

Peer Review

Review of: "An Explanation for Dreaming Based on Neuronal Maintenance"

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I enjoyed reading this manuscript because it deals with a fascinating problem (i.e., the role and meaning of dreaming) and contains much information on different aspects (theoretical and experimental). The author exhibits a wide knowledge of different characteristics of dreaming and evaluates several implications for humans and animals. However, I am not completely convinced about his main interpretation, which is that dreaming is used as a maintenance tool for neurons (the author names it the “neuronal maintenance hypothesis”). I am providing below a critical constructive comment on some points in the manuscript.

The author says that “The bizarre and hallucinatory quality of dreams does not align with any well-defined function.” Although I respect this position, I think it is too rationalistic. Symbolic, mythological, and hallucinatory events can transport a deep meaning as well (as always exploited in art and poetry). Maybe a proto-logic (see the pivotal work by Arieti on schizophrenia) can have a role in discovering unknown relationships and hidden links.

A problem with this manuscript is the use of the term consciousness and its relation to dreaming. I know that the author is an expert on consciousness and has written many interesting works on this subject. However, I found it difficult to follow how this term is exploited in the present manuscript, what definition of consciousness is used, and whether the author thinks there is a strict link between consciousness and REM dreaming or not. At the beginning, the author defines consciousness as a module that “allows individual experience to select aspects of life,” which seems to be restrictive to me, similar to a definition of attention. Then the author says that “REM sleep reflects a state different from consciousness” and also says that “whatever function dreams have, it does not require awareness of content,” introducing the new concept of awareness. One of the reasons introduced by the author to distinguish dreaming from awareness is that we often do not remember dreams. But this does not

exclude that we are conscious (with the meaning of being aware of our experience) during dreaming, even if this is subsequently forgotten. We can be conscious of an experience in our lives and subsequently forget it. The position of the author is partially contradicted below, where he says, “children have more REM sleep than adults. Presumably, they need to develop the neural machinery for consciousness.” It seems that the author’s opinion is that REM dreams are not conscious but are used to reinforce circuits subsequently used for consciousness. However, in a subsequent section, the author minimizes the role of dreaming as a mechanism for learning and reinforcement. Finally, in a subsequent point, he says, “I expect dreams to be restricted to conscious animals.” Hence, the relationship between consciousness, awareness, and dreaming should be clarified.

The more important assumption is presented on page 6, concerning the need for neurons to be frequently activated, i.e., a neural maintenance hypothesis. This is interesting, but I cannot find any reference to possible experimental or clinical support. Hence, at present, the assumptions remain quite vague. Moreover, maintenance could be just the evolutionary starting point of a phenomenon that was subsequently exploited to realize more complex functions.

Another aspect introduced by the author is the “internal interpreter” (page 8), which transforms an illogical, random appearance of neuron activity into a story. I am not convinced about this kind of “*deus ex machina*.” Conversely, I found the analysis at the bottom of page 8 much more interesting, where occasional firing is transformed into a more coherent activity by several constraints, including the importance of activated circuitry, daily experience, and sensory inputs. For instance, if one random activity emerges during dreaming, it can activate memory traces (in a Proustian way) stored in past life and autobiographic memory, thus starting a partial crunch of life coherently. This is much more convincing than the “interpreter.” Similarly, a random activation of a neuron coding for a feature can activate the overall semantic network coding for an object, including that feature, producing the activity of an overall object.

The author criticizes the idea that dreaming is important for learning (or at least reduces its importance), indicating that the effect can be negative. But this negative effect can occur in pathological conditions only (like anxiety). A nightmare does not always have a detrimental effect on the life of a healthy subject. Moreover, there are many data linking dreaming with memory consolidation (see, for instance, Klinzing et al., *Nature Neuroscience*, 2019).

I agree (page 11) that neural firing during dreaming can initially be “accidental byproducts of maintenance.” Still, we can suppose it might be just the starting point for a fascinating phenomenon that

can have important additional outcomes for learning, development, and adaptation, not just the unique aim of maintenance.

Declarations

Potential competing interests: No potential competing interests to declare.