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Creativity, Laterality and Critical State Balance in Learning

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Abstract

Understanding the intersecting cognitive pathways that are integral to ways of thinking, creating and functioning in both art and science is an important grounding for a STEAM educational approach. We combine three divergent concepts, including creativity, hemisphere laterality, and critical state theory, to argue for a more balanced approach to learning as part of a modern meaning-centered education in STEAM. Reviewing the concept of hemisphere laterality, or how the two hemispheres of our brain have different (though not disconnected) ways of processing sensory information, we note how these two means of interpreting the world have become unbalanced in traditional modes of learning. We then discuss creativity as a mechanism that serves to balance the work of both hemispheres. Finally, critical state theory is introduced as an argument for why our brains need to exist in a more dynamically balanced state to function well in contemporary society.

Keywords

creativity, hemisphere laterality, learning, critical state, balance

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Introduction

Even though innovative and adaptive response from both art and science is viewed as critical to tackling contemporary social and environmental challenges, our education systems are slow to respond. The value of art-science interactions is often found in the generative output of collaborations between specialists. But another important objective is integrating the multidisciplinary experience within an individual person; starting with students, this is a goal of the STEAM movement. Critical to this is understanding the intersecting cognitive pathways that are integral to ways of thinking, creating and functioning in both art and science.

Although understanding the mutual interactions between different bodies of knowledge and ways of knowing is critical to teaching and learning, it is often out of sync with formal educational systems which still often operate under the premise that the way we learn is secondary to what we learn. Frequently, information is taught that has been abstracted from its context and has no relevance to our personal experience. The result is, in effect, we are often only using half of our learning potential. Because our brain functions in duel (often seemingly opposing) ways, it may only be when this system is in a state of creative balance that its halves can function in a complimentary mode optimized for learning. Here we explore these concepts of hemisphere laterality, creativity and critical state balance further, beginning by reviewing ideas about hemisphere laterality, or the different functioning of the left and right hemispheres of the brain. We then examine how the process of creativity can serve to combine the two hemispheres actively in learning. These concepts are then fit together in a model informed by critical state theory, showing that a state of balance is needed to function well in a world characterized by constant change and uncertainty.

Hemisphere Laterality: A split between left and right brain?

The study of split brain functioning has been popular since the early experiments of Broca (1861), who proposed a left hemisphere (LH) bias for the language functions of the brain. Even through the 1960's a dogmatic split was upheld, with the LH viewed as being dominant in all areas of higher cognitive functioning (e.g. speech, writing and comprehension of language), with the right hemisphere (RH) held to be largely devoid of, or at best 'retarded in', the linguistic and mathematical functions commonly associated with a higher intelligence. Preservation of such dogma is most obvious in the ever-popular left-brain vs. right-brain identity divisions alleged between scientists and artists. However, more recent experimental work has shown that the RH is also critically involved in a range of cognitive activities. Using a domestic chick model it has been shown that the RH is involved in cognitive processes relating to conspecifics, picking out novelty within an environment and maintaining a broad focus useful in monitoring for predators (Rogers, 2000).

Research with chick models showed that the LH appears specialized for selecting cues, allowing for the sorting of objects into functional categories (such as discriminating between edible grains and inedible pebbles) and generally operating with a much narrower focus of attention than the RH (Vellortiga, Rogers and Bisazza, 1999). However, this work also demonstrated the integrated cognitive processing that exists between hemispheres. An example can be found in the learning process associated with imprinting, which is predominantly carried out in a forebrain structure known as the hyperstriatum ventral (IMHV). Both the left and right hemisphere correlates of this structure are involved with short-term memory, but only the left is associated with long-term memories. The right IMHV initiates by sending its information to an area known as S', which is thought to add contextual information to a memory, before it is passed to the LH to be coded into a long-term memory (Vellortiga, Rogers and Bisazza, 1999).

This suggests the RH has a more holistic associative role, with the contextual colouring within the S' area providing the necessary depth and dimension that goes into the formation of a lasting memory (Bowden and Beeman, 1996).

In humans hemispheric biases appear in different kinds of neuroprocessing; where the LH is understood to be primarily analytic and sequential, the RH is more spatial and synthetic (Sperry, 1982). Where the LH is particularly adept at storing already known information and forming basic descriptive systems, the RH seems to focus primarily on integrating new and novel stimuli (Goldberg and Costa, 1981). Such hemispheric biases have been most convincingly confirmed in subjects with damaged temporal lobes: damaged left lobes resulted in a preference for new hypotheses to a given problem (even if a previous hypothesis had proven to be correct), whereas a damaged right lobe resulted in a preference to stick with a previous known hypothesis even if it was known to be wrong (Rauch, 1977). However, despite such biases, it is also increasingly recognised that there is no absolute discrimination between the hemispheres; both will be involved in most cognitive processes, such that it is more a question of primary (or dominant) functions than absolute ones (Gazzaniga, 2000). Experiments on commissurotomy, or 'split-brain', patients have revealed that in fact the RH does have a latent capacity for language; the LH simply acts as the dominant hemisphere for such activity (Sperry, 1982). Indeed, when in the process of comprehending words, the RH has been shown to be able to weakly activate a larger semantic field of related words and meanings, compared with the LH, which seems to strongly activate closely associated words and meanings (Beeman et al. 1994). There are many examples of our split yet interactive modality, e.g. when confronted with new stimuli, the RH organises the initial orientation and will then check this against the storehouse of concepts in the LH. If the concept is archived there, the LH will then take over control of the cognitive task. However if no reference exists for the stimulus, it is up to the RH to process the new stimulus and assemble it into a concept, which then becomes the domain of the LH (Goldberg and Costa, 1981).

Implications for Learning

Our split functioning bias has significant implications for our approach to learning in formal education systems. Although we possess two different but complimentary ways of interpreting the world, there remains an overemphasis on the LH way of thinking, to the exclusion of the RH. Indeed McGilchrist (2009) argues that the historical imbalance in these two modes has lead to an imbalance in our wider society and way of modern life.

We are taught, primarily through textbooks, about concepts generally lying outside of our contextual experience, such that most of our learning is relegated to symbolic codes and fragments of factual information, the primary domain of the LH. This bypassing of our RH mode of thought may mean we forgo contextual associations valuable for effective comprehension and integration of new information. It has been found that in a problem-solving context there is greater activation of solution-relevant information in the RH than in the LH, implying that the RH is better able to access a broader range of information for integration and application (Bowden and Beeman, 1998). Thus, instead of deriving information from within a broader context (RH function) and then categorizing it (LH function) we may have flipped the system upside down, teaching the concept as abstracted from the context. Information devoid of contextual relevance often fails to engage many of us, or worse leaves us in a state of confusion as to the meaning, priority and application of what we have learned. To make the most of our split brains and dual modes of information processing, we need to approach learning in a different way, which is able to integrate the whole and the part, the new and the known, the conceptual matrix and the individual aspect.

Creativity: A Mechanism of Balance

A blend of divergent and convergent cognitive capacities

Facilitating creativity is one approach to learning that can effectively join both hemispheres of our brain in function. First described as a four-part process consisting of preparation, incubation, illumination and verification (Wallace 1926), creativity has since been seen as a dynamic blend of processes that co-occur and reoccur in any given body of work (Eindhoven and Vinacke 1952). Critically, this dynamic process does not unfold in discrete step-wise stages but as a mix of cognitive capacities (Guilford 1950). Guilford's work on theories of intelligence has defined creativity as a capacity of the intellect consisting primarily of two thought processes, including both divergent and convergent thinking. Although divergent thinking has come to be thought of as synonymous with creativity, Guilford deemed both types of thought as equally important in the creative process. Where divergent thought involves idea generation, with variety and volume being of central importance, convergent thinking encompasses the use of known facts to deduce best solutions (Guilford 1959).

An interaction between two logics of the brain

Divergent and convergent modes of thought have also been described as the product of two cognitive processes, the primary and the secondary, which are in turn equivalent to two forms of logic termed paleologic (from the Greek, paleo, meaning old) and Aristotelian logic (Arieti 1976).

In Aristotelian logic the world is broken up and segmented into concepts that are symbolic representations of reality, helping us categorize and make sense of our world. Things are grouped into classes which all share similar characteristics and so can be grouped into a general concept. An example is the Linnaean classification system: we start with general concepts such as demarcating animal from plant, and then we may see that some animals have a vertebral column. From this shared feature the subphylum of Vertebrata is formed, comprised of seven living classes and so forth. This sort of thinking is not confined to taxonomy but permeates our organised interpretation of the world and thus very perception of reality. Using this mental construct we can make assumptions about the future based on what we know of the past. However there is also a danger to this mode of thought in that it can lead to fixed, inflexible definitions and views. Categorisation of concepts can blind us to the need to draw linkages or observe further. Habits of thought form easily and can create a lazy and inflexible mind, content to categorize and fix but not question further.

In contrast, paleologic is understood as a more flexible system able to make class distinctions on much looser premises, seeing things as similar or even identical by virtue of a common characteristic. For example a beach ball could be seen as similar to an apple in that they are both round. Arieti (1976) suggested that this type of cognition is mostly an unconscious process in which our brains are constantly trying to draw comparisons and make contextual linkages with every new experience we encounter. In this way we make sense of what we don’t know by relating it to what we do know. Paleologic can thus be seen as the underlying mechanism in metaphorical thinking, where difficult concepts are related to alternate parallels within our experience.

These two modes of logic together form a flexible, discriminative system. The alternate logics of both help us to make sense of the world. For example if we know there is a relationship between A and C then we need to find the B that can bridge the gap. Our paleologic is used as an idea generation system to come up with many different concepts for B but it is ultimately up to the process of our secondary Aristotelian logic to evaluate which idea has the most merit for a situation (Arieti, 1976).

Living and learning in a critical state

There are many natural systems that we understand to exist in a state of relative balance, or what is also known as in a 'critical state'. The critical state is positioned between the conditions of order and chaos, which are equivalent to subcritical and supercritical states, respectively (Paczuski, and Bak, 1999). A subcritical system is seen to represent uniformity and order with very little change present, making learning unnecessary, while a supercritical system is one that is in constant change, with no uniformities or order and thus no regularities that can be learned. It is between this rigid order and wild chaos that a balance often resolves that represents order without rigidity and change without chaos. It has been suggested that a critical state may also be present within our brains, representing the optimal state of function in terms of learning and adaptability (Chialvo, 2010).

Critical balance in the human brain has been speculated to be a product of what is known as emergent complexity (Chilavo, 2010). Complex systems are large conglomerates of smaller interacting elements, each exhibiting non-linear dynamics. Emergence refers to the large, often unexpected, patterns that occur as a product of the whole being greater than the sum of its parts. For example in an ecological system in which different species support and influence one another, there is a high level of complexity out of which emerges a flourishing ecosystem able to support life (Bak, Tang and Weisenfeld, 1988). If the system were too sensitive it would be chaotic and could not have reached a stable state. Conversely if the system were too rigid it would break at the first hint of stress. Thus it can be seen to exist in a dynamic state of criticality representing a high level of uncertainty. A small change can lead to a high level fluctuation within the system or it can leave it relatively unchanged.

In the critical state condition within the human brain there is also uncertainty and unpredictability and so a need for flexibility within a system to cope with this. The divergent cognitive styles of our two hemispheres contribute to a potential state of balance. The LH, with its fixation on categorization, allies with the more uniform world of the subcritical where everything is fixed and so adaptive learning becomes unnecessary. The RH, with its broader scope and panache for the new and ever changing, can be seen to represent the more chaotic world of the supercritical where things are constantly in flux and so learning (recognizing patterns) becomes impossible. This then suggests that it is in the middle, where these two systems overlap, that the ability to creatively adapt to an ever-changing world is maximized. Our dual yet integrated mental hemispheres are well adapted to live in an uncertain world, a critical system within a critical system (Tagliazucchi and Chialvo 2011). Such adaptation can be seen as the essence of learning, and it is thus by facilitating integrated use of both hemispheres, and the learning styles that they represent, that modern education systems can maximize learning potential.

When we relate ideas of creativity (divergent and convergent thinking, Paleologic and Aristotelian logic) and critical state (subcritical and supercritical) to models of brain lateralization, the similarities are clear. Parallels exist between RH specialisation and the divergence/paleologic/supercritical state, and between the LH and the convergence/Aristotelian logic/subcritical state. Time and time again, a duel function of our intellect has been suggested, as well as a fundamental interaction between the two. This demands social recognition and valuing of a dynamic interaction between the two that repositions art and science on equal terms and is supported by education systems at all levels.

References

Arieti, S. 1976. *Creativity: The Magic Synthesis*. New York: Basic Books.

Bak, P., Tang, C., and Wiesenfeld, K. 1988. Self-organized criticality. *Physical Review A*, 3, 364-374.

Beeman, M., Friedman, R.B., Grafman, J., Perez, E., Diamond, S., and Lindsay, M.B. 1994. Summation priming and coarse semantic coding in the right hemisphere. *Journal of Cognitive Neuroscience*, 6, 26-45.

Bowden, E.M., and Beeman, M. 1998. Getting the right idea: Semantic activation in the right hemisphere may help solve insight problems. *Psychological Science*, 9, 435-440.

Broca, P.P. 1861. Loss of speech, chronic softening and partial destruction of the anterior left lobe of the brain. *Bulletin de la Société Anthropologique*, 2, 235-238.

Chialvo, D.R. 2010. Emergent Complex Neural Dynamics. *Nature Physics,* 6, 744-750.

Eindhoven, J. E., and Vinacke, W. E. 1952. Creative processes in painting. *Journal of General Psychology,* 47, 165–179.

Gazzaniga, M. S. 2000. Cerebral specialization and interhemispheric communication: Does the corpus callosum enable the human condition? *Brain*, 123, 1293–1326.

Goldberg, E., and Costa, L.D. 1981. Hemisphere differences in acquisition and use of descriptive systems. *Brain and Language*, 14, 144-173.

Guilford, J.P. 1950. Creativity. *American Psychologist*, 5, 444-454.

Guilford, J.P. 1959. Three faces of intellect. *American Psychologist,* 14, 469-479.

McGilchrist, I. 2009. *The Master and his Emissary*. New Haven: Yale University Press.

Paczuski, M., and Bak, P. 1999. Self-organization of complex systems. In: *Proceedings of 12th Chris Engelbrecht Summer School*. Also as arXiv:cond-mat/9906077.

Rauch, R. 1977. Cognitive strategies in patients with unilateral temporal lobe excisions. *Neuropsychologia*, 3, 385-396.

Rogers, L.J. 2000. Evolution of hemispheric specialization: advantages and disadvantages. *Brain and Language,* 73, 236-253.

Sperry, R. 1982. Some effects of disconnecting the cerebral hemispheres. *Science*, 217, 1223-1226.

Tagliazucchi, E., and Chialvo, D.R. 2011. *The Collective Brain is Critical*. arxiv:1103.2070v1 [q-bio.NC].