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The Dreaming Brain

The brainwave patterns of sleep are not all the same. In humans, sleep is composed of ninety minute cycles and the stages of sleep alternate within each sleep cycle. Rapid Eye Movement (REM) sleep occurs at the end of each cycle. The first epoch of REM sleep of the night is short, lasting only about five to ten minutes. As the ninety minute cycles of sleep progress, the length of the REM sleep epochs gradually increases, so that the REM sleep of the last ninety minute cycle is usually the longest of the night and may be just short of an hour in duration. REM sleep is loosely known as dream sleep. Dream imagery can occur during other phases of sleep, although dream mentation following awakenings from REM sleep is typically the most vivid. Normal REM sleep is characterized by an electroencephalographic pattern of low voltage, mixed frequency electroencephalographic (EEG) waveforms, which is similar to that seen during waking. REM also involves paralysis of the body, so that one does not act out their dreams. This paralysis occurs for all muscles except the extraocular muscles, the diaphragm, and the stapedius muscle in the middle ear.

How is it that dreaming actually occurs? During waking, the parietal association cortex takes visual information from the occipital cortex, somatosensory information from the post central gyrus, and auditory information from the temporal lobes and combines it all on a higher level to make the cortical representation of your waking sensory world. The P300 waveform is a cortical potential that is thought to represent this highest level of parietal cortical processing. A study looking at cortical potentials discovered a positive potential of relatively long duration with peak latency of about 200 msec in the mid-parietal area that appeared only during REM sleep and occurred in association with bursts of rapid eye movements. This positive potential may represent the equivalent of a P300 appearing in response to visual images in a dream.[1] Another study examined the eye movements of wakefulness and compared them to the eye movements of REM sleep. Saccades in wakefulness were recorded during a self-paced visual search task. Brain potentials were averaged and time-locked to the onset of eye movements of REM sleep. The authors concluded that rapid eye movements elicit activity in the cortical visual area suggesting that rapid eye movements may trigger dream images.[2] A third study examined the EEG potentials of REM and determined that the P250R waveform accompanied with rapid eye movments reflects activities involved with the cognitive processes occurring when a subject scans a dream image during REM sleep.[3]

Although the exact latency of the waveforms in these studies varied slightly, the conclusion of each is that these waveforms may represent the equivalent of the cortical representation of dream imagery.

The generation of REM sleep begins in the brainstem. Ponto-geniculo-occipital (PGO) waves are waveforms that originate in the pons of brainstem, progress to the lateral geniculate nucleus of the thalamus which is important in the normal processing of vision, and then extend to the occipital cortex which is where the cortical representation of vision occurs. In cats, PGO waves have been found to be synchronized with and phase locked with sawtooth waves.[4] Sawtooth waves are an electroencephalographic waveform in the theta frequency seen in bursts during REM sleep. A study was performed looking at the pattern of waveforms that are seen during REM sleep. Seventy-seven (85%) of a total of 91 REM sleep cycles demonstrated a relatively stereotyped sequence of events: the paralysis of REM sleep, the appearance of sawtooth waves, and finally ending with the first phasic burst of rapid eye movements.[5]

How is it that a sound in our bedrooms or a touch while we are in REM is sometimes incorporated into our dreams? It has been shown that REM sleep duration and PGO spike density can be enhanced by auditory stimulation. In a study of cats somatic stimulation was applied at the beginning and throughout each REM sleep period. This resulted in a significant increase in REM duration (60.2%) and PGO spike density.[6] Could this be reflective of the mechanism that occurs when a stimulus in the real world is incorporated into our dreams, such as when we dream that an air raid siren is going off only to then awaken and realize that it was only the alarm clock? Sweet dreams….

[1] Electroencephalogr Clin Neurophysiol. 1988 Nov;70(5):396-403
[2] Sleep. 2005 Sep 1;28(9):1077-82
[3] Electroencephalogr Clin Neurophysiol. 1990 Jul;76(1):19-28
[4] Psychiatry Clin Neurosci. 2001 Jun;55(3):189-90
[5] Electroencephalogr Clin Neurophysiol. 1997 Dec;103(6):627-32
[6] Brain Res. 1987 Jan 1;400(1):155-8