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# From Incubation to Insight: Working Memory and the Role of the Cerebellum

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## COMMENTARY

# From Incubation to Insight: Working Memory and the Role of the Cerebellum

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From the time I was honored with an invitation to write a commentary on the article *How Working Memory and the Cerebellum Collaborate to Produce Creativity and Innovation*, I have been wearing the article night and day. I take it to the shower. It comes back to me when I am reading, when I am cooking, or if a take a walk. One night I jumped from bed and wrote an extensive draft, which I have dismantled and elaborated, fragment by fragment, in following days.

In their theoretical article, Vandervert, Schimpf and Liu combined previously unrelated domains: creativity and working memory. Their contribution provides a pathway to understand not only what happens during creativity and innovation but also how these processes occur by pointing out the involvement of the cerebellum, which makes cognitive functions faster, more efficient and adaptative, and engages language, attentional, and visuospatial processes and imagery. By doing so, Vandervert et al. also combined emerging knowledge of two fields that are often considered contradictory: neurobiology and cognitive psychology (cf. Kandel, Schwartz, & Jessel, 2000).

### The Involvement of the Cerebellum in Creativity

The cerebellum (from the Latin "little brain") was originally considered the organ of love in phrenologic maps, and its size and development was considered an indicator of sexual capacity (Afifi & Bergman, 2005). Further clinical observations and surgical data during the last 2 centuries showed the involvement of the cerebellum in equilibrium and motor coordination, and symptoms such as asthenia (lack of energy), ataxia (motor incoordination), vertigo, and atonia (lack of normal muscular tonus) were described when this structure was damaged (Afifi & Bergman, 2005; Sadock & Sadock, 2005). The cerebellum was also found to be involved in other functions that are critical for life and survival such as affective, visceral, and endocrine responses (Afifi & Bergman, 2005).

For decades the cerebellum was considered a structure involved in motor processing, and little attention was given to its other functions. Further, in early brain imaging methodologies the cerebellar blood flow was used as a normalization parameter for brain activation data, and only structures having higher blood flow than the cerebellum were considered significant (e.g., Castañeda et al., 2003). Therefore, valuable information about the functioning of this structure might have been lost due to these methodological issues.

In recent years, with the use of more sophisticated brain imaging analysis methods such as statistic parametric mapping SPM (Friston et al., 1995), the involvement of the cerebellum in the processing of cognitive and emotional behavior has been researched and recognized. For example, using statistic parametric mapping analysis in a study of brain activation during the perfor-

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mance of creative tasks from the Torrance Test of Creative Thinking (Torrance, 1990), our research team found a positive significant correlation between the figural and verbal creativity indexes and the cerebral blood flow in the right anterior cerebellum and the right precentral gyrus, the Brodmann area (BA) 6, the right postcentral gyrus (BA 3), the left middle frontal gyrus (BA 11), the right rectal gyrus (BA 11), the right inferior parietal lobule (BA 40), and the right parahippocampal gyrus (AB 35; Chávez, Graff-Guerrero, García-Reyna, Vaugier, & Cruz-Fuentes, 2004; Chávez-Eakle, 2004, in press). These brain areas are involved in multimodal processing, in complex cognitive functions (such as imagery, association processes, memory and novelty processing, among others) and in emotion processing (Rhawn, 1996; Simons & Spiers, 2003). These findings support the involvement of the cerebellum in creativity, which seems to be performed by a highly distributed brain system (Chávez-Eakle, 2004). Further research is needed to elucidate how the cerebellum and these cortical structures interact during the creative process. Functional connectivity comprises the identification of regions that are interacting during a cognitive task, and there is a temporal correlation between their haemodynamic signals (Varela, Lachaux, Rodriguez, & Martinerie, 2001). The use of both functional magnetic resonance imaging and magneto-encephalography, as planned by Vandervert et al. will provide high-quality functional imaging and critical temporal information about functional connectivity among these brain regions. Furthermore, if they would consider other types of analysis, such as nonlinear analysis (Martinerie et al., 1998), this could enhance our knowledge of functional connectivity and the role of the cerebellum in the synchronization of neural events because it will take into account the extended spatio-temporal nature of the brain processes involved in creativity.

## Working Memory, Cerebellar Models, and Creativity Theories

Combining the working memory model with dynamic models of the cerebellum for the study of creativity as proposed by Vandervert et al. has the potential of providing a better understanding of the fluid transition between conscious and unconscious elements during creativity. This could provide supporting data to other creativity theories such as the involvement of preconscious processes as proposed by Kubie (1958); a flowing, flexible, permanently receptive and open state, faster than ordinary conscious processes; Koestler's (1964) bisociation of previously unrelated matrixes; and Rothenberg's (2000) homospatial and Janusian processes, the first involving superimposition of discrete entities, visual or any other kind of mental images, and the second consisting of actively conceiving multiple opposites or antitheses (verbal or conceptual) simultaneously and consciously, which makes it different from the primary process.

## From Incubation to Insight

Sometimes insights are achieved while we take a shower, when we are reading, when we cook or take a walk, even when we go to bed, in sum when we perform any other apparently unrelated activity; a process that has been described as *incubation* (Torrance & Safter, 1990; Wallas, 1926), and that is one of the most intriguing and fascinating components of creativity. Incubation "calls for little or no conscious effort and bright ideas come in flashes while a person is doing something else" (Torrance & Safter, 1990). Merging the working memory model with dynamic models of the cerebellum, as proposed by Vandervert et al., might also make available valuable data that will allow us to elucidate how certain information remains in an accessible state, ready to be used, mixed or carried out, and emerges when performing simple or complex everyday cognitive and motor tasks during the process of incubation.

Nevertheless, it is relevant to point out that creativity should not be reduced to working memory, a construct that has fluctuated from specific models of short memory (Kandel et al., 2000) to very broad definitions involving the whole process of thinking. Further, creativity integrates other processes such as volition, empathy, and emotion and has shown to involve other bilateral brain structures (Bekhtereva, Dan'ko, Starchenko, Pakhomov, & Medvedev, 2001; Carlsson, Wendt, & Risberg, 2000; Chávez et al., 2004; Chávez-Eakle, 2004; Martindale, 1990), which suggests that the cerebellum is a component of a highly distributed brain system (Chávez et al., 2004). These dynamic models of the cerebellum contribute to making clearer the role of this structure in modeling, controlling, and processing cognitive and motor information; in making rapid and accurate mental shifts of attention between different sensory

modalities; in planning and word retrieval (Afifi & Bergman, 2005), processes that are key in creativity. However, these models do not yet explain what causes the leap from everyday creativity to outstanding creativity. Furthermore, there is still much to inquire about the neurochemical events and mechanisms involved, and the role of the cerebellar histological organization in modules of basic circuits (Kandel et al., 2000), in the modulation of these distributed brain processes and in the emergence of a unified cognitive moment (Varela et al., 2001), essential in creativity.

### Gathering Data From First-Person Events

Another interesting aspect of the analysis made by Vandervert et al. is the use of Einstein's descriptions of his own creative discoveries. To observe the workings of one's own mind is existentially and experientially relevant and has been an important topic of psychology and philosophy (Claxton, 1999). *First-person events* refer to the lived experience associated with cognitive and mental events, which has also been denominated as *qualia* or phenomenal consciousness (Varela & Shear, 1999). First-person events can be useful to inquire about experience and to reconsider and challenge constructs and theories, to identify gaps in previous conceptions, and to gather knowledge when the events are not approached through a priori conceptions (Chávez, 2004), or as it is stated in the field of creativity: resistance to premature closure (Torrance & Safter, 1999). Indeed, returning to observations and descriptions might expand notions that have become theories, including the working memory model. After all, creativity involves challenging our constructs before they become dogma.

### Shifting Paradigms

In the cerebellum, motor and cognitive information are processed through the same mechanism (Afifi & Bergman, 2005), which points out that the dichotomies of mind/body and motor/cognitive are no longer useful. As Vandervert et al. remarked, "[a]t the neurological level, movements and thoughts are identical control objects… in thought ideas and concepts are manipulated just as limbs are in movements." Nature tends to repeat successful patterns. In the cerebellar neuronal circuitry there is no distinction between movement and thought, and both are controlled in the same way. This might explain why understanding and insight are sometimes gained through movement and not only by pianists or dancers. Mind and body are not two entities related to each other but an inseparable whole when functioning. Everything we know of consciousness is related to movement, changes in the organization of movement are intimately related to the conscious experience (Ginsburg, 1999).

The way we think about our creativity, ourselves, and our brain has been changing as a consequence of conceptual and methodological transformations. With the latest brain-imaging technologies and methods of analysis, new information about the brain, and in particular the cerebellum, is becoming available. This creative leap makes possible a new approach to the study of the creative process itself, including the enigmatic phase of incubation and the emergence of insight.

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