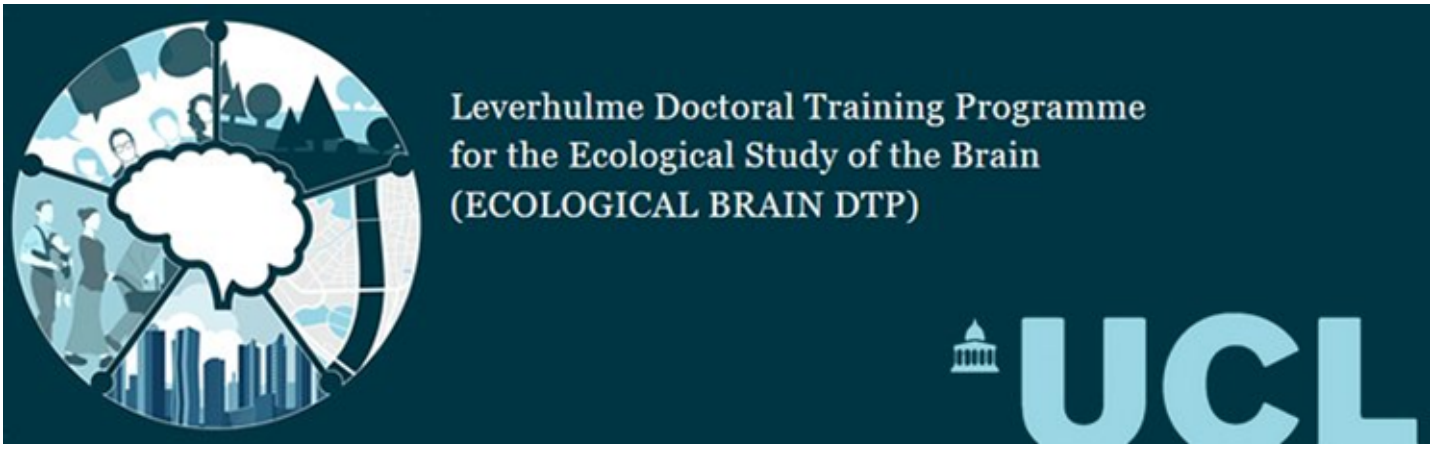

Leverhulme Doctoral Training Programme for the Ecological Study of the Brain

POSSIBLE PHD PROJECTS

You can submit your own research proposal. Alternatively, you can choose one of the PhD projects below that have been suggested by some EcoBrain supervisors. Please note that these are not the only projects available this year. **Please contact the supervisor of your choice to discuss possible projects before submitting your application.**

Last update: 13th November 2023

1. The universality or distinctiveness of musical processing across the senses

Dr. Velia Cardin, Head of Deafness and Neural Plasticity Lab (PALS) velia.cardin@ucl.ac.uk

The aim of these projects is to understand the universality or distinctiveness of musical processing across the senses.

Students could work on:

1) Developing multisensory technologies that allow a visual and somatosensory experience of different aspects of music, such as low-level features like notes, through to mid-level expressive gestures like phrasing and performance motive, and larger-scale formic and stylistic aspects.
2) Understanding which properties of music can be perceived by different sensory modalities in deaf and hearing individuals
3) Determine whether musical processing is modality specific or independent using fMRI or EEG in deaf and hearing individuals
4) Understanding what aspects of music and sound elicit different types of body responses, and how to measure them in real-world and lab settings.
5) Exploring how to build wearable devices that transform sound into vibrotactile feedback to share musical experience across deaf and hearing individuals.

2. How do individuals attain status in social hierarchies?

Dr. Pranjal Mehta, Associate Professor, Experimental Psychology (PALS) pranj.mehta@ucl.ac.uk

Status hierarchies are pervasive across species, but the precise mechanisms that influence status attainment in human hierarchies remain unknown. For example, who is more likely to rise to high-status leadership positions, and how? The primary aims of this PhD project are to:

(i) Examine the interplay between the hormonal reproductive axis (testosterone, estradiol), the hormonal stress axis (cortisol), and the social context in influencing status attainment.

(ii) Examine gender differences in the mechanisms for status attainment

(iii) Devise psychological interventions that influence status attainment via hormonal and behavioural changes.

(iv) Examine the consequences of status attainment for stress and well-being

We will use a variety of methods to address these questions, including pharmacological hormone administration, a smartphone application for non-invasive physiological measurement, experimental manipulation of social context, and behavioural observation in laboratory and field studies. Field studies are expected to involve real-world organisational and political hierarchies.

3. Large language models to accelerate research in psychology and neuroscience

Prof. Bradley Love, Experimental Psychology (PALS) b.love@ucl.ac.uk

Potentially disruptive findings are overlooked due to the rapid expansion of the scientific literature. We propose a human-machine teaming solution in which machines assist humans in integrating vast scientific literatures. While the focus will be on neuroscience and psychology, the approach will apply broadly and should encourage its adoption across science. Our tool, BrainGPT, will be trained to capture data patterns in the neuroscience literature, taking advantage of recent advances in large-language models. Researchers will be able to prompt BrainGPT with proposed study designs for which BrainGPT will generate likely data patterns reflecting its current synthesis of the scientific literature. Using BrainGPT, models in computational neuroscience and psychiatry can be assessed against the field's general understanding of a domain (e.g., instant meta-analysis). BrainGPT can help identify anomalous findings, whether because they point to a breakthrough or contain an error. Importantly, BrainGPT will not summarise nor retrieve articles. In such cases, large-language models often confabulate, which is potentially harmful. BrainGPT should be particularly useful for understanding mental health and neurodegenerative diseases, especially when important insights from the behavioural, social, biological, computational, and animal literatures need to be integrated to devise the most effective treatments.

BrainGPT is an open-source community effort and the PhD student would help coordinate the 1600+ volunteers. Other activities during the PhD include evaluating human experts and large language models (including BrainGPT) on neuroscience benchmarks, considering human-machine teaming approaches, training BrainGPT on the neuroscience and other literatures, considering the importance of multimodal source of training information beyond text to provide model grounding, and to evaluate and boost models' abilities to quantify the uncertainty in their predictions.

4. Is social interaction the *cradle* of language development?

Prof. Gabriella Vigliocco, Experimental Psychology (PALS) g.vigliocco@ucl.ac.uk

Understanding how children acquire language is one of the great challenges for the social sciences. Beginning in infancy, children depend on others to learn language. It is therefore not surprising that a great deal of current research has focused on identifying specific aspects of social interaction that can foster learning. As language skills, and particularly vocabulary development, predicts academic achievement and later success in life, identifying what makes it successful clearly has an important societal impact.

It is well established that children's cognitive abilities and family-related economic factors have an impact on language development. Parental socio-economic status predicts the amount of child-directed interaction, while the *quantity* of input within the interaction, especially in infancy, predicts the later language skills of children. Evidence, however, also clearly suggests that the *quality* of interaction – the specific communicative behaviours by the caregiver and child in interaction – matters and is only partially predicted by socio-economic status.

Focusing on word learning/vocabulary development and using a mixture of naturalistic observation and experiments, a wealth of previous studies (on infants and children up to preschool years) have identified three broad groups of factors that characterise caregiver-child interaction and predict learning. These are: (i) caregiver's direct behaviours toward the child (e.g., referential labelling, prosodic modulations, gestures and visual attention (gaze); (ii) child's behaviours such as gaze or points toward objects; (iii) and crucially, coordination between caregiver and child. This latter includes caregiver's behaviours in response to child's behaviours (e.g., caregiver's expansions of the child's previous utterances, or caregiver's labelling of an object *while* the child is visually attending to it). However, previous studies have mainly focused on only a single group of factors (e.g., caregiver's behaviours or child's behaviours or coordination) and within this, often only on a single behaviour (e.g., the role of prosodic modulation by the caregiver).Thus, we know that *some* behaviours can impact word learning and vocabulary growth, but we do not know which ones are better predictors when analysed together, nor their distribution or co-occurrence at different developmental stages (e.g., are the gestures produced by the child a better predictor of later vocabulary than the amount of joint attention during an interaction?).

This PhD project aims at characterising the multiple behaviours, especially coordinated behaviours between caregiver and child during interaction and establish which among these behaviours best explain vocabulary development. The project will combine a large scale corpus analysis of naturalistic dyadic interaction between caregiver and child (70 dyads, children aged 2-4) from the ECOLANG corpus to characterise the most common behaviours and to establish correlations with learning outcomes. Well-controlled learning experiments with children in the same age range (potentially including hyperscanning using fNIRS) will then be designed to establish whether the factors identified in the corpus analysis have a causal role in learning.

5. The early home environment and children's cognitive and socio-emotional outcomes across the childhood years: genetic nurture effects and environmental mediation

Prof. Eirini Flouri, IOE - Psychology & Human Development e.flouri@ucl.ac.uk

This project will use observational and molecular genetic data from a large UK birth cohort to explore the role of the indoor and outdoor home environment (measured early in childhood using independent observations, parent reports and objective data) in children's cognitive and socio-emotional development from early childhood until the end of the primary school years. The environment will be measured in terms

of physical characteristics and emotional atmosphere, with robust controls for related constructs such as the home learning environment and home chaos (i.e., home confusion and disorganisation). Both children and parents are fully genotyped so the relevant polygenic risk scores of the parent and child will be used to ascertain both the size of genetic nurture effects and the extent of environmental mediation.