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Poster presentation

Anticipating uncertain events: estimates of probability driving anticipatory eye movements

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Introduction

Animal and human sensorimotor behavior is influenced by expecting that a particular event will occur. Such expectancy is likely to rely on an internal estimation of the probability of occurrence of different events. Furthermore, expectancy can affect several aspects of the behavioral response, like reaction times [1], visuomotor gain [2] and anticipatory motor responses [3]. In this study, we analyze anticipatory smooth pursuit eye movements as a function of the relative probability of occurrence of different target motion types. Smooth pursuit eye movements (SPEM) permit the stabilization of the image of moving targets on the retina. In humans, visually guided SPEM start typically with a 100 ms latency with respect to target motion onset, leading to an initial lag of the eye relative to the target position (retinal error) and speed (retinal slip). Anticipatory SPEM (aSPEM) can be initiated some hundreds of milliseconds before target onset when the motion characteristics are totally or partially predictable and they might help reduce retinal error and slip.

Methods

We collected high-resolution eye movement recordings from four human subjects instructed to track a simple moving target with their eyes. In two different experiments, we manipulated the probability p of one of two possible random occurrences of either target direction (Right or Left) or speed (High or Low speed), while the other variable was kept constant. The probability bias p was 0,0.1,0.25,0.5,0.75,0.9 or 1 across different experimental blocks, each of them including 250 to 500 trials. We analyzed anticipatory SPEM velocity both as a function of the recent trial-history and as a function of a long term estimate of the block probability bias p. We compare our results with the predictions of different models of the effect of experience on motor preparation.

Results and model

A simple leaky-integrator model [2,4], accounting for a suboptimal accumulation of information across trials, can explain a significant part of the fluctuations of aSPEM as an effect of the recent trial history in the direction-randomization experiment. Considering the global characteristics of aSPEM across blocks with different p, we have observed (1) a monotonic (close to linear) dependence of the mean aSPEM upon p, (2) a nonlinear (quadratic) dependence of the variance of aSPEM upon p and (3) a unimodal distribution of anticipatory SPEM progressively shifting, as a function of p, between the distributions observed in the two deterministic conditions ($p = 0$ and $p = 1$). To explain these observations, we propose a model based on an internal continuous representation of the estimate of p and on the Bayesian accumulation of probabilistic information. In addition, we assume an independent motor component of aSPEM variance that is proportional to the mean absolute aSPEM velocity. Finally, we consider the possibility that the parameters of the aSPEM distribution are tuned to minimize a cost function proportional to the quadratic retinal slip. Our model captures the main properties of experimental data and it

definitely outperforms a model based on a discrete representation of expectancy states (the Finite State Markov Model, [3]).

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