

## Poster Presentations

**P001 COMMUNICATION FROM THE CEREBELLUM TO THE NEOCORTEX DURING SLEEP SPINDLES**

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**Introduction** Surprisingly little is known about neural activity in the sleeping cerebellum.<sup>5–17</sup> Using long-term wireless recordings, we have made routine recordings of local field potentials (LFPs) and action potentials for the entirety of natural sleep in non-human primates.

**Methods** We were able to record simultaneously from the primary motor cortex (M1), the thalamus and the cerebellum using both rigid multi-contact linear electrode arrays and flexible microwires.<sup>11–12</sup> Recording for the entirety of the natural sleep was achieved using a custom-made wearable device.

**Results** We find that the M1 and cerebellum communicate with each other during sleep,<sup>13–14</sup> with cerebellum-to-M1 signals passing via the thalamus. We find that both M1 and cerebellar neuronal firings are broadly synchronous and phase-locked to the sleep cycle.<sup>7</sup> Additionally, both spikes and LFPs in M1 and cerebellum also show coherence at slow (<1Hz), delta (1-4Hz) and alpha (7–15Hz) frequencies.<sup>8–15–16</sup> We also see phase-locking between the spikes of M1 and the LFPs of the cerebellum (and vice versa) at these same frequencies. Using Granger causality analysis on the LFPs we were able to observe directed connectivity from motor cortex to the cerebellum in deep sleep. This suggested a neocortical origin of slow oscillations. By contrast, sleep spindles (in the alpha frequency range) in light sleep revealed a causal influence from the cerebellum to motor cortex, going via the thalamus.

**Discussion** Our results shed new light on the mechanisms of sleep spindle generation<sup>9</sup> and show that the cerebellum is an active participant of sleep. We postulate that the cerebello-thalamo-neocortical pathways is implicated in sleep-dependent consolidation of procedural learning.<sup>1–4–6–18–20</sup>

**REFERENCES**

- Bastian AJ. Learning to predict the future: the cerebellum adapts feedforward movement control. *Current opinion in neurobiology* 2006;**16**(6):645–9.
- Nishida M, Walker MP. Daytime naps, motor memory consolidation and regionally specific sleep spindles. *PLoS one* 2007;**2**(4):e341.
- Fogel S, Albouy G, King BR, Lungu O, Vien C, Bore A, et al. Reactivation or transformation? Motor memory consolidation associated with cerebral activation time-locked to sleep spindles. *PLoS one* 2017;**12**(4):e0174755.
- Diekelmann S, Born J. The memory function of sleep. *Nature reviews Neuroscience* 2010;**11**(2):114–26.
- Canto CB, Onuki Y, Bruinsma B, van der Werf YD, De Zeeuw CI. The Sleeping Cerebellum. *Trends Neurosci* 2017;**40**(5):309–23.
- Latchoumane CV, Ngo HV, Born J, Shin HS. Thalamic Spindles Promote Memory Formation during Sleep through Triple Phase-Locking of Cortical, Thalamic, and Hippocampal Rhythms. *Neuron* 2017;**95**(2):424–35.e6.
- Mano N. Changes of simple and complex spike activity of cerebellar purkinje cells with sleep and waking. *Science* 1970;**170**(3964):1325–7.
- Staresina BP, Bergmann TO, Bonfond M, van der Meij R, Jensen O, Deuker L, et al. Hierarchical nesting of slow oscillations, spindles and ripples in the human hippocampus during sleep. *Nature neuroscience* 2015;**18**(11):1679–86.
- Luthi A. Sleep Spindles: Where They Come From, What They Do. *The Neuroscientist : a review journal bringing neurobiology, neurology and psychiatry* 2014;**20**(3):243–56.
- Xu W, de Carvalho F, Jackson A. Sequential neural activity in primary motor cortex during sleep. *J Neurosci* 2019.

- Kelly RM, Strick PL. Cerebellar loops with motor cortex and prefrontal cortex of a nonhuman primate. *J Neurosci* 2003;**23**(23):8432–44.
- Holdefer RN, Miller LE, Chen LL, Houk JC. Functional connectivity between cerebellum and primary motor cortex in the awake monkey. *Journal of neurophysiology* 2000;**84**(1):585–90.
- Rowland NC, Goldberg JA, Jaeger D. Cortico-cerebellar coherence and causal connectivity during slow-wave activity. *Neuroscience* 2010;**166**(2):698–711.
- Watson TC, Becker N, Apps R, Jones MW. Back to front: cerebellar connections and interactions with the prefrontal cortex. *Frontiers in systems neuroscience* 2014;**8**:4.
- D'Angelo E, Koekkoek SK, Lombardo P, Solinas S, Ros E, Garrido J, et al. Timing in the cerebellum: oscillations and resonance in the granular layer. *Neuroscience* 2009;**162**(3):805–15.
- Courtemanche R, Robinson JC, Aponte DI. Linking oscillations in cerebellar circuits. *Frontiers in neural circuits* 2013;**7**:125.
- Seshagiri DV, Botta R, Sasidharan A, Kumar Pal P, Jain S, Yadav R, et al. Assessment of Sleep Spindle Density among Genetically Positive Spinocerebellar Ataxias Types 1, 2, and 3 Patients. *Annals of neurosciences* 2018;**25**(2):106–11.
- Manoach DS, Thakkar KN, Stroynowski E, Ely A, McKinley SK, Wamsley E, et al. Reduced overnight consolidation of procedural learning in chronic medicated schizophrenia is related to specific sleep stages. *Journal of psychiatric research* 2010;**44**(2):112–20.
- Farmer CA, Chilakamari P, Thurm AE, Swedo SE, Holmes GL, Buckley AW. Spindle activity in young children with autism, developmental delay, or typical development. *Neurology* 2018;**91**(2):e112–e22.
- Russek EM, Momennejad I, Botvinick MM, Gershman SJ, Daw ND. Predictive representations can link model-based reinforcement learning to model-free mechanisms. *PLoS computational biology* 2017;**13**(9):e1005768.

**P002 USING ANTHROPOMETRIC MEASUREMENTS TO DETERMINE THE IDEAL MATTRESS FIRMNESS**

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**Introduction** There is limited evidence to suggest that a ‘one-size fits all’ mattress provides the appropriate support in individuals with diverse body shapes, a greater understanding of how different mattresses affect the human body is required. By having a more objective approach to choosing a mattress, individuals may improve quality of sleep.

**Materials** A ten-camera infrared movement analysis system recorded Upper-Mid Thoracic, Mid-Lower Thoracic, Lower Thoracic–Upper Lumbar, Upper-Lower Lumbar and Lower Lumbar–Pelvic areas of the spine in side lying. Deviations away from a neutral position were assessed under different conditions. Three aesthetically identical mattresses were tested, internally each mattress contained a different firmness of spring unit (soft, medium, firm). In addition, height, weight, shoulder width and hip circumference measurements were taken to determine differences in body types.

**Results** Spinal alignment was assessed on sixty healthy participants and no significant differences were seen between the different mattress configurations. However further analysis showed significant differences in spinal alignment between the different mattress conditions within different body shape subgroups. Subgroups were defined using body weight, height, BMI, shoulder width and hip circumference. Those with a higher body weight had a more neutral spinal alignment when on a firmer mattress, whereas those with a lower body weight were better suited to a softer mattress. Shorter people were better aligned on a softer mattress, and a medium mattress kept the spine in a more neutral position amongst taller individuals.