Sleep does not cause false memories on a story-based test of suggestibility

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ABSTRACT

Sleep contributes to the consolidation of memories. This process may involve extracting the gist of learned material at the expense of details. It has thus been proposed that sleep might lead to false memory formation. Previous research examined the effect of sleep on false memory using the Deese-Roediger-McDermott (DRM) paradigm. Mixed results were found, including increases and decreases in false memory after sleep relative to wake. It has been questioned whether DRM false memories occur by the same processes as real-world false memories. Here, the effect of sleep on false memory was investigated using the Gudjonsson Suggestibility Scale. Veridical memory deteriorated after a 12-h period of wake, but not after a 12-h period including a night's sleep. No difference in false memory was found between conditions. Although the literature supports sleep-dependent memory consolidation, the results here call into question extending this to a gist-based false memory effect.

1. Introduction

Sleep contributes to the consolidation of episodic memories (e.g., Weber, Wang, Born, & Inostroza, 2014), as well as declarative memories (e.g., Ellenbogen, Payne, & Stickgold, 2006; Gais & Born, 2004). Sleep-dependent memory consolidation has been argued to be a complex, selective process, during which a process of memory triage takes place to determine which memories are consolidated and in what form (Stickgold & Walker, 2013). According to Stickgold and Walker (2013), during or shortly after encoding memories are tagged for consolidation, and only relevant information is processed during sleep. This results in discriminatory incorporation of selected memories, for example emotional memories (Payne & Kensinger, 2010; Stickgold & Walker, 2013) or memories with future relevance (Fischer & Born, 2009; Saletin, Goldstein, & Walker, 2011; van Dongen, Thielen, Takashima, Barth, & Fernandez, 2012; van Rijn, Lucignoli, Izura, & Blagrove, 2017; Wilhelm et al., 2011), over others. In addition, they propose that new knowledge is formed during two types of sleep-dependent memory integration: item-integration, where newly learned memories are added to existing schemas, and multi-item generalization, where new memories are combined to create a new schema. During multi-item generalization the gist of a set of memories can be extracted, which leads to a combined representation of related memories, while individual items are forgotten (Stickgold & Walker, 2013). In line with the general account of the role of sleep in gist extraction, sleep is proposed to strengthen newly acquired memories through reactivation during slow wave sleep (SWS), until they become integrated with pre-existing knowledge networks in the neocortex (Diekelmann & Born, 2010). The replay of memories during SWS has been proposed to be the underlying mechanism for schema formation and gist extraction (Lewis & Durrant, 2011). During SWS, overlapping replay of memories strengthens areas of similarity (Lewis & Durrant, 2011). Additionally, a process of synaptic

downscaling takes place during SWS, in which recently potentiated synapses are downscaled. In this process stronger interconnections between overlapping areas survive, whereas weaker associations are lost (Tononi & Cirelli, 2003). During sleep, shared elements of memories are abstracted from a set of related memories, eventually producing a schema (Lewis & Durrant, 2011). Importantly, it has been suggested that this gist extraction can result in false memories being formed (Lewis & Durrant, 2011; Payne et al., 2009; Stickgold & Walker, 2013).

False memories are recollections of events or stimuli that never actually took place, or which are remembered in a distorted way (Roediger & McDermott, 1995). A commonly used method to research false memories is the Deese-Roediger-McDermott (DRM) paradigm (Deese, 1959; Roediger & McDermott, 1995). In this paradigm, participants learn lists of semantically related words (e.g., *rest*, *bed*, *dream*, *wake*) from which a critical theme word, or lure (here, *sleep*), is omitted. At retest, participants have been found to falsely remember learning the critical lure. Testing is done using either a free recall or a recognition test. In free recall, participants are instructed to recall as many words as they can remember, within a set time frame. In recognition, participants are presented with a series of words, one of which is the lure, and are tested on their recognition of each word (Roediger & McDermott, 1995). Several studies have employed the DRM paradigm to examine whether sleep can cause false memories. In these studies, participants learn multiple DRM lists and are retested after either a period of wake, sleep or sleep deprivation. Results are mixed, with some studies reporting an increase in false memories after sleep (Darsaud et al., 2010; Diekelmann, Born, & Wagner, 2010; McKeon, Pace-Schott, & Spencer, 2012; Payne et al., 2009) or sleep deprivation (Diekelmann, Landolt, Lahl, Born, & Wagner, 2008; Diekelmann et al., 2010), whereas others have reported a decrease in false memories after sleep (Fenn, Gallo, Margoliash, Roediger, & Nusbaum, 2009; Lo, Sim, & Chee, 2014), or no effect of sleep on false memory (Cox, Carter, Willner, Blagrove, & van Rijn, 2016).

Sleep is thought to facilitate memory consolidation by extracting the gist of the learned material, in this case the DRM lists, at the expense of the details. This gives rise to a number of mechanisms by which sleep might enhance the recall of false memories. For example, it might be beneficial in some situations to remember the general meaning of information and not all specific details; this would enhance the retrieval of unstudied critical lures because they represent the gist of the DRM list (Lo et al., 2014; Payne et al., 2009). Also, the emotional context may enhance gist memory at the expense of specific details (McKeon et al., 2012). Additionally, the absence of external memory cues during free recall could lead to self-cueing, in which own cues are generated during retrieval so as to remember studied items, which increases the likelihood of falsely remembered unstudied lures as caused by the extraction of generalized features during sleep (Diekelmann et al., 2010). Finally, with free recall, participants need to actively retrieve the studied words, relying more on integrated memory of the lists, which could lead to more spontaneous generation of unstudied items after sleep (McKeon et al., 2012). All of these explanations assume that the processing of memories during sleep results in a gist of the learning being abstracted, with specific and generalized information then being stored, leading to the production of false memories either as part of gist formation, or as a deduction at testing via retrieval of the gist of what was learned (Landmann et al., 2014).

However, it has been questioned whether DRM false memories occur by the same processes as real-world false memories (Frenda, Patihis, Loftus, Lewis, & Fenn, 2014; Ost et al., 2013). Using a richer, more real-world like misinformation task, Frenda et al. (2014) and Lo, Chong, Ganesan, Leong, and Chee (2016) found an increase of false memory after sleep deprivation, but not after sleep. The present study aimed to examine the effect of sleep on false memory in a novel manner that more closely resembles real life, using the story-based non-forensic version of the Gudjonsson Suggestibility Scale (GSS) 2 (Gudjonsson, 1987). The GSS tests for false memory about a story through the use of leading questions, which act as recognition items, but without corresponding veridical information. The GSS was designed to measure susceptibility to suggestion (Gudjonsson, 1984) and has been shown to correlate with real-world instances of false memories or false confessions about criminal acts (Gudjonsson, 1991a,b). The test consists of a short auditory presented story about an incident and a set of 20 questions about this story, 15 of which are leading questions that cannot be answered from the information provided in the story. The other five questions, which are non-leading, are intended to conceal the real purpose of the scale, and are not included in the measurement of suggestibility. Participants listen to the story, recall what they remember from it, and are then tested by answering the 20 questions. After answering all 20 questions, participants receive feedback on their performance. This feedback is typically negative, but can also be neutral (McMurtrie, Baxter, Obonsawin, & Hunter, 2012). After receiving feedback, they answer the questions again. In the present experiment, participants listened to the GSS 2 story and then, 12 h later, after either a period of wake or a period of sleep, answered the questions about it.

Sleep deprived individuals have been found to be more suggestible on the GSS than controls who are not sleep deprived (Blagrove, 1996). This may indicate that sleep deprivation leads to a failure to discriminate between the original story and the suggestive questions. Alternatively, sleep deprived participants could be less motivated and confident in their ability to answer the questions correctly (Blagrove, 1996). This second explanation was tested in a subsequent study, in which participants gave confidence ratings on a scale of 1 (*extremely uncertain*) to 5 (*extremely certain*) after answering each question. Sleep deprived participants were again significantly more suggestible, but their levels of confidence were the same as for the controls. It was thus proposed that the effect is not caused by motivational deficits, but by cognitive deficiencies in source memory due to effects of sleep loss on the prefrontal cortex (Blagrove & Akehurst, 2000).

Mazzoni (2002) distinguish between 'naturally occurring' and 'suggestion-dependent' memory distortions. Naturally occurring memory errors can arise at any time and result from the way memory works. Suggestion-dependent memory distortions, on the other hand, occur due to the presence of external suggestions, such as leading questions. DRM errors are a type of naturally occurring memory errors, whereas GSS errors are suggestion-dependent (Mazzoni, 2002). Given that sleep has been shown in some studies to result in naturally occurring DRM false memories (e.g., Darsaud et al., 2010; Diekelmann et al., 2010; McKeon et al., 2012; Payne et al., 2009), our aim in this study is to test whether suggestion-dependent false memories are augmented by sleep.

Whereas the DRM paradigm has been used to examine the effect of sleep, sleep deprivation and wake on false memory, sleep and non-sleep deprived wake groups have not been compared directly on the GSS before now. The GSS uses a narrative, the gist of which