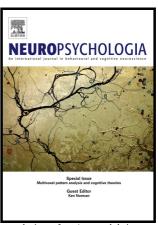
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ACCEPTED MANUSCRIPT

Active inference and the anatomy of oculomotion

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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,

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