

## COGNITION

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One of the defining characteristics of sleep is that the individual becomes relatively unresponsive to external stimuli. Thus, if we fall asleep while the television is on, we do not appear to process what is being broadcast while we are asleep; we have no memory for having heard anything while asleep. In fact, if we remember hearing anything, we attribute that to waking up briefly during the program. Almost by definition, if we sleep, we do not expect to remember hearing anything.

Even though we cannot remember doing so, it is likely that we process information from our environment during sleep. For example, we almost never fall out of bed, despite turning over and moving often during sleep. How do we know where the edge of the bed is?

Considerable evidence exists to indicate that we can be awakened more easily by meaningful than nonmeaningful stimuli (see AROUSAL). The common observation that parents can sleep through a thunderstorm but wake to the cry of their child is true. We are also more easily awakened from sleep by hearing our own name than by hearing an equally loud, but meaningless sound. How do we know which sound to awaken to?

Many important questions about mental activity during sleep are just beginning to be

understood: How much information from the environment can be processed by the sleeper? Why do we remember so little of what happens during sleep? What sorts of mental activities are associated with sleepwalking and sleepwalking? Are dreams meaningful, and if so, why aren't they better remembered? Can we become aware that we are dreaming during a dream, and can we control our dreams? What are the possibilities for learning during sleep?

An important theme of these questions is the lack of memory for events that take place during sleep (see AMNESIA; MEMORY). Individuals can be taught to respond to external stimuli in all stages of sleep, but they have little memory for doing so. In one study, sleepers were taught to take a deep breath whenever they heard a tone (Badia et al., 1985). In the morning, the sleepers were asked how many times they heard the tone. Despite taking deep breaths in response to a tone as many as 50 to 100 times during the night, the sleepers reported that they only heard and responded to the tone six or eight times during the night.

Research in other areas of cognitive psychology indicates that it is important to distinguish between explicit and implicit memory when dealing with issues of awareness. *Explicit memory* refers to the conscious recollection of recently presented information, whereas *implicit memory* refers to memories that are encoded and influence performance even though there is no awareness of them (Schacter, 1987). Thus, for example, if pairs of words are played through earphones for surgery patients while they are under anesthesia (Kihlstrom et al., 1990), the patients do not remember hearing the words (explicit memory) but are more likely to produce the paired word when asked to free-associate to the first word of each pair (implicit memory) than if the words had not been played.

Something similar may happen during sleep. Perhaps explicit memory for information during sleep is disrupted, but implicit memory remains. One recent experiment examined this hypothesis by evaluating the effect of sleep onset on memory. Pairs of words were played as individuals fell asleep (Wyatt et al., 1992), and participants were awakened after either 30 seconds or 10 minutes of sleep and tested for explicit and implicit memory of the words. Most participants who were allowed to sleep 10 minutes could not recall any of the words played during the 3 minutes

just before they fell asleep; memory was not disrupted for participants who were only allowed 30 seconds of sleep. Even in the 10-minute condition, however, some types of memory for the words were still available as indicated by cued-recognition and implicit memory tests. In these tests, the first word of each pair was played and the participants had to respond either with the word they had heard paired with it (cued recognition) or with any word that came to mind (implicit memory). Although the patterns of memory performance on these two tests were different, both indicated that some memory remained even when participants could not initially recall hearing the words.

One usually experiences light sleep during the first 10 minutes of sleep. It is not surprising, therefore, that cognitive processing of external stimuli continues during the lightest stages of sleep. This study indicates, however, that even light sleep disrupts the conscious recall of events that immediately precede sleep.

How much processing of external stimuli takes place during later, deeper stages of sleep? Research on auditory EVOKED POTENTIALS during sleep indicates that stimuli are processed at the auditory cortex during sleep. Early components of the evoked potential (the first 100 milliseconds) are observed in all stages of sleep; the later components, however—those usually associated with more elaborate cognitive processing—are either delayed or absent.

Studies of cognitive processing during sleep have typically found a lack of memory for information presented during sleep unless the presentation was immediately followed by physiological arousal. The longer the arousal, the better the memory. Attempts to distinguish between explicit and implicit memory for information presented during sleep later in the night have not been fruitful. Thus, although information during sleep may reach the auditory cortex so that meaningful stimuli can be identified and we can be awakened if necessary, we are not likely to remember the stimuli unless we wake up during or immediately after them. This phenomenon may also explain our poor memory for dreams.

We typically do not remember dreams unless we wake up during them. Thus, people are usually aware of dreaming only when they wake up in the morning, because they are more likely to wake up during a dream and stay awake for a long

enough time to consolidate the dream content. Attempts to help individuals become aware of their dreams while still dreaming (called LUCID DREAMING) indicate that it is possible to become aware of some cognitive processes during sleep.

Overall, the evidence indicates that cognition does not stop during sleep, just our awareness of it. The relationship between cognition and sleep is one of the most exciting and challenging topics in sleep research.

(See also PERCEPTION DURING SLEEP; SENSORY PROCESSING AND SENSATION DURING SLEEP.)

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