DANISH RESEARCH
CENTRE FOR
MAGNETIC RESONANCE

LONDON
MATHEMATICAL
LABORATORY

Project description “The ergodicity experiment”

Ergodicity is a foundational concept in physics. It refers to two types of average. The first is an ensemble average, which is an average over all possible states of a system at a single point in time. The second is a time average, which is an average over all states visited by a system over a long time. Ergodicity determines whether these averages are identical.

Here we ask how the brain computes averages when making decisions. This is a crucial question because current theories of decision making ignore time averages, focusing exclusively on ensemble averages. This is a problem in settings where ergodicity is broken and the two averages differ. It is a problem because it is the time average, not the ensemble average, that is most relevant to an individual person’s future. In this project we will test a new theory proposed by Ole Peters, which places time averages at the core of human decision making. This “ergodic decision theory” offers a simple explanation of how humans respond to risk, how they value time, and how they estimate uncertainty. It makes predictions, the first of which have been corroborated by data collected by Oliver Hulme, suggesting that humans optimise time averages. This is important because it suggests the brain will compute time averages when making decisions.

Combining functional neuroimaging and ergodic decision theory, we will explore how time averages are computed by the reward system. In doing so, we explore how well the theory generalises over large populations, how robust it is over long timescales, and how it extends to different dynamical settings. This project brings together physicists and mathematicians from the London Mathematical Laboratory with neuroscientists from the Danish Research Centre for Magnetic Resonance. In placing decision theory on physical foundations, we hope this provides a more rigorous path toward understanding how the reward system works, and how decisions are made.