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Review

Neuropsychiatry of creativity

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ABSTRACT

In this paper, we review in brief the development of ideas that over time have tried to explain why some individuals are more creative than others and what may be the neurobiological links underlying artistic creativity. We note associations with another unique human idea, that of genius. In particular, we discuss frontotemporal dementia and bipolar, cyclothymic mood disorder as clinical conditions that are helping to unravel the underlying neuroanatomy and neurochemistry of human creativity.

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1. Introduction

Defining creativity is difficult, especially when addressing the subject in relation to the arts. The polymath author–philosopher Arthur Koestler in The Act of Creation gave the term 'bioassociation' to distinguish "routine skills of thinking on a 'single plane', as it were, from the creative act, which … always operates on more than one plane". It is embedded within a metacognition, which began for our ancestors with the "dawn of symbol-consciousness … a kind of diluted Eureka process, spread out in time …" [1]. The psychoanalyst Anthony Storr approved of the definition as "the ability to bring something new into existence", emphasizing the unconscious as well as the conscious contributions to creativity and the accentuation and synthesis of opposites [2]. Creativity in these terms suggests a phenomenon unique to *Homo sapiens* whereby something new is created which has some kind of subjective value (e.g., an idea, a joke, a literary work, a painting or musical composition, a solution, or an invention). There is a qualitative impetus behind any given act of creation, and it is generally perceived to be associated with intelligence and cognition. However, a further aspect has to be considered. Other authors have emphasized the social benefits of the created entity. According to Plucker, creativity involves the interactions among aptitude, process, and environment by which an individual or group produces a perceptible product that is both novel and useful as defined within a social context [3].

How can this process be translated into cognitive terms using a neurobiological perspective? In this regard, some elements are relevant, namely the role of frontolimbic networks and the specialization of brain hemispheres; one way of exploration of creativity is with the techniques of neuroscience, and another is by the study of the influence of brain disorders.

2. Some history

The French physician Moreau de Tours, in 1859, referred to creativity as a *névrose*, a theme taken up by Cesare Lombroso. Lombroso's view was that genius was a variety of insanity. Lombroso documented the relevant signs in people of genius. These ranged from the small stature of Aristotle, Plato, Mozart, Beethoven, Charles Lamb, De Quincey, and Blake to those of greater height than average, such as Goethe, Petrarch, Schiller, Tennyson, and Whitman. A cretin-like physiognomy was accredited to Socrates, Rembrandt, Pope, and Darwin, while left-handedness was a trait of both Leonardo da Vinci and Michelangelo. Lombroso referred to genius as a "true degenerative psychosis belonging to the group of moral insanity". In a potential reference to the later link with bipolar disorders, he further commented "… but the most special characteristic of this form of insanity appears to reduce itself to an extreme exaggeration of two alternating phases, erethism and atony, inspiration and exhaustion …" [4].

Several writers at this time noted an association between "excessive activity" of the intellect and "expansive forms of mental aberration". Nisbet brought forward the known neuroanatomical and neurophysiological evidence, placing Lombroso's theories on an apparently better scientific standing. For him "… apparently at the opposite poles of the human intellect, genius and insanity are, in reality, but different phases of a morbid susceptibility of, or want of balance in, the cerebrospinal system" [5].

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Nisbet, like Lombroso, gave countless examples of men of genius who showed one or another of the stigmata of mental illness, or in whom it could be shown in their families. Nisbet reflected on the creative process, noting that: "The man of genius overflows with ideas; countless memories are stirred in his brain, and he discovers combinations and affinities in facts, tones and colours that lie beyond the scope of the ordinary mind. In all these accomplishments, the madman is his equal. Both the man of genius and the madman owe their characteristics of thought and action to the excessive stimulation, the depression, or the excitability of certain regions of their brain" [5].

Sully [6] observed that "the wide and penetrating vision of the poet is the correlative of his quick, delicate, and many-sided sensibility". This "exquisite sensibility" was connected to "a delicate poise of nervous structure". In other words, there was something about the organization of the brain in creative people, that is associated with the development of such talent. This organization also led to a tendency for suffering, solitude, and a mood of discontent, all "unfavourable to mental health". Creation involved "the full tension of the mental powers, the driving of the cerebral machine at full speed".

Sully noted the great strain that such creative tensions involved and how this "stress and storm should afterwards leave the subject exhausted and prostrate" [6]. The possession of the tendency to genius also carries with it the proclivity for breakdown. The man of talent follows, creatively, lines already laid down; the man of genius "is a mode of variation of human nature which, though unfavourable to the conservation of the individual, aids in the evolution of the species".

Three different views were therefore crystallizing. In the first one, genius was seen to be a divine inspiration. In the second, it was considered a reflection of mental abnormality; in the other, the presence of genius itself was somehow damaging to the mental health, both of the creators and the recipients of their creativity! Melancholy, excitement, and exhaustion became common themes.

The first perspective, that of creativity, especially genius as a reflection of divine intercession, has almost lost its relevance in a more secular society. The second idea could at least in part be rejected on account of the number of geniuses that have lived without evidence of insanity and on the grounds of having no real scientific substance other than multiple anecdotes.

Most authors who discuss artistic creativity do not single out poetry as a different form of genius, for example, to be distinguished from musical or mathematical genius, but some clearly have. However, the evidence, as it appears in later studies, actually does support a distinction between different forms of creativity and their relationship to psychopathology. Russell Brain thus put it: "The poet, who uses words to evoke images, and images to move and delight, is the very opposite of the thinker, who must detach his thought from the concrete and purge it of feeling. Can anyone doubt that these differences between geniuses and ordinary folk and between one type of genius and another depend on differences of neural organisation …" [7].

3. Toward a neurology of creativity

From a cognitive point of view, observational learning, memory, cognitive flexibility, and novelty seeking represent basic elements of creativity. Observational learning is defined as the addition of a novel behavior to an individual's behavioral repertoire via watching another, irrespective of the cognitive processes used in the learning of this behavior [8]. While this ability may not be strictly required to produce an innovative product, along with memory for the learned act, it is part of the creative process. Novelty seeking can be defined as an exploratory activity in response to novel stimulation while cognitive flexibility implies a fluidity of thought, a huge move away from the concrete. Thus, central to artistic creativity has been the development of symbolic thought, allowing the mind disengagement from the immediate present and metarepresentation given over to intentions, beliefs, and recursive "generative processes of combining and recombining items into virtually infinite numbers of novel sequences" [9]. Theory of mind, mental time travel, and both linguistic and nonlinguistic symbolic representations are a part of human creative ability.

While it is clear that these attributes are not *tout á fait* the prerogative of the human mind. From an evolutionary perspective, it is quite unclear when over the past million years or so their coalescence emerged to provide for us such a rich world of imagination, reflected in the arts. However, their emergence must be related at least to the development of the hominid brain, revealed in part by differences between the brains of *H. sapiens* and, for example, our nearest living relatives, the chimpanzees. To discuss this further is beyond the scope of this paper, but certain cerebral structures and circuits have been singled out for attention. These include areas of the frontal and temporal cortex, the basal ganglia, and the cerebellum [10].

The importance of the frontal lobes is central to almost all studies of creative ability, and converging evidence from PET, MRI, and EEG studies suggests that the activation of the frontal lobes clearly differentiates creative from noncreative tasks [11]. However, as discussed by Flaherty [12], creative drive and the generation of ideas depends on interactions between the frontal lobes with the temporolimbic structures. Further, these studies also suggest that the frontal lobes of more creative individuals are more efficient. Thus, creative people may be endowed with brains that store extensive specialized knowledge in their temporoparietal cortex, capable of frontal mediated divergent thinking and with a special ability to modulate the frontal–limbic connections.

From a neurobiological point of view, novelty seeking has been classically associated with dopamine levels and the frontal lobes [13]. In this regard, dopamine seems to modulate not only novelty seeking but also reinforcement as demonstrated in both drug-seeking and risk-seeking behaviors.

Evidence suggests that the cerebellum is involved in the link between seeing and doing — or processing movements and behavior that have been observed, for the individual to produce them later [14]. The cerebellum is also critically involved in the internal representation of action, an ability used to understand and learn the skills of others by observation. In this regard, it is impossible not to mention the role of mirror neurons. Mirror neurons are believed to be involved in understanding the behavioral actions made by others by matching the visual description of an action with the internal motor representation of the same action in the observer [15]. The integration of perceptual predispositions with the motor system involving cortical–basal ganglia thalamic reintegrative loops represents important neuronal elements for creativity [16].

Is there a hemispheric dominance for creativity? An analysis of EEG coherence pointed to the important role of the right hemisphere in creative people [17]. Bogen and Bogen [18] viewed creative innovation as a process dominated by the right hemisphere, which is associated with global and holistic processing. Findings have shown positive correlations between figural and verbal creativity and cerebral blood flow in the right precentral gyrus. Indeed, studies have shown a correlation between level of activity and assessments of creativity in the right cerebral hemisphere [19]. Jung-Beeman et al. [20] reported that the right anterior superior temporal gyrus was particularly involved with the Aha! moment of insight when problem solving. However, this is not the whole story, since many other studies observe significant correlations in both cerebral hemispheres, depending on the type of activity investigated, and note the importance of the left hemisphere for some language-dominated cultural creativity, which has been acknowledged since the time of Broca.

Finally, it is impossible not to mention the role of the unconscious and sleep. The former has received considerable attention in the past, even if now avoided or elided by modern neuroscience. More recently, the importance of sleep in enhancing creative problem solving for items that were primed before sleep has been examined [21]. This seems to be particularly the case for REM sleep and not the result of selective improvements in memory [22].