Inferring cognitive traits of individual subjects through gaze controlled video games

Bolis D[1], Heinzle J[2], Mathys C[2,3,4], Stephan KE[2,3,5]

[1]Max Planck Institute of Psychiatry, Munich, Germany, [2]Translational Neuromodeling Unit (TNU), Institute for Biomedical Engineering, University of Zurich and ETH Zurich, Zurich, Switzerland, [3]Wellcome Trust Centre for Neuroimaging, University College London, London, United Kingdom, [4]Max Planck University College London Centre for Computational Psychiatry and Ageing Research, London, United Kingdom, [5]Max Planck Institute for Metabolism Research, Cologne, Germany

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Conventional paradigms can successfully capture many cognitive processes, unveiling several (patho-)physiological mechanisms. However, often they come at the cost of tedious tasks for the participants, which can impose critical restrictions especially when it comes to certain neurocognitive conditions. Immersive videogames could provide an entertaining alternative of higher ecological validity. Eye or other body movements could then be modeled for unveiling cognition, for example by modeling frameworks based on predictive coding theories for brain function.

In this project, we present an approach that combines video games, eye tracking and Bayesian modeling (i.e. HGF, [1]) for studying learning and decision-making. To that end, first, an interactive videogame was developed. The player's goal was to maximize a score by efficiently exploiting regularities in the environment, i.e. the game's structure. Second, we conducted a proof-of-concept study with 10 healthy volunteers, considering different probabilistic conditions across two spatial dimensions. Behavior was monitored by recording eye-gaze and/or mouse-movements. Third, the behavioral responses were modeled with a two-dimensional Bayesian framework using hierarchical-Gaussian-filtering, as well as classic reinforcement learning, yielding insights about both learning and decision-making processes. Bayesian model comparison was used to infer on the cognitive strategy applied by the participants.

According to the winning model, subjects appeared to use a volatility dependent learning rate. Their response variability was found to be highly influenced by the precision (i.e. confidence) of predictions and responses appeared to be spatially correlated. Finally, spill-over effects between the learning and the response model were identified across dimensions for certain subjects. The 2D computational framework implemented in this study provides a first step towards interactive paradigms that allow for a detailed investigation of multimodal prediction precision. As such it could be well suited to study spectrum conditions such as autism or schizophrenia for which aberrant precision has been hypothesized.

1. Mathys C, Daunizeau J, Friston KJ, & Stephan KE. (2011). A Bayesian foundation for individual learning under uncertainty. *Frontiers in human neuroscience, 5*:39.