merritt, 2014). Although, it is wishful thinking that introducing a fun variety of chairs into the classroom will lead to a sudden spike in student creativity, I believe that the enthusiastic response of our education system to flexible seating could represents the beginning of the wide-spread acceptance of a new and less rigid model of “the typical classroom”, and maybe one day, too, of “the typical brain”.

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