NENS Exchange Grant Final Report

Federica Bencivenga

Exchange Period Details

Home program: PhD Program in Behavioral Neuroscience, Department of Psychology, Sapienza University of Rome (IT)

Home supervisor: Gaspare Galati

Host program: MSc Neuroscience, Institute of Psychiatry, Department of Neuroscience, King's College London (UK)

Host supervisor: Caroline Catmur

Exchange Period: March 2023 – May 2023

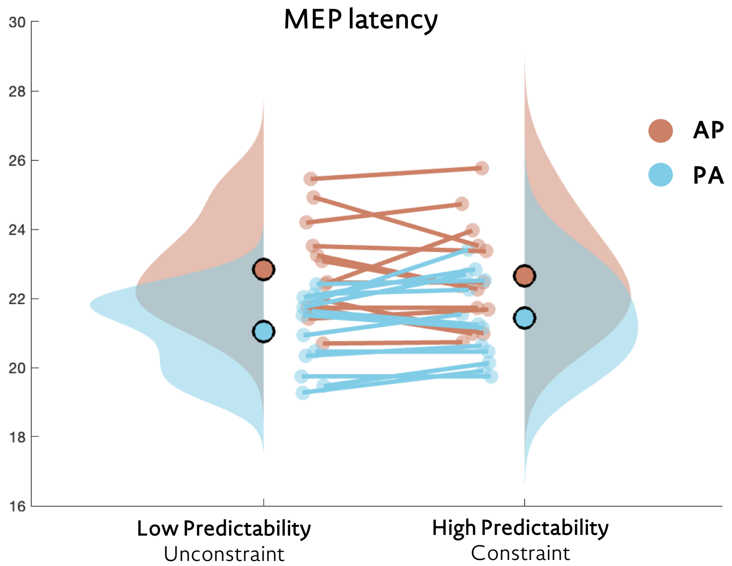
Report

Integration between different neuroimaging techniques to unveil the neural underpinnings of action execution and observation is a key challenge of my career as a PhD student. As my work focuses on hand movements carried out to interact with objects in the environment, different techniques may provide insights into the temporal and spatial neural dynamics underlying individual-environment interactions. During the first part of my PhD, I leveraged the spatial resolution of functional magnetic resonance imaging (fMRI) to identify segregated brain areas in the parietal lobe subserving hand-object interactions and applied effective connectivity analyses to disambiguate the bidirectional influences between parietal and premotor areas during individual-environment interactions.

Thanks to the NENS Exchange Grant, I was hosted at the King's College London for a methodological training on transcranial magnetic stimulation (TMS), a non-invasive technique able to temporarily disrupt activity in brain areas providing a strong temporal resolution. My internship spanned from the fundamentals of TMS applications to the motor field, i.e., assessment of corticospinal excitability using single pulse stimulation, to paired-pulse stimulation to probe intrahemispheric cortico-cortical modulation of corticospinal excitability, to double coil paradigms to test intra- (e.g., SICI protocol; Kujirai et al. 1993) and inter-hemispheric connectivity (e.g., IHI protocol; Ferbert et al., 1992). The last period of my internship was focused on the cortico-cortical paired associative stimulation (ccPAS; Rizzo et al., 2009), a more recent TMS paradigm to boost connectivity between brain regions. This training widened my knowledge of the cortical mechanism of motor control as assessed from a totally new perspective in my career: the study of the neurophysiological, mechanical, and proprioceptive correlates of hand-object motor behaviors.

During my 3 months stay, I integrated the skills I gained on the TMS technique with my previous experience with virtual reality and motion tracking systems to implement multiple experimental paradigms.

In one of the experiments we run, we assessed the sensorimotor processing load during a grasp-lift paradigm using PA/AP administration of single TMS pulse on the motor cortex. We used a T-shaped object with an asymmetrical center of mass which stresses the force-to-position coordination, namely the process through which we scale the grip and load force based on the position of our fingers on the objects (Davare et al., 2019). We distinguished a condition with low sensorimotor processing, in which the participants were instructed on the fingers' position by visual cues, and a condition with high sensorimotor processing, in which movements were unconstrained and therefore the force-to-position coordination was more variable across trials. We tested the hypothesis that TMS pulses applied on the motor cortex in antero-posterior (AP) direction, which indirectly recruits alphamotor neurons through cortico-cortical fibers, would reveal the stronger cortico-cortical, sensorimotor processing during the "unconstrained" condition when compared to the standard postero-anterior (PA) direction of the stimulation. Our hypothesis was supported by the evidence of a longer latency of motor evoked potentials in the AP direction, especially during the unconstrained condition.



Other ongoing projects included the attempt to identify neurophysiological hallmarks of the integration between visual, tactile, and proprioceptive inputs, and the contribution of the ipsilateral motor cortex to the sensorimotor processing during unilateral motor tasks.

The gained experience enriched my PhD work by broadening my horizons in the field of motor control, but also prepared me for the next steps of my career. First, I feel now confident to plan and perform experiments using TMS when I will move back to my home lab, and apply this technique to my currently ongoing projects. Second, the ultimate aim of TMS studies in the motor control field is to understand how to use it for therapeutical interventions in conditions whereby motor functions are impaired. My training on the repetitive TMS to boost the activity of a single brain area, and the ccPAS protocol to boost connectivity between brain regions, will allow me to plan rehabilitation protocols in brain damaged patients.

Beyond the strict implications for my PhD training, being hosted in a leading University in UK allowed me to interact with other researchers besides my host lab, sharing advice and knowledge about virtual reality environments implementation, social cognition, and muscular control. I attended research retreats and monthly department meetings in which I had the chance to introduce and discuss my work.

From a personal side, “When a man is tired of London, he is tired of life; for there is in London all that life can afford”. London is by far the most vibrant city I lived in, but also the most expensive! I couldn’t have afforded the living expenses without the NENS exchange grant, therefore I am beyond grateful for this opportunity.

References

Davare, M., Parikh, P. J., & Santello, M. (2019). Sensorimotor uncertainty modulates corticospinal excitability during skilled object manipulation. Journal of neurophysiology, 121(4), 1162-1170.

Ferbert, A., Priori, A., Rothwell, J. C., Day, B. L., Colebatch, J. G., & Marsden, C. (1992). Interhemispheric inhibition of the human motor cortex. The Journal of physiology, 453(1), 525-546.

Kujirai, T., Caramia, M. D., Rothwell, J. C., Day, B. L., Thompson, P. D., Ferbert, A., ... & Marsden, C. D. (1993). Corticocortical inhibition in human motor cortex. The Journal of physiology, 471(1), 501-519.

Rizzo, V., Siebner, H. S., Morgante, F., Mastroeni, C., Girlanda, P., & Quartarone, A. (2009). Paired associative stimulation of left and right human motor cortex shapes interhemispheric motor inhibition based on a Hebbian mechanism. Cerebral cortex, 19(4), 907-915.