University Alliance DTA^3
Doctoral Training Alliance

DTA^3 Programme Research Projects Proforma

Partner University	Liverpool John Moores University
Faculty/School/Department/Research Centres	Science
Supervisory Team: please provide details of first, second, and where relevant, third supervisors for this project, and any external supervisors/advisors, where applicable	
First supervisor	Prof Simon Bennett https://www.ljmu.ac.uk/about-us/staff-profiles/faculty-of-science/sport-and-exercise-sciences/simon-bennett
Second supervisor	Dr Ruth Ogden https://www.ljmu.ac.uk/about-us/staff-profiles/faculty-of-science/natural-sciences-and-psychology/ruth-ogden
Third supervisor	Dr Matthew Andrew https://www.ljmu.ac.uk/about-us/staff-profiles/faculty-of-science/sport-and-exercise-sciences/matthew-andrew
External/industrial supervisor	
Contact details for project (for informal applicant queries)	Simon Bennett Professor of Sensorimotor Neuroscience School of Sport and Exercise Sciences, Tom Reilly Building, Byrom Street, Liverpool, L3 3AF 0151 904 6257 (s.j.bennett@ljmu.ac.uk)
DTA Programme(s): please tick which DTA programme(s) this project relates to:	
DTA Applied Biosciences for Health (Healthy Ageing)	
Project title	Now where was I? The changing role of prefrontal and motor cortices as a function of healthy ageing
Project description: please provide a brief description, using the headings given below, of the project (max. 450 words) which will used as part of the advertising material and will be placed in the public domain. **Please also indicate whether there are any confidentiality/sensitivity/IP issues of the research which should not be made publicly available.**	

Co-funded by the Horizon 2020 programme of the European Union

This project has received funding from the European Union's Horizon 2020 research and innovation programme under the Marie Skłodowska-Curie grant agreement No 801604.

Many human behaviours performed on a daily basis are supported by an interrupted flow of visual information. Although these typically go unnoticed, the human brain's ability to fill in the gaps in missing visual information is not infallible. For example, while we have shown that neurotypical young adults use predictive processes to control ocular pursuit of transiently occluded trajectories, these same processes can be impaired in those with acquired brain disorders, mild cognitive impairment and Alzheimer's disease. Here, we will combine behavioural and neurophysiological protocols to investigate key areas of the cortical network that underlie complex oculo-manual behaviour of young and elderly neurotypical adults, with the overall aim to advance knowledge of normal human function in a task that requires sensorimotor processes common to those of everyday activities. We have developed an innovative experimental protocol (i.e., dual-task remembered pursuit) that requires a momentary shift of eye gaze, and thereby overt attention, between a moving and stationary object. This places greater demand on attentional and representation process in order keep track of the primary object as it moves in an eccentric location. The task will be performed with eyes alone or eyes and upper limb (active or passive movement), and will enable us to investigate with TMS and NIRS the contribution from motor and pre-frontal cortical network (M1, DLPC) in the presence of motor afference and/or efference. Insights from our work with neurotypical young and elderly adults will inform future research with neuroatypical populations who have impaired predictive sensorimotor processing.

Objective 1 and 2: Investigate ocular behaviour, and functioning of the pre-frontal (DLPFC) and motor cortex, during dual-task remembered pursuit protocol; Investigate the contribution from motor efference and/or movement-elicited afference during dual-task remembered pursuit.

Hypotheses: i) Ability to relocate the eyes on the pursuit object will be improved when there is concurrent wrist motion; ii) Measures of ocular pursuit will be influenced by the demands of a secondary task, but less so during oculo-manual pursuit; iii) ΔHbO and ΔHbR in M1 will differ between conditions of ocular and oculo-manual pursuit, and will be increase in DLPFC while completing dual-task pursuit compared to control conditions.

Objective 3 and 4: Investigate factors that influence the functional state of the extensor carpi radialis representation in M1 during dual-task pursuit; Investigate the consequence of a temporary central perturbation to the ECR representation in M1 or DLPFC on the ocular response.

Hypotheses: i) Increase in excitability of M1 while completing the secondary task; ii) Excitability of the motor system related temporally to completion of the secondary task; iii) Contribution of movement-elicited afference and motor efference related to the functional state of M1.

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Lay summary (max 200 words) to be used for reference as part of the selection process where non-specialists are involved
There are many situations in daily life where our view of the surrounds are interrupted, such as when attention is shifted to another location. Accordingly, the human brain has evolved predictive processes that fill in the gaps in degraded visual information. We have shown that typically-developed young adults use these predictive processes to achieve safe and effective behaviour. However, there is evidence these same processes can be impaired in those with acquired brain disorders and neurodegenerative brain disease. This could have serious consequences when driving or preparing food with sharp objects and hot surfaces Therefore, it is important to better understand complex coordinated movements between the eyes and hand, and associated brain-behaviour relationships. We will compare conditions where the upper limb is moved actively by the participant or passively by a motor, thus enabling us to examine the contribution of signals from the upper limb to the brain (afference) or from the brain to the upper limb (efference). This will be confirmed by measuring blood flow in the relevant areas of the cortex or temporarily disrupting information processing using a magnetic pulse. The findings are intended to inform treatment/rehabilitation programmes aimed at maintaining performance of everyday life tasks.
Industrial/Employer placement opportunity please include details, where known, of any external placement opportunities or collaborations available to the student as part of the project
International placement opportunity please include details, where known, of any potential international placement opportunities or collaborations available to the student as part of the project
The supervisory team comprises 3 internationally-recognised scientists who have published over 100 research articles with external collaborators. The first supervisor has established collaboration and ongoing student placement opportunities through the Erasmus+ programme with colleagues working at several European universities including: University of Ghent (Dr Frederik Deconinck) Free University of Amsterdam (Prof Geert Savelsbergh) Université Caen (Prof Nicolas Benguigui) Université of Toulouse (Dr Robin Baurès) Universidad Complutense de Madrid (Dr Oscar Martinez de Quel)

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Scientific, economic and societal impact of the project

The main pathways to impact are as follows:

1) Neurotypical Adults: Currently, understanding regarding the cortical network that underlies oculo-manual behaviour of young neurotypical adults is restricted to tasks that require relatively simple tracking of internally-generated or externally-generated motion. Through the use of a novel dual-pursuit task, combined with behavioural and neuropsychological methods, our findings will inform understanding of how young neurotypical participants respond to the more challenging attentional and representational demands of tasks that are more analogous to those performed in everyday life.

2) Normal Ageing: While predictive eye movements are maintained as a function of normal ageing, there is also evidence that older adults exhibit worse attentive tracking performance than young adults if there are multiple independently moving items. This could reflect an impairment in updating and maintaining representations in visual-spatial working memory (e.g., DLPFC), the same processes that are involved in complex oculo-manual pursuit in dynamic surrounds. Using the methods and conceptual knowledge gained from this proposal, academics will be better placed to determine the potential means of deterioration in oculo-manual behaviour as a function of normal ageing. The outcomes could help understand the impact of normal ageing on eye-hand coordination in daily task such as driving, thus informing tests of driver awareness and ability.

3) Brain injury, degeneration and pathology: Predictive processes important for gaze control are impaired in those with mild traumatic brain injury, mild cognitive impairment and Alzheimer's disease. It has been suggested that the impairment could be a result of difficulties in updating and maintaining representations in visual-spatial working memory. This implies a role for DLPFC, the same cortical area involved in complex oculo-manual pursuit in dynamic surrounds. This proposal will provide baseline data and methods against which academics can better understand the fundamental control mechanisms that operate in neuroatypical adults.

4) Peripheral neuropathy: In the UK, it is estimated that almost 1 in 10 people aged 55 or over are affected by some degree of peripheral neuropathy (http://www.nhs.uk/Conditions/Peripheral-neuropathy/Pages/Introduction.aspx). When this involves damage to nerves that relay information regarding movement-elicited afference (i.e., sensory ataxia), there are often problems with upper-limb coordination. In particular, sensory neuropathy causes impairment of input regarding the position of the upper limbs, which could impact upon oculo-manual control. Indeed, while individuals with sensory neuropathy can often deal with the impaired upper limb afference by increasing their reliance on vision, this is not always possible as in the case of dual-task remembered pursuit. Better understanding of the challenges faced by these individuals will inform equipment design and/or training programmes that facilitate the intact sensorimotor processes.

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Additional admissions requirements: please state if there are any specific admissions requirements for this project i.e. subject specific degree qualifications or disciplines, relevant skills, experience etc
An undergraduate and/or postgraduate degree in a relevant field (Experimental Psychology, Neuroscience, Cognitive Science) Programming skills in Matlab and an affinity towards quantitative methods are preferred Experience of eye and/or upper limb movement analysis, transcranial magnetic stimulation or NIRS is essential

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