Stage-dependent cortical/hippocampal reactivation may explain the differences in recall frequency between REM and NREM mentation

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Summary. Previous research has demonstrated that dream recall rates differ between REM and NREM sleep. However, the neurological mechanisms responsible for this difference are not fully understood. Here recent research is discussed regarding the characteristics of neural reactivation during REM and NREM in response to pre-sleep memory acquisition. It is proposed that differential reactivation of cortical and subcortical areas during REM and NREM may offer one possible explanation for why there are differences in dream recall rates from REM and NREM sleep.

Keywords: REM dreams; NREM dreams; dream recall frequency; neurological substrates

Differences have been noted between REM (Rapid Eye Movement sleep, characterized by 7-10 Hz brainwave activity and rapid/conjugate movement of the eyes) and NREM (Non-REM; all other sleeping brain states) dreams. Some studies on sleep state mentation (dreaming) have suggested that REM and NREM dreams differ in terms of quality (Monroe, Rechtschaffen, Foulkes, & Jensen, 1965). Further research has suggested that REM dreams reflect emotional and procedural learning, while NREM dreams reflect declarative learning – however, it is currently unclear from research findings whether there are actually distinct stage-dependent differences between the content of REM and NREM dreams (Cavallero, 1993; Cicogna, Cavallero, & Bosinelli, 1986; Monroe et al., 1965; Nielsen, 2000).

One difference between REM and NREM dreams that has been well supported is the difference in recall frequency. While the actual percentages reported vary slightly, research studies consistently report that REM dreams are more frequently recalled than NREM dreams (Nielsen, 2000). Estimates of recall frequency suggest that the recall rate from REM is approximately 80-85%, while the recall rate from NREM is only 40-45% (Nielsen, 2000). Further research has also suggested that even following training to increase dream recall, the recall rate from NREM sleep appears to remain stable and does not approach the 80-85% recall frequency that would be expected from REM sleep (Schredl, Brennecke, & Reinhard, 2013). Although this finding has been consistently reported, conclusive evidence demonstrating why the difference between REM and NREM dream recall exists has not yet been reported. One theoretical explanation that has been proposed is that dreams are tied to REM brain processes, and that less frequent and covert REM brain activity occurring within NREM sleep stages may produce infrequent sleep mentation (Nielsen, 2000). Further research, however, has suggested that differences in recall processes between REM and NREM sleep may be responsible for the discrepancy in recall frequency between REM and NREM dreams (Schredl, Brennecke, & Reinhard, 2013); the same study also suggested that, in opposition to what would be predicted by the covert REM model proposed by Nielsen (2000), dream recall frequency from NREM sleep is not influenced by temporal proximity to REM sleep stages.

One possible explanation of the neurological systems responsible for producing the difference in REM and NREM recall rates is that this difference may be a result of the way the brain becomes differentially reactivated during REM and NREM sleep. It has been previously demonstrated (using PET imaging of cerebral blood flow during sleep) that during REM, areas of the cortex become reactivated in patterns which mimic brain activations during learning while awake (Maquet et al., 2000). During NREM sleep, subcortical areas become reactivated in the same manner (Peigneux et al., 2004). REM activity has been found to be related to the consolidation of emotional and procedural memories from the waking day, while NREM activity relates to the consolidation of declarative information (Diekelmann, Wilhelm, & Born, 2009; Nishida, Pearsall, Buckner, & Parker, 2009; Payne, Chambers, & Kensinger, 2012; Smith, 2008). These reactivations are seemingly in accordance with known characteristics of the dream experience, such as the continuity hypothesis (the incorporation of waking day information into dream imagery; Erlacher & Schredl, 2010; Schredl & Hoffman, 2003); the reactivation of specific brain areas in response pre-sleep experience would seem to help explain why waking day information is often incorporated into dream imagery.

While brain reactivation during sleep can involve both neocortical and subcortical areas (Maquet et al., 2000; Pei-

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gneux et al., 2004), the brain becomes differentially reactivated in response to pre-sleep learning such that cortical reactivations are more strongly represented in REM than NREM (with NREM being more strongly implicated in the reactivation of subcortical areas). It can be suggested based on these findings that, because most of the areas of the brain required for the production of sensory experience (primary visual, auditory, and motor cortices, for example) are cortical rather than sub-cortical, the reactivation of areas related to the generation of sensory experience is more likely to occur during REM rather than NREM sleep (thereby producing the possibility for the perception of sensory experience most frequently during REM rather than NREM sleep).

The benefit of such an approach to explaining the difference in recall rates is that the underlying neural mechanisms that relate sleep mentation, memory consolidation, and neural reactivations during sleep have already been confirmed by previous research findings (Maquet et al., 2000; Peigneux et al., 2004). In order to determine whether this approach to explaining the differences between REM and NREM recall rates is accurate, however, further experiments would need to confirm that subcortical reactivation alone during NREM sleep is not sufficient to produce the vivid imagery/experience of a dream in the absence of experience-dependent cortical reactivation.

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