**BBSRC MIBTP Studentship Project**

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| **Project Title** | Assessment and reduction of human cognitive ageing using evolutionary relevant computerised foraging tasks and transcranial direct current stimulation. |
| **Project Summary**  |
| Identifying when and how cognitive decline occurs in healthy ageing and how we can prevent it is of enormous importance in our increasingly ageing population. The literature suggests that ecologically valid tasks offer the best characterisation of the pattern of cognitive functions that decline, are spared or improve with ageing. A first aim of this study is to identify executive and memory functions that are affected by healthy ageing by refining and validating a new task that captures the requirements of efficient foraging for ephemeral fruit resources. Theories of primate brain evolution suggest that these requirements triggered the emergence of large brains and higher cognitive functions in human ancestors. Implementing such requirements in cognitive tests offers an ecologically valid context for assessing the cognitive profile of heathy ageing and in the most evolutionary relevant task domain. An important consequence of brain expansion is the considerable increase in metabolic cost of large brains. Thus, it has been argued that ageing processes resulting in the reduction of brain metabolism represent an adaptation when the requirement of learning new environments and regularities is reduced because of the experience accumulated by ageing individuals during their lifespan. Although functional when the lifespan of individuals was shorter, metabolism reducing functions induce cognitive decline in modern living conditions that considerably increased life expectancy. A corollary of this proposal is that interventions increasing brain metabolism should ameliorate, and even reverse, age related decline in cognitive functions supporting foraging efficiency. The second major aim of this study is to determine if affecting brain metabolism with transcranial Direct Current (tDCS) (applied over the scalp can improve cognitive functions assessed by foraging tasks. This project will involve a series of experiments where the performance of a sample of younger individuals (below 35 years of age) is compared with that of older individuals (above 65) in touch screen and immersive virtual reality based foraging tasks. Further experiments will involve other age groups across adult human lifespan. In these tasks, icons of different shapes represent different species of trees that can yield fruit rewards according to specific spatiotemporal and probabilistic patterns depending on the conditions of specific experiments. Uniquely, the tasks afford the measurement of a number cognitive functions implicitly contributing to foraging efficiency defined as the number of targets visited before all the available resources are depleted. These include: 1) working memory for targets selected within a given trial (simplifying a foraging bout) to prevent revisits of locations where resources have been already depleted; 2) long-term memory for targets that do not yield reward across trials and that should be avoided;  3) the ability to detect, monitor and exploit temporal and probabilistic regularities with which targets yield fruit rewards; and  4) the ability to encode the spatial location of targets despite the presence of competing visual information.  This project will determine which of these ecologically valid and evolutionary relevant measures of cognitive function change with normal ageing and are affected by brain stimulation. This study will identify cognitive markers of heathy ageing and determine the conditions under which non-invasive, non-pharmacological interventions can slow or reverse cognitive decline Techniques that will be undertaken during the project:The techniques used for this study comprise computerised cognitive testing, paired with non-invasive brain stimulation (transcranial direct current stimulation, tDCS). Participants of different age groups will be tested using simulated foraging tasks implemented using touch-screen and virtual reality environments. The same number of participants within each age group will be assigned to a tDCS stimulation condition and sham condition according to a between subject design. Depending on the specific experiments, repeated measure procedure will be used as well, with participants receiving both a tDCS and a sham stimulation in separate testing sessions. A double blind procedure will be used always. Stimulation procedure and tDCS parameters will be those that proved effective in pilot tests carried out by the supervisors and which showed an enhancement of working memory capacity following anodal stimulation to the left Dorso-Lateral Prefrontal Cortex. The foraging tasks will immediately follow tDCS (or sham) stimulation. A difference between age groups in the sham condition would indicate an age effect on the functions assessed. A difference between tDCS and sham condition for participants within the same age group would reveal an effect of brain stimulation and confirm the involvement of DLPFC in these functions. The pattern of interactions between age groups and tDCS/sham conditions will reveal the extent to which tDCS can compensate for decline in the functions assessed. Anodal stimulation of other areas such as the right DLPFC and parietal cortex will also be used to assess the specific involvement of these different brain areas in the functions assessed. Data analyses will comprise ANOVA models and trend analyses carried out using statistical packages such as IBM SPSS Statistics 28 and JASP 0.16.3.BBSRC Strategic Research Priority: Understanding the Rules of Life - Neuroscience and behaviour, Integrated Understanding of Health - Ageing |
| **References** |
| Alekseichu, I., et al (2016). Transcranial electrical stimulation of the occipital cortex during visual perception modifies the magnitude of BOLD activity: A combined tES–fMRI approach, NeuroImage, 140:  110–117 Reser, J.E. (2009). Alzheimer's disease and natural cognitive aging may represent adaptive metabolism reduction programs. Behavioral and Brain Functions, 5: 13 Talbot, S. Gerdjikov, T. & De Lillo, C. (2022). Two variations and one similarity in memory functions deployed by mice and humans to support foraging. Quarterly Journal of Experimental Psychology 1–15. |