**They who dream by day**: Parallels between Openness to Experience and dreaming

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Abstract: Individuals high in the personality trait Openness to Experience appear to engage spontaneously (during wake) in processes of elaborative encoding similar to those Llewellyn identifies in both dreaming and the ancient art of memory (AAOM). Links between Openness and dreaming support the hypothesis that dreaming is part of a larger process of cognitive exploration that facilitates adaptation to new experiences.

Based on parallels between the hyperassociative phenomenology of rapid eye movement (REM) dreaming (henceforth *dreaming*) and the ancient art of memory (AAOM), Llewellyn theorizes that the function of dreaming is to facilitate elaborative encoding of memories. The AAOM provides a fascinating source of inspiration for theories of dreaming, but it is an optional cognitive technology, taught to many educated people hundreds of years ago but rarely seen today; this raises the question of the existence of more common waking states related to dreaming. We believe a more ubiquitous parallel exists between dreaming and waking, and that elaborative-encoding processes akin to those of dreaming commonly occur spontaneously during wake in the segment of the population high in the personality trait Openness to Experience.

Edgar Allan Poe (1848/1975, p. 649) described creativity by noting, “They who dream by day are cognizant of many things which escape those who dream only by night,” and this epigram provides a good description of Openness, which is one of the five major dimensions of human personality and encompasses traits related to imagination, creativity, and perceptual sensitivity (John et al. 2008). Properly speaking, Openness is half of that major dimension, which is now often labeled Openness/Intellect, and describes variation in a general tendency toward cognitive exploration (DeYoung, in press; DeYoung et al. 2012).

Openness/Intellect reflects the ability and tendency to seek, detect, comprehend, appreciate, and use information. Whereas the Intellect half of this dimension describes engagement with abstract, semantic information, Openness describes engagement with sensory and episodic information. Although Openness and Intellect vary together on average, one may find people high in Openness but low in Intellect, and vice versa.

What are the links between Openness and dreaming? First, a simple observation: Openness is the one major personality trait that predicts the tendency to report more dreams and more vivid dreams (Watson 2003). The other links are psychological and neurobiological. Dreaming is “close to imagination” (Nir & Tononi 2010, p. 97), and *Imagination* has been proposed as an alternative label for Openness, which encompasses fantasy proneness (Saucier 1992). Llewellyn proposes that dreaming is an imaginative mnemonic process that identifies associations of recently encoded memories with older memories. Further, these associations are often remote, based on emotional and motivational similarity, or on analogies between specific elements of the memories, rather than on logical connections. Openness strongly predicts the ability to identify remote associations in wake and to engage in *divergent thinking*, the generation of many unusual and creative solutions to problems like “What are all the uses you can think of for a brick?” (McCrae 1987; Silvia et al. 2008; 2009). Both dreaming and Openness appear to facilitate elaborative encoding and thinking outside the box.

These psychological similarities between dreaming and Openness may stem from neurobiological similarities. In REM, the balance of neuromodulators in the brain is dramatically different than in wake. Serotonin, which stabilizes information processing (Spoont 1992), and norepinephrine, crucial for defensive reaction to unexpected events (Yu & Dayan 2005), are almost entirely suppressed, whereas acetylcholine, centrally involved in learning and neural plasticity, is elevated. In wake, acetylcholine levels are elevated in environments characterized by “expected uncertainty,” in which the organism can predict the utility of learning (Yu & Dayan 2005). Finally, dopamine is not reduced in REM, although its concentration shifts from cortex to striatum, and evidence suggests it is actually necessary for dreaming (Solms 2000). Dopamine potentiates cognitive flexibility and exploration, consistent with the hypothesis that dreaming is a form of cognitive exploration (Peterson & DeYoung 2000). Acetylcholine and dopamine, the two neurotransmitters that appear to play a key role in dreaming, have both been linked empirically and theoretically to Openness (DeYoung et al. 2011; Grazioplene et al. 2013). We are not hypothesizing that people with high levels of Openness have the same dramatically altered balance of neuromodulators seen in dreaming. However, individual variation occurs in all neuromodulators, and we are hypothesizing that the waking neuromodulator balance in those high in Openness is more similar to that of dreaming than it is in those low in Openness. In addition to similarity in neurotransmitters linked to dreaming and Openness, there is also similarity in larger brain systems. Dreaming engages the brain’s so-called default mode network (DMN), which appears to be crucial for all forms of episodic simulation (memory, imagination, perspective-taking), and Openness and divergent thinking are both associated with heightened connectivity in the DMN (Adelstein et al. 2011; Takeuchi et al. 2012).

In one regard, we believe the parallel between dreaming and AAOM may be misleading. The purpose of the AAOM is to improve recall rather than to gain new understanding, and Llewellyn suggests that dreaming shares this purpose. However, she also notes that “elaborative encoding works through exploring meaning, inference, and implications,” and that novelty “determines the extent of elaborative encoding” (sect. 4.2, para. 2). We believe that the function of this exploration is not simply to improve recall, but to discover potentially useful patterns in experience that had not been grasped previously. (Note that these discoveries need not become conscious to be useful, although both the facilitation of insight by REM [Cai et al. 2009; Wagner et al. 2004] and the prevalence of dream interpretation suggest that they may sometimes become conscious.) Dreaming is likely to be part of the general process of cognitive exploration that facilitates human adaptation to novelty (Peterson & DeYoung 2000). Openness/Intellect reflects individual variation in that process during wake. Llewellyn states that mnemonic connections in dreaming “will be hyperassociational rather than more linear-logical, as in wake” (sect. 4.2.3, para. 2), but not all associations formed in wake are linear-logical. Hyperassociational phenomenology, milder than but directly analogous to dreaming, is a normal experience for those high in Openness. Openness is associated with some increase in risk for psychosis, but nonetheless seems to be adaptive, in part because it facilitates creativity (DeYoung et al. 2012). In dreaming, the brain appears to give free rein to hyperassociative elaborative encoding. In wake, this exploratory mnemonic process is not silenced but merely subordinated, and its degree of subordination varies with Openness.

A hippocampal indexing model of memory retrieval based on state trajectory reconstruction

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