Brain Waves of Dreaming Sleep Found For First Time

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Sunnybrook and University of Toronto researchers are the first in the world to find and identify the fundamental waveform of dreaming sleep, providing potential links to learning and memory, potentially important for conditions such as stroke recovery.

"We are finally able to confirm the existence of 'PGO' waves, the fundamental basis of dreaming, as a feature of human rapid eye movement (REM) sleep, something we have never seen before," says Dr. Brian Murray, senior author of a new study and sleep specialist and neurologist at Sunnybrook Health Sciences Centre. "Until now, we were only able to see these brain waves in animals, and didn't know if they existed in humans, but we now know they're there. This finding has tremendous implication for further research into stimulating the brain to improve brain health outcomes."

PGO (Ponto-geniculo-occipital waves, or P waves) are a hallmark of mammalian sleep, occurring during, and immediately before, REM sleep. The P waves are the most fundamental waveform for dreams, being detected even before an electroencephalogram (EEG) test shows anything.

The study involved a patient with Parkinson's disease, who was undergoing a neurosurgical procedure to help relieve symptoms of the disease, mainly to help him walk better. Pre-operative MRI scans helped sleep researchers determine the area they wanted to investigate. Electrodes were implanted 1.5 millimetres apart, into a specific area deep in the brain, localized as close as possible to the human P-wave source, within an incredible 3 millimetre area. The little waveforms were detected during REM sleep and before it, and found somewhere in the centre of the brain, a spot fairly difficult to reach. Recordings of electrode waves were mapped and a large area of the brain is changed when each P-wave occurs.

"They come from an area called the pons, a small area at the base of the brain," says Dr. Andrew Lim, lead author on the study and neurology resident at University of Toronto and Sunnybrook Health Sciences Centre. "This waveform is a piece of the puzzle we found. It's not just important that they're there, but also because they potentially affect the entire brain."

"This is a particularly important finding for sleep researchers," says Dr. Murray, who is also an assistant professor in the Division of Neurology at University of Toronto. "We think these waveforms are fundamental to help us understand how the brain changes in sleep with learning and memory. This is the start of a stream of 'space age' work using deep brain recordings and stimulation to understand sleep, cognition, and various neurodegenerative disorders. These waves are incredibly interesting little things."

The findings of the study, published in the July issue of the journal *Sleep*, support commonality in how mammals sleep, and invite further exploration of the importance of brain interactions in human REM sleep control, dream generation, and learning.

"This area of the brain is difficult to study, as a similar study in a normal subject is ethically impossible. This was an excellent opportunity to investigate the area while a patient was undergoing a neurosurgical procedure for another reason," says Dr. Lim. "The fact that we saw the waveforms in this patient means they definitely exist in humans; it's there," adds Dr. Murray, "Now that we can visualize them, we can look at how they are involved in neurodegenerative conditions, stroke recovery, learning and memory, etc."

This phase of the study involved recording the brain waves while the electrodes were embedded in the brain during surgery. "In our follow-up study, the second phase allowed us to look at ways to increase the amount of dreaming sleep by stimulating the electrodes post-surgery, in order to potentially improve neurological function," says Dr. Murray. "After surgery, the electrodes can be stimulated by a programmed device, like a pacemaker for the brain. We expect to publish findings from this next phase of the study in the next year. We expect those findings to be significant for patients as the stimulation may make a big difference to the quality of their sleep as well as other neurological functions, and therefore its effects on their health."

Sleep is known to be important for cognition, brain functioning, and overall health. The amount and quality of dreaming sleep is associated with mood disorders such as depression, and neurological conditions such as dementia. "With our upcoming research, we have envisioned a prosthesis where we can improve sleep," says Dr. Murray. The researchers presented preliminary results for the study's second phase at a sleep conference earlier this year.

This University of Toronto Division of Neurology collaboration included Movement Disorder Scientists at Toronto Western Hospital. Dr Lozano, a neurosurgeon internationally known for his deep brain stimulation work, performed the surgical procedure to treat the patient's symptoms of Parkinson's Disease, and Sunnybrook's sleep experts conducted the sleep research work. Other collaborators include Drs. Moro, Hamani, Hutchison, Dostrovsky, Lang and Wennberg.

Contact:
Nadia Norcia Radovini, Communications Advisor
Sunnybrook Health Sciences Centre

Sunnybrook Health Sciences Centre
(416) 480-4040