Consciousness and Cognition 27 (2014) 168–171

Contents lists available at ScienceDirect

Consciousness and Cognition

journal homepage: www.elsevier.com/locate/concog

Bottom-up or top-down in dream neuroscience? A top-down critique of two bottom-up studies

David Foulkes [a], G. William Domhoff [b,*]

[a] 90339 Highway 101 North, Florence, OR 97439, United States
[b] Department of Psychology, University of California, Santa Cruz, Santa Cruz, CA 95064, United States

ARTICLE INFO

Article history:
Received 12 December 2013

Keywords:
Dreaming
Neurocognition
Sensory–motor impairments
Bottom-up vs. top-down

ABSTRACT

Recent neuroscientific studies of dreaming, specifically those in relation to waking sensory–motor impairments, but also more generally, betray a faulty understanding of the sort of process that dreaming is. They adhere to the belief that dreaming is a bottom-up phenomenon, whose form and content is dictated by sensory–motor brain stem activity, rather than a top-down process initiated and controlled by higher-level cognitive systems. But empirical data strongly support the latter alternative, and refute the conceptualization and interpretation of recent studies of dreaming in sensory–motor impairment in particular and of recent dream neuroscience in general.

1. Introduction

In cognitive psychology, a distinction is made between information-processing systems that are "top-down", i.e. largely self-contained and not dependent on information from other systems or sources, and those that are "bottom-up", i.e., largely dependent on information from outside sources. On the face of it, it would seem that the dreaming system must be a top-down information processor. We have proposed (Domhoff, 2001; Foulkes, 1999) that this system involves the reprocessing of a somewhat dissociated network of memories and knowledge in the form of a conscious and generally plausible dream narrative, and that, once in motion, the dream system "does its own thing", without constraint from outside factors.

Hobson (1988, 2002), however, has proposed an influential theory of dreaming in which both its form and content are a function of sensory–motor information transmitted from the brain stem to interpretive areas in the cerebral cortex. He interpreted spike-wave activity running from the brain stem to the cortex as imparting information that became the raw material of dreaming. Since this bioelectric activity is observed only immediately preceding and during REM sleep and since he believed REM sleep was the only occasion for dreaming, he therefore gave the brain stem a critical role in dream formation. A theory of this sort faces enormous theoretical and empirical objections. Theoretically, information transmission from the hindbrain has not been and cannot be observed. The imposition of informational language on physical–chemical processes in the brain stem can only be conjectured, but never proven (McGinn, 2013).

Empirically, results from many studies of experimental stimuli applied during REM sleep (Domhoff, 2003) show that such stimuli very rarely achieve any kind of representation in dream narratives, and that, when they do, the narrative seems to determine the fate of the stimulus, rather than the stimulus determining the fate of the narrative. These observations strongly suggest the primacy of imagination in dreaming, unconstrained by extra-systemic stimuli. At this level, moreover,

* Corresponding author. Fax: +1 831 459 3517.
E-mail address: domhoff@ucsc.edu (G.W. Domhoff).

http://dx.doi.org/10.1016/j.concog.2014.05.002
1053-8100/

information processing can directly be observed. One can compare evident mnemonic inputs to dreaming (the specific memories and general knowledge that seem to have had a role in dream formation) with their appearance or reflection in the ensuing dream narrative.

It may be wondered if the top-down model of dreaming is consistent with the bursts of brain stem activity preceding and accompanying the cortical arousal of REM sleep. The answer is yes, because these impulses simply activate and maintain a state of arousal permitting the dream system to operate on its own terms. We also note that dreaming has been shown to occur in all non-REM stages of sleep as well as in relaxed wakefulness (Domhoff, 2011), although special patterns of brain stem activation have been observed in none of these other states.

Evidence for a top-down construal of dreaming now goes well beyond the data cited above on the effects of external stimuli on dream content. Converging evidence, evaluated by neuroscientists Nir and Tononi (2010), found support for a top-down model, in specific contrast to Hobson's bottom-up model. They state "that dreaming may be closely related to imagination, where brain activity presumably flows in a 'top-down' manner (p. 97)". But this is neither the historical nor the current understanding of dreaming in neuroscience. Particularly before the discovery of REM sleep by Aserinsky and Kleitman (1953) and Aserinsky (1996), the sleep stage from which involved dream sequences most often are reported, it generally was thought that dreams had their sources in bodily or external stimuli occurring haphazardly during sleep. More recently, Hobson's indefatigable promotion of his own bottom-up model seems to have carried the day.

We stress the importance of identifying the type of information-processing system that dreaming is since that knowledge, in turn, must constrain any plausible neurophysiological model of dreaming. If you don't understand what kind of process dreaming is, psychologically, obviously you won't be successful in explicating it neurophysiologically. As cases in point, we note two recent studies of dreams in relation to sensory–motor impairments (Saurat, Agbakou, Attigui, Golmard, & Arnulf, 2011; Voss, Tuin, Schermelleh-Engel, & Hobson, 2011). As long-time dream researchers, we feel that these studies are deficient in conceptualization and interpretation because their authors do not understand the sort of process that dreaming is.

2. An analysis of two bottom-up articles

Bottom-up or top-down? This choice is certain to affect the motivations and interpretations of empirical research on dreaming and sensory–motor impairment. If you believe in the primacy of lower-level sensory–motor systems in dream generation, you would expect that their impairment would have clear and direct effects on the incidence and content of dreaming. If, however, you believe in the primacy of higher-level cognitive systems in dream generation, you would not expect such effects.

The two studies we critique in this section found that sensory–motor impairment did not affect dreaming in general or in the modality that is impaired. Specifically, Saurat et al. (2011) found that persons with congenital and acquired paraplegia had dreams of walking as often as did controls and that there was no correlation between dreams of walking and the duration of paraplegia. Voss et al. (2011) found that the dreams of congenitally paraplegic and deaf-mute persons were not greatly different from those of controls in either sensory or motor representations. Our first reaction on hearing these results is that they add still more evidence for the top-down theory and against the bottom-up theory.

But the authors seem to cling to a bottom-up view, in one case, in spite of evident surprise at the results, which Saurat et al. (2011, p. 1430) find "remarkable." They do make the reasonable surmise that knowing that sensory–motor events happen in the world (through observation, conversation, etc.) is sufficient to support their appearance in dreams, although they nonetheless gratuitously add neural mechanisms to support their bottom-up view ("cerebral walking programs," "mirror neurons"). Voss et al. (2011, p. 686) find their results quite "comfortable" within a bottom-up framework through the gratuitous introduction of a hypothetical construct of "protoconsciousness." Protoconsciousness is said to develop in REM sleep and to provide "a virtual reality model of the world that is of functional use to the development and maintenance of waking consciousness," according to the Voss et al. co-author who originated the concept (Hobson, 2009, p. 803). Again, couldn't we just say that simply knowing about sensory and motor activities is a sufficient condition of their dream portrayal?

3. The theoretical importance of blind dreamers

But there remain puzzles in impairment dreams. How, for example, can someone who has never seen know how to represent that modality in dreams, as claimed in a recent and controversial article by Bertolo et al. (2003)? Partly, the answer surely lies in other forms of non-visual imagery that preserve spatial and metric information, without any reliance on the visual system's information as to hue or brightness (Kerr & Domhoff, 2004). Because these spatial images have some similarities with visual images, they can, in part, be described in visual terms. In communicating with a visual community, it is probably easier to say that one "saw" something than that one merely "felt" or "sensed" it. It is also known that congenitally blind people use "saw" metaphorically based on the widely understood conceptual metaphor that "knowing" or "experiencing" is "seeing" (Hurovitz, Dunn, Domhoff, & Fiss, 1999). And even in the dreams of sighted people, probing after awakenings in sleep laboratories often establishes that the dreamer didn't actually "hear" a conversation, but just knew that it had taken place.

Interestingly, both Saurat et al. (2011) and Voss et al. (2011) cite the Bertolo et al. (2003) article without acknowledging the empirically based rebuttal by Kerr and Domhoff (2004), seemingly to leave it an open question as to whether visual