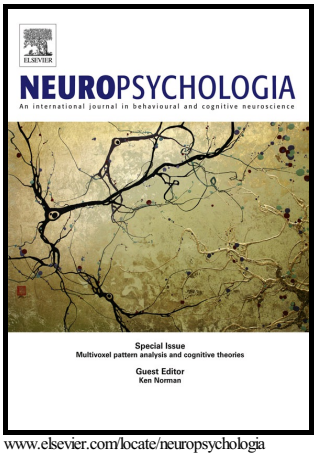
Active inference and the anatomy of oculomotion

Thomas Parr, Karl J Friston



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Active inference and the anatomy of oculomotion

Thomas Parr*, Karl J Friston

Wellcome Trust Centre for Neuroimaging, Institute of Neurology, University College London, WC1N 3BG, UK.

*Correspondence: 12 Queen Square, London.

thomas.parr.12@ucl.ac.uk

k.friston@ucl.ac.uk,

Abstract

Given that eye movement control can be framed as an inferential process, how are the requisite forces generated to produce anticipated or desired fixation? Starting from a generative model based on simple Newtonian equations of motion, we derive a variational solution to this problem and illustrate the plausibility of its implementation in the oculomotor brainstem. We show, through simulation, that the Bayesian filtering equations that implement 'planning as inference' can generate both saccadic and smooth pursuit eye movements. Crucially, the associated message passing maps well onto the known connectivity and neuroanatomy of the brainstem – and the changes in these messages over time are strikingly similar to single unit recordings of neurons in the corresponding nuclei. Furthermore, we show that simulated lesions to axonal pathways reproduce eye movement patterns of neurological patients with damage to these tracts.

Keywords: Free energy; saccades; oculomotor; brainstem; predictive coding; active inference

1. Introduction

There are many neurological (Sereno and Holzman 1995, Büttner, Helmchen et al. 1999, Perry and Zeki 2000, Anderson and MacAskill 2013) and psychiatric (Holzman and Levy 1977, Lipton, Levy et al. 1983, Sereno and Holzman 1995) conditions that cause impairments of eye movement control. As such, assessment of oculomotion forms a crucial part of any neurological examination. We aim to characterise the functional anatomy of eye movement control by appealing to active inference, a principled approach to describing Bayes optimal behaviour (Friston, Daunizeau et al. 2009). Our agenda here is to try and understand the oculomotor system in terms of its computational anatomy,