Searching the Neural Basis of Creativity

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ABSTRACT
This paper proposes a neurological model for creative behavior. Accounts of the brain parts involving different functions in creative behavior are reviewed. In doing so, previous attempts to link synesthesia and creativity, as well as music performance and creativity are evaluated. Finally, the model proposed, and the specific role that dopamine plays on this circuit leading to creative behavior, are discussed.

Keywords
Creativity, Cognition, Human Brain, Neuroscience, Music, Synesthesia.

INTRODUCTION

What is about the mind that lets people take pleasure in shapes, colors, sounds, jokes, stories and myths? [9]

The study of creativity has been of central interest to generations involved in art and design. Hundreds of articles and books have been written about it. However, we don’t have a clear idea about how creativity emerges from of human mind yet. And this is in part because we still don’t know what the human mind is. Indeed, we are still living under the influence of the duality of mind-brain (since Rene Descartes). Today, in cognitive sciences is accepted the idea that the mind and the brain are two parts of the same thing. The sum total of thoughts, beliefs and experiences of a human being emerge from the patterns of firings in the brain. If the brain ceases its functions, the mind is gone. This knowledge has come to us from more than one hundred years ago, when scientist began to observe the correlation in “patients” with damage in their brains and their behaviors. In most of the cases, damage to a specific part of the brain, drives to abnormalities in mental or body functions. More than a century of such observations has allowed us to make maps of the brain’s areas of functions, and to localize particular cognitive operations. However, must be said that such maps do not show us what a person is thinking. But localization of mental functions is a strong argument for the involvement of the brain in thought and the thesis that thoughts comes from the brain. This work proposes to search patterns of emergence since the human brain in creativity. In doing so, two approaches to creativity will be explored; the relation among synesthesia and creativity, and studies of music and creativity. An introduction to brain functions and localization will be the first step to link today’s knowledge with neural models proposed by studies in music and synesthesia.

THE HUMAN BRAIN

The human brain is divided up into four lobes; frontal, temporal, parietal and occipital, plus the cerebellum. The frontal lobe also contains the motor cortex, and the parietal lobe the sensory cortex. The eyes are below the frontal lobe, and the ears in the inferior part of the temporal lobe.

In a gross generalization, the frontal lobe is responsible by planning, decision making, and the personality. The motor cortex, in the frontal lobe is the part of the brain that process and send information to the muscles in order to produce movement. The parietal lobe is responsible by processing spatial information. This is where the things are located in space, including our own body; and the sensory cortex is the part that feels physic stimuli, mostly related to the touch sense. The occipital lobe carries the processing of visual information, and the temporal lobe is responsible by audition and memories in its more inner parts.

Also, the Limbic system must be named. It is the most internal part of the brain, which carries autonomous functions and also is involved in emotions and production of some neurotransmitters.
SYNESTHESIA

Synesthesia is a condition in which one sensory perception triggers sensations in at least other modality when the first perceptual channel is stimulated. The most common form of relation in this kind is the correlate between temperature and color. Some colors are warm and others are cold. Some neurological theories postulate a genetic mutation causing hiper-connectivity between sensory centers of the brain [5]. The most common form of synesthesia is grapheme-color, in which viewing letters and numbers induces the perception of colors.

However, it is not clear that color perception recall letters and numbers. This work explores two debates related to neural bases of synesthesia. Has been said that synesthetic people shows above average levels of creativity. They also scored higher than non-synesthetic people in Fluency, Flexibility and Originality when given Torrance Test of Creative Thinking [7]. This review is going to examine a proposed neural model of synesthesia, as well as its correlate and link with creative behavior.

Neural Mode of synesthesia

Hubbard and Ramachandram propose their Local Cross-activation model for synaesthetes. This model is based on the fact that Visual Word Form Area (VWFA) lies adjacent to V4, the region that process color in visual cortex (extrastriate cortex). Hubbard and Ramachandram propose that grapheme-color synesthesia may arise from direct cross-activation between these adjacent brain regions. [5]

One potential mechanism for this would be the observed prenatal connection between inferior temporal regions and area V4 [5, 10]. Although being adjacent to each other increases the likelihood of brain regions being connected to each other, they suggest that it is the presence or absence of such early connections that is important, not the fact that brain regions are adjacent per se.

Multiple Neural Mechanisms

It is quite likely, given that graphemes, phonemes, music and colors are processed by different brain regions, that forms of synesthesia have different architectural substrates. Ward and Simmer [10] suggest that common neuro-physiological mechanisms may be shared across different forms of synesthesia. Nunn et al. [8] studied word-color synaesthetes with blocks of either pure tones or single words. In their study Nunn presented to synaesthetes a word-color task. Using Positron Emission Tomography (PET), they hope to found activation in visual areas while playing sounds. However, Nunn’s finding shows activation in the posterior inferior temporal lobe, as well as the junction among the parietal and the occipital lobes, but didn’t show activation in the early visual zones (V1, V2-V3 and V4). They also testes control subjects in the same task, and the controls only show activation in the temporal lobe. In previous color-word study using fMRI techniques, Nunn also report that visual areas involved in processing color (V4) were active in synaesthetes when the tone was played and active in non synaesthetes (controls). The controls also didn’t show activation in V4 after even after being “trained” and mentally “see” the color when listed the tone. These two studies provide basis to suspect that in synaesthetes, different perceptual processing areas of the brain are activated when a stimulus is presented.

Activation of Early Visual Areas in Grapheme-Color Synesthesia

Hubbard and Ramachandram propose a dual model of neural mechanism for grapheme-color synesthesia. They claim that the local crossed activation between the auditory cortex (A1) and the color processing cortex (V4) has two steps. The first one is a bottom-up process, in which the neural signal stimulate the auditory cortex and through some connection also stimulates V4. Then, a second process provides feedback to early visual cortices (V1, V2) When saying that this is a top-down process, they imply that is mediated by frontal cortex, but is unclear how much of this process is voluntary and conscientious.

Common or Special Mechanisms?

One final questions is related to the idea that synesthesia depends on neural circuits spatially developed by synaesthetes or relay in common neural circuitry. To date, there is no clear evidence about any position; however, some suggest that synesthesia could be result of some connections remaining from intrauterine life and latter we losses those connections [5, 10].

Creativity and Synesthesia

Ward et al. [10] studied the relation between synaesthetes and creativity using two psychometric tests of creativity (Remote Associates Test, Alternate Uses Test). Previous to the test, synaesthetes were asked about the amount of time they engaged in creative arts and in which kind of art they spend their time. Correlations among the kind of synesthesia and the type of art they used to practice were found. For example, synaesthetes experiencing music-color perception were more likely to play musical instruments than the other synaesthetes in the group. However, there was no relation among this fact and the result they perform on the tests of creativity.

Indeed, Ward et al. claims that synaesthetes may have better bottom-up access to some associations in creative thinking (according to the measures of the tests), but the subjects (synaesthetes) were not specially able to use them with flexibility. They perform as normal subjects in task demanding divergence thinking (flexibility). This finding is crucial because brings light to the definition of creativity since a neurological point of view, at the same time that separates perceptual correlates of creativity and decision making in creativity. According to the correlates of the mind-brain, we must keep in mind that the frontal cortex is the part involved in decision making. Therefore, thinking process is driven by the frontal cortex, while perceptions are localized in visual (occipital) and auditory (temporal) cortices. We can understand this interaction as inputs and outputs in the creative-cognitive process. Additionally, we
have to keep in mind that creativity is usually defined as the ability to generate novel solutions to problems. This leads us to the second vision explored in this study.

**SKILL ACQUISITION**

**Music**

Musical activity involves nearly every region and subregion of the brain. Listening to music starts in the ears, when audio waves reach the tympanic membrane, and its vibration is transmitted through the obstacles in the middle ear to the cochlea. The cochlea is the organ that converts this mechanical impulse into electrical signal, through the organ of corti which fires as a response to that mechanical impulse. The neural signal goes through the auditory nerve to the auditory cortex in the temporal lobe. Here, the signal makes connections with additional regions of the temporal lobe, like the hippocampus, where memories are stored. In this way, using these connections we can learn new pieces of music as well as recall those that we know and have heard before. Now, if we really like the song that we are hearing, (or if we don’t) more connections travel to the emotional centers in the amigdala, a sub-center located in the limbic system.

However, why some people have better aptitude for music than others is something very complex, definitely more complex than a bunch of neurons interconnected firing at different ratios. According to Ericsson, expert’s performance can be explained as the result of individuals’ prolonged efforts to improve performance while negotiating motivational and external constraints [2]. Counter to the common belief that expert performance reflects innate abilities and capacities; research in different domains of expertise has shown that expert performance is predominantly mediated by acquired complex skills and physiological adaptations [3].

Performers can acquire skills that circumvent basic limits on working memory capacity and sequential processing. Deliberate practice can also lead to anatomical changes resulting from adaptations to intense physical activity. As result of their studies following musicians and sports players, Ericsson and Charness found that the only differences among virtuous or “Gifted people” and very good, indeed professional players were the huge amount of hour of practices. The virtuous group had practice for more than twice times than the professionals. Indeed, this work is cited in a huge amount of literature in psychology studies about performance in arts and sports.
DISCUSSION
Starting with synaesthetes’ studies, we know that visual and auditory mental representations in associative cortex emerge driving activity in perceptual processing areas and the dorsal and ventral pathways. This process is mediated by the frontal cortex and the Amigdala, but is unconscious. The frontal lobe plays a lead role in driving perception and attention, both imperative cognitive resources used in creative behavior.

Thus, creativity is product of bottom-up and top-down processes. Bottom-up processes are perceptual processes driven by connections among brain regions. In synaesthetes, as well as in normal people, these connections are part of the brain system required to enhance creative drive and creative behavior. Dopamine level influences novelty seeking, idea generation and creative drive. Creative drive is not a skill. Top-Down processes are conscious processes that allow the subject to seek his/her goals. The Locus of causality is the psychological dimension by which prolonged efforts results in improving skills and performance. Indeed, the locus of causality leads to Flow state. This is, deliberate practice can cause physical changes in body and brain, guiding the subject to forget about his or her environment and lose him or herself in the creative task. This idea is supported by Hebbian learning theory, which claims that neurons firing together develop stronger connections. Finally, Flaherty has studied the role played by dopamine in creative drive [4] suggesting this neurotransmitter as the main cause in goal oriented behavior and self rewarding mechanism inside the frontal cortex.

REFERENCES