A non-invasive alternative to selective sleep restriction in rodents using somatosensory stimulation

Dillon Huffman [1] • Asma'a Ajwad, MS [1] • Kevin Donohue, PhD [2] • Bruce O'Hara, PhD [3] • Sridhar Sunderam, PhD [1]

[1]Biomedical Engineering, University of Kentucky • [2]Electrical and Computer Engineering, University of Kentucky • [3]Biology, University of Kentucky

Abstracts will be considered for both poster and platform presentations

Sleep disorders

Sleep plays a vital role in physiological and homeostatic processes, with each state of sleep (Rapid Eye Movement (REM), non-REM (NREM)) mediating unique aspects of learning, memory, and cognition. A common approach to investigating these state-specific contributions is by restricting the state in question and observing the consequences. However, experimental tools to identify and selectively interrupt sleep are still underdeveloped; most of which being stressful to the animal, infringe on normal behavior, or are open-loop in operation. To this end, we sought to accomplish the common goal of REM Sleep Restriction (RSR) by means of automated, non-invasive vibro-tactile stimulation, which was applied via a tactile transducer mounted under the floor of the cage (MouseQwake; Signal Solutions, LLC.), and could be activated with predetermined stimulation parameters (frequency/amplitude) to yield more subtle or intense intervention. Eight C57BL\6 mice (4M, 4F) were instrumented with EEG/EMG headmount electrodes according to IACUC-approved protocols. Following recovery, signals were fed into an unsupervised computational model which estimated sleep-waking states in real time, and triggered stimulation upon detecting REM sleep. Each animal underwent four trials (each using a unique frequency/amplitude combination), which consisted a 12-hour baseline, as well as a time-locked 12-hour trial of RSR (stimulation triggered when REM detected) on the following day. Data was then manually scored by human raters, and the effect of stimulation on REM sleep was assessed. While more subtle stimulation showed no clear effect, more intense stimulation drastically affected REM sleep – reducing mean REM bout duration by 50-70% depending on stimulation parameters. The overall proportion of REM sleep was also reduced by as much as 40% during the first 4 hours of RSR, which eventually led to a homeostatic rebound to compensate for lost REM. In conclusion, this system provides a non-invasive alternative to currently available systems for sleep restriction in rodents. The stimulation parameters can be tuned to suit a particular animal or experimental condition, and can be programmatically adapted to compensate for persisting sleep resulting from homeostatic- or circadian-dependent changes in arousal thresholds. Moving forward, automated selection of stimulation parameters, and the incorporation of non-invasive sensors to alleviate the need for surgical implantation of EEG/EMG. These improvements will result in a completely non-invasive system that could be implemented without having any experience in surgical methods or sleep scoring and analysis.

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