Summer Placement Projects

MRC Cognition and Brain Sciences Unit
Undergraduate Summer Placement Scheme 2025

Monday 7th July – Friday 15th August

Project A. Motor augmentation approaches to expand movement abilities

Supervisors: Tamar Makin, Ema Jugovic, Allie Williams, Celia Foster

Scientific problem to be addressed

Motor augmentation enhances or extends human motor capabilities using technology, and may take a physical (e.g. robotic limbs, extra fingers) or neuromuscular (e.g. EMG-based control and biofeedback) approach. It aims to improve performance or aid in the development of new abilities beyond biological constraints, such as the integration of supernumerary limbs or enhanced muscular control. Both approaches rely on developing proprioceptive awareness—whether through learning to integrate a robotic limb with natural movement or refining muscle coordination and awareness in yoga. Yoga trains the brain to synchronise specific muscles for precise control, much like rehabilitation strengthens neural pathways. Similarly, using an additional robotic body part requires adapting movement strategies and sensorimotor feedback to integrate it seamlessly with the body.

Both studies use empirical testing to explore the mechanisms of motor learning, either during natural movement practices (e.g. yoga) or using a robotic augmentation device (the Third Thumb, a supernumerary robotic thumb) as participants complete behavioural tasks that challenge them to develop new movement abilities. We will study sensorimotor learning throughout training, exploring how to best optimise learning using biofeedback and machine learning to enhance training efficacy. Ultimately, this research advances our understanding of the neural mechanisms behind motor control and the development of expertise, paving the way for more effective strategies to optimise and enhance human movement capabilities.

Types of activities the student will be involved in

The main role of the student will be assisting with experimental paradigms and data collection across a range of studies, involving motion tracking, robotic limbs and the development of wearable technologies using EMG and biofeedback. We are looking for hard-working and motivated students with a keen interest in sensorimotor neuroscience to work with our lab across several ambitious projects. Specifics will be tailored to the student based on interest, skill set and lab needs.

Methods and skills to be used and acquired

The student will learn from their involvement in running a motor augmentation study with strong real world components requiring substantial technological and programming setup, gaining experience with techniques such as EMG, motion tracking, biofeedback, robotic limbs and technical data collection. The student will also benefit from experience interacting with participants, as well as gaining unique insight into designing and implementing motor augmentation studies across physical and neuromuscular approaches.

Key References

Clode, D., Dowdall, L., da Silva, E., Selén, K., Cowie, D., Dominijanni, G., & Makin, T. R. (2024). Evaluating initial usability of a hand augmentation device across a large and diverse sample. *Science robotics*, *9*(90), eadk5183.

Ctrl-labs at Reality Labs, Sussillo, D., Kaifosh, P., & Reardon, T. (2024). A generic noninvasive neuromotor interface for human-computer interaction. *Biorxiv*, 2024-02.

Farina, D., Stegeman, D. F., & Merletti, R. (2016). Biophysics of the generation of EMG signals. *Surface electromyography: Physiology, engineering, and applications*, 1-24.

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Kieliba, P., Clode, D., Maimon-Mor, R. O., & Makin, T. R. (2021). Robotic hand augmentation drives changes in neural body representation. *Science robotics*, *6*(54), eabd7935.

Krakauer, J. W., Hadjiosif, A. M., Xu, J., Wong, A. L., & Haith, A. M. (2019). Motor learning. *Compr Physiol*, *9*(2), 613-663.

Project B. Investigating the reactivation of working memory content and rules using M/EEG and decoding

Supervisor: Yuena Zheng

Scientific problem to be addressed

Traditional working memory theories propose that sustained neuronal firing is the basis for holding information in mind. However, recent studies suggest that working memory can also be maintained in an activity-silent way, i.e., through changes in synaptic weights, and can be reactivated by giving a neutral impulse. While retaining the original information is crucial, goal-directed behaviour often requires further manipulation of stored information based on task rules and the maintenance of newly derived information. Here we aim to investigate whether, beyond the originally memorised information, task rules and manipulated information are also maintained in a similar way and can be reactivated. To address this question, we will use concurrent magnetoencephalography (MEG) and electroencephalography (EEG) recordings and machine-learning-based neural decoding.

Types of activities the student will be involved in

The student will receive training and then engage in data acquisition with MEG and EEG. They will also have the opportunity to assist with participant recruitment, analyse behavioural and neuroimaging data using Python, and collect structural MRI scans.

Methods and skills to be used and acquired

The student will learn how to collect M/EEG data. Additionally, depending on the student's interest, they will have the opportunity to analyse data and learn coding.

Key References

Duncan, D. H., van Moorselaar, D., & Theeuwes, J. (2023). Pinging the brain to reveal the hidden attentional priority map using encephalography. *Nature Communications*, *14*(1), 4749.

Stokes, M. G. (2015). 'Activity-silent'working memory in prefrontal cortex: a dynamic coding framework. *Trends in cognitive sciences*, *19*(7), 394-405.

Wolff, M. J., Ding, J., Myers, N. E., & Stokes, M. G. (2015). Revealing hidden states in visual working memory using electroencephalography. *Frontiers in systems neuroscience*, *9*, 123.

Wolff, M. J., Jochim, J., Akyürek, E. G., & Stokes, M. G. (2017). Dynamic hidden states underlying working-memory-guided behavior. *Nature neuroscience*, *20*(6), 864-871.

Zheng, Y., Lu, R., & Woolgar, A. (2024). Radical flexibility of neural representation in frontoparietal cortex and the challenge of linking it to behaviour. *Current Opinion in Behavioral Sciences*, *57*, 101392.

Project C. Tracking cortical entrainment to tactile features

Supervisors: Chentianyi Yang, Andrew Thwaites

Scientific problem to be addressed

Signals from skin receptors undergo multiple transformations as they travel from the periphery to the cortex. Theories of peripheral touch encoding treat each receptor as a distinct channel. Merkel cells respond to low-frequency deformations, while Pacinian corpuscles detect higher frequencies. These signals travel through the spinal cord and thalamus to reach the cortex. However, beyond the periphery, the cortical processing of touch remains less understood. While sensory inputs are integrated to create perceptual qualities, the specific roles of different cortical regions in touch processing and the latencies at which this processing takes place are not well understood. This study investigates where and when somatosensory signals emerge in the cortex by analysing two key transforms (vibration detection and vertical skin displacement) and comparing them with electro- and magneto-encephalographic (EMEG) recordings.

Types of activities the student will be involved in

The student will receive training in EMEG data acquisition, and support the acquisition of these data with the supervisor, assisting in the running of a study of around 20 participants. They will also run data analyses, code in Python, and collect structural MRI scans.

Methods and skills to be used and acquired

The student will have the opportunity to use MNE-Python to do EMEG data preprocessing, and to carry out cortical entrainment analysis using the Kymata-Core package in Python.

Key References

Greenspon, C. M., Valle, G., Shelchkova, N. D., Hobbs, T. G., Verbaarschot, C., Callier, T., ... & Bensmaia, S. J. (2024). Evoking stable and precise tactile sensations via multi-electrode intracortical microstimulation of the somatosensory cortex. *Nature Biomedical Engineering*, 1-17.

Shelchkova, N. D., Downey, J. E., Greenspon, C. M., Okorokova, E. V., Sobinov, A. R., Verbaarschot, C., ... & Bensmaia, S. J. (2023). Microstimulation of human somatosensory cortex evokes task-dependent, spatially patterned responses in motor cortex. *Nature communications*, *14*(1), 7270.

Thwaites, A., Glasberg, B. R., Nimmo-Smith, I., Marslen-Wilson, W. D., & Moore, B. C. (2016). Representation of instantaneous and short-term loudness in the human cortex. *Frontiers in Neuroscience*, *10*, 183.

Project D. Perception of pitch with hearing implants

Supervisors: Dorothée Arzounian, John Deeks

Scientific problem to be addressed

This project will investigate the mechanisms that underlie our perception of pitch, in order to determine how to better convey pitch information for people with a neuro-prosthetic hearing device (cochlear implant).

Cochlear implants are medical devices that restore a sensation of sound for people with profound deafness. The implant stimulates the auditory nerve with electrical currents at multiple sites along the length of the inner-ear organ (the cochlea). The pitch of the produced sensation depends both on the locations being stimulated and on the temporal pattern of stimulation. However, we know very little about how temporal patterns from different stimulation sites get fused during perception.

This project will explore how the brain integrates temporal patterns from different regions of the cochlea. To this end, we will test how people with normal hearing perceive sounds that are designed to mimic the sensations experienced by patients who hear through a cochlear implant.

Types of activities the student will be involved in

The student will be involved in data collection, data analyses, interpretation and presentation of results. Based on their skills and interest they may get involved in programming experiment variants.

Methods and skills to be used and acquired

This is a great opportunity for someone interested in auditory perception to learn about cochlear implants and gain skills in psychophysics and experimentation with human subjects, as well as in manipulation and interpretation of behavioural data.

Key References

De Groote, E., Macherey, O., Deeks, J. M., Roman, S., & Carlyon, R. P. Temporal pitch perception of multi-channel stimuli by cochlear-implant users.

Macherey, O., & Carlyon, R. P. (2010). Temporal pitch percepts elicited by dual-channel stimulation of a cochlear implant. *The Journal of the Acoustical Society of America*, *127*(1), 339-349.

Macherey, O., & Carlyon, R. P. (2014). Cochlear implants. *Current Biology*, *24*(18), R878-R884.