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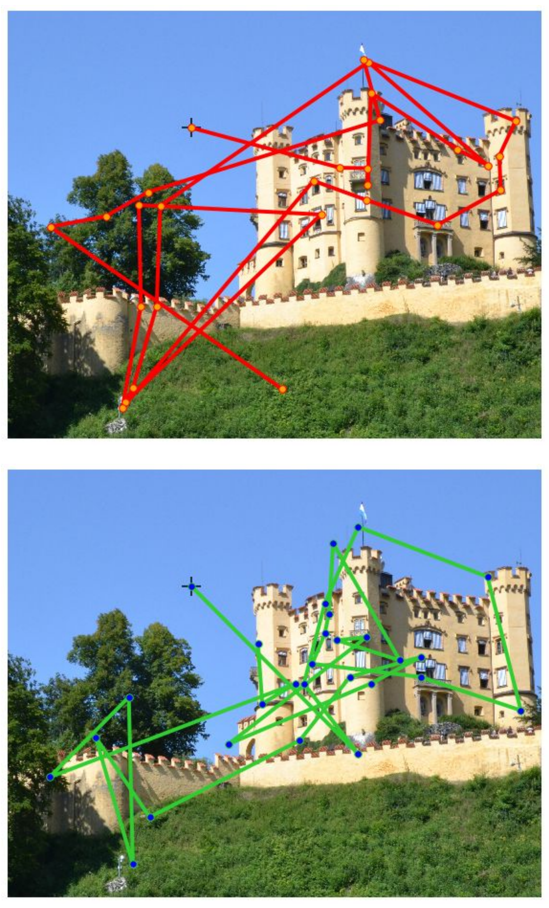
Modelling Attention Shifts During Natural Scene Viewing

Universität Potsdam

Driving Mechanisms of Eye Movement

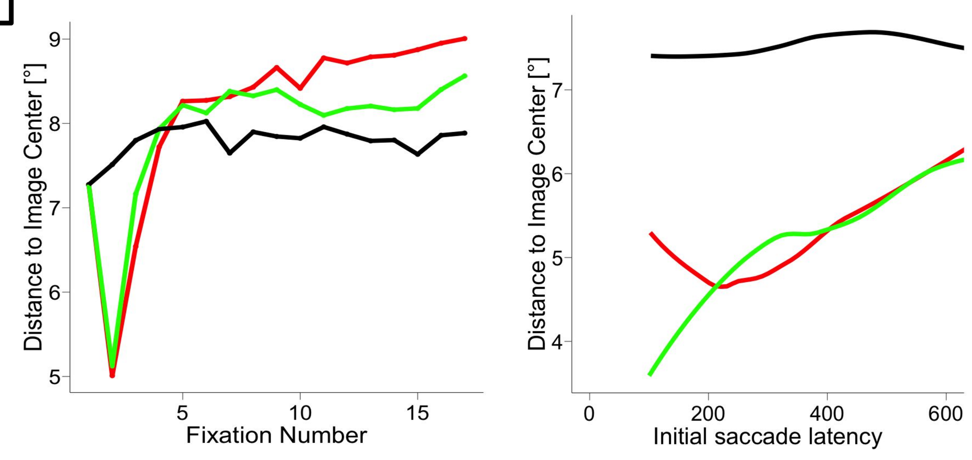


Typical human scan path

Model-simulated scan path

Central Fixation Bias

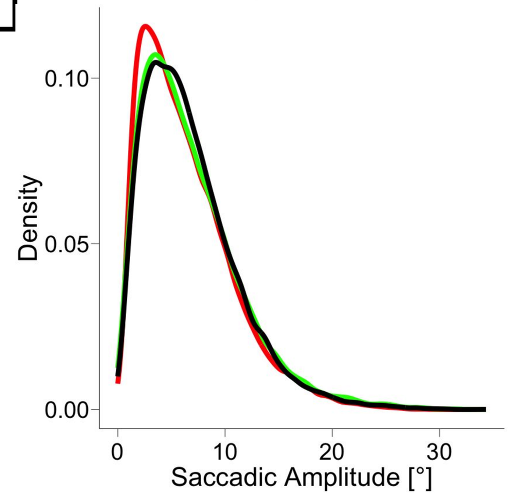
σ_{CB} ω_{CB}



Modelled by:
Biased Initialization Map

Limited Attention Field

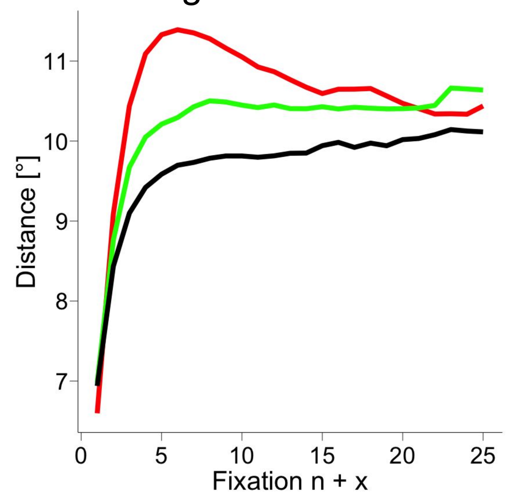
σ_A ω_A λ



Modelled by:
Attention Pathway

Inhibitory Tagging

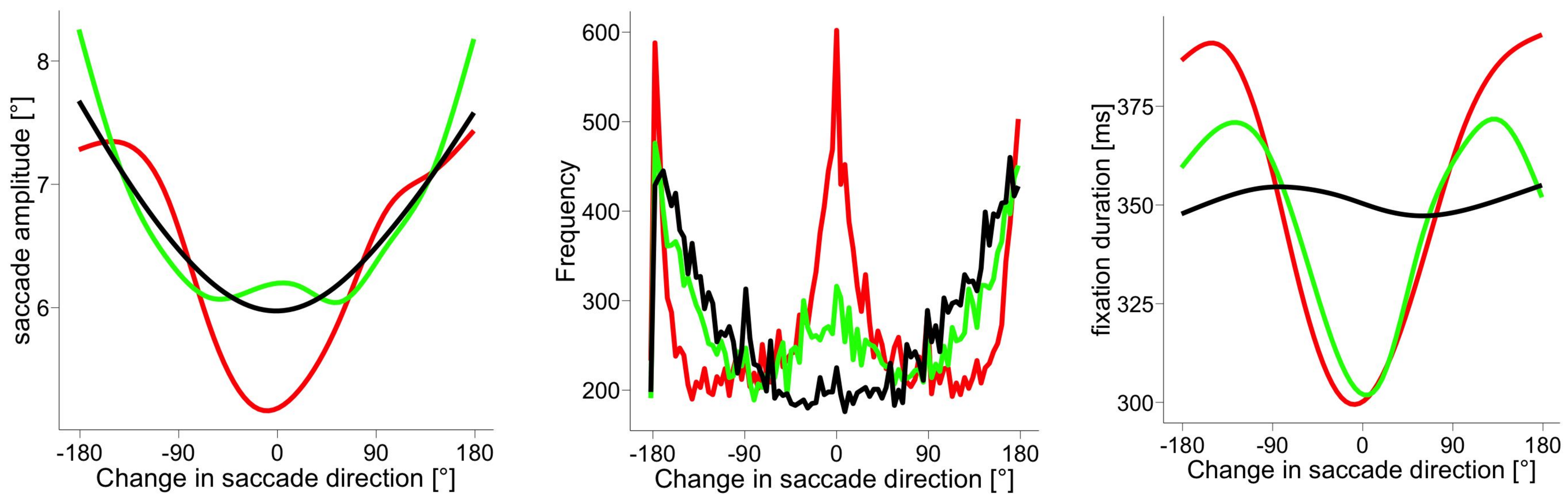
σ_I ω_I γ CF



Modelled by:
Inhibition Pathway

Remapping and Facilitation of Return

η ω_{FoR} τ_{Pre} τ_{Post} ν σ_{Post}



Remapping Modelled by:
Pre- and Postsaccadic shifting of the locus of attention

Facilitation Modelled by:
Reduced decay of attention around the previous fixation position

Methods

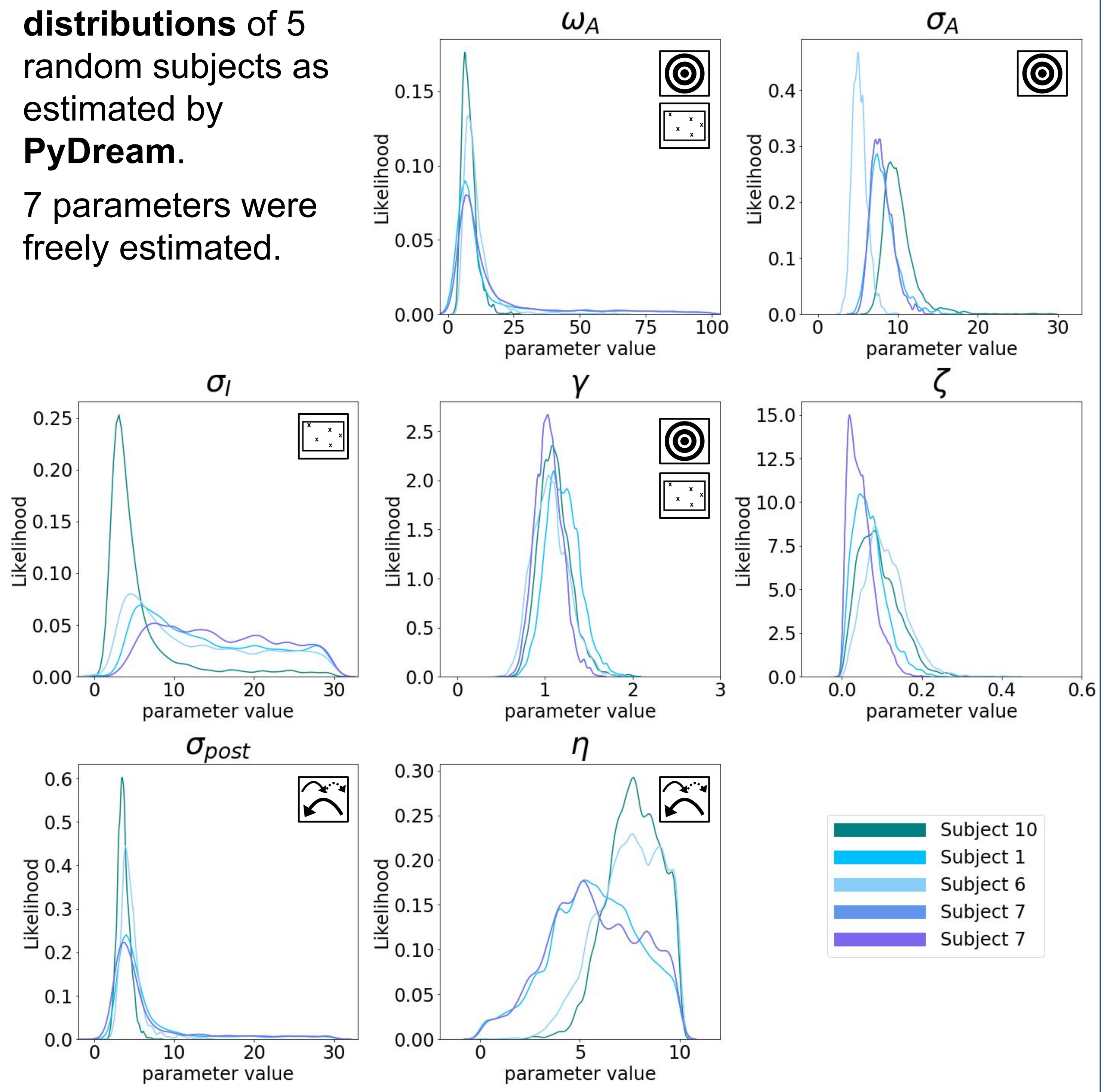
- We present a **mechanistic scan path model** that incorporates 5 experimentally founded mechanisms of eye movement (see left).
- The model is an extension of the **SceneWalk** (Engbert et al, 2015) model
- The core difference is that the model evolves in 3 distinct phases. In addition to the main phase there is a **pre- and post-saccadic attention shift**
- Parameters are estimated in a fully **Bayesian** framework using Differential Evolution Adaptive Metropolis (**DREAM**, Laloy et al, 2012)
- Parameter fitting was separated from analysis by using training and test datasets. Presented results are for the test dataset.

Empirical Data
SceneWalk
SceneWalk +

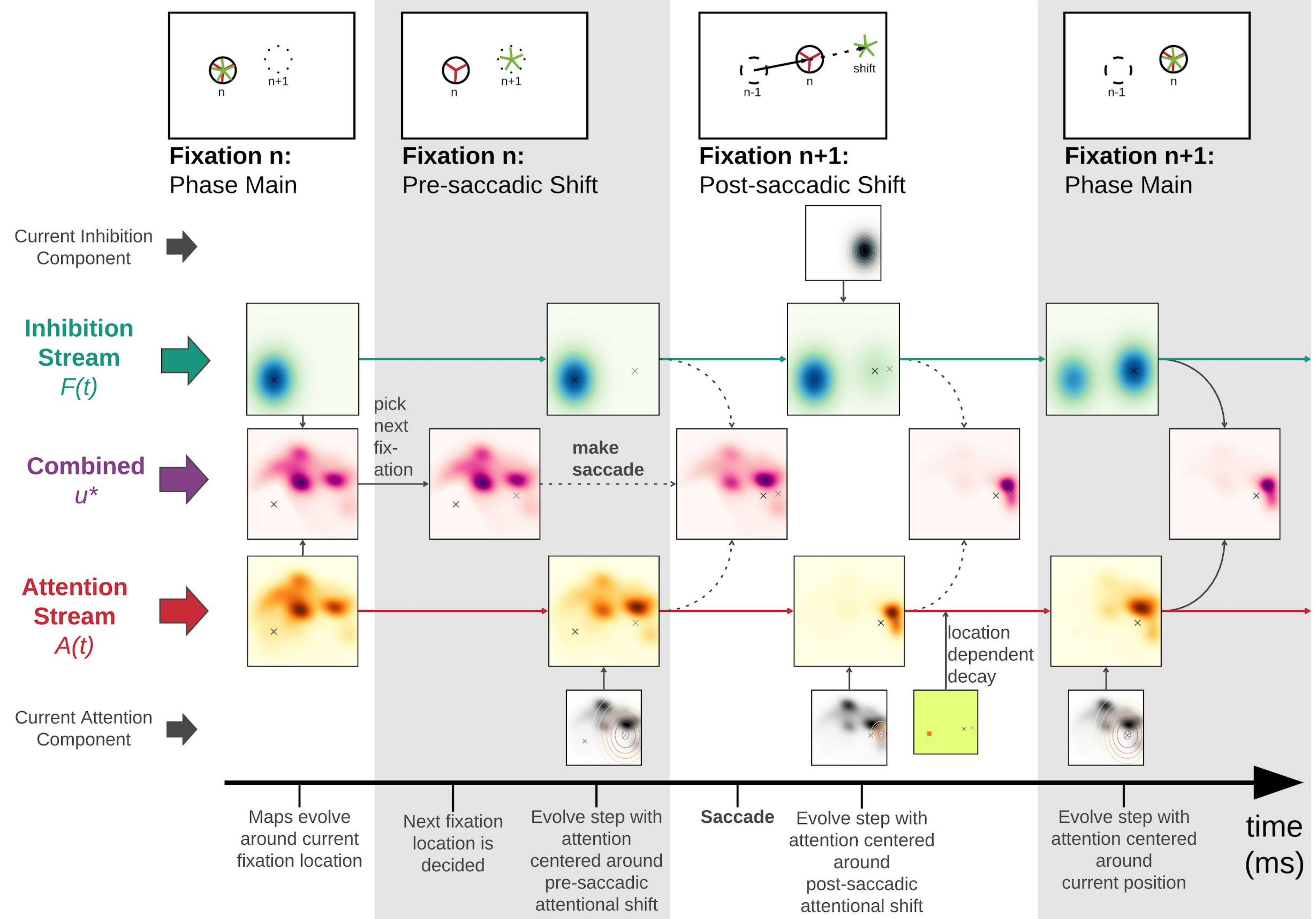
Parameters

Posterior likelihood distributions of 5 random subjects as estimated by **PyDream**.

7 parameters were freely estimated.



Model



Each fixation has the phases: (1) **pre-saccadic**, (2) **post-saccadic**, and (3) **main**. They differ in the location of the center of attention and inhibition. The following operations are **executed in each phase**:

1. Compute a gaussian around the center of Attention/Inhibition ($x_{A/F}$, $y_{A/F}$) on a grid

$$G_{A/F}\left(x, y; x_{A/F}, y_{A/F}\right) = \frac{1}{2\pi\sigma_{A/F}^2} \exp\left(-\frac{(x - x_{A/F})^2 + (y - y_{A/F})^2}{2\sigma_{A/F}^2}\right)$$

2. Evolve the Gaussians over time by evaluating the following differential equation at each gridpoint

$$\frac{\mathrm{d}A(t)}{\mathrm{d}t} = -\Omega_A A(t) + \Omega_A \frac{S \cdot G_A}{\sum S \cdot G_A}$$

$$\frac{\mathrm{d}F(t)}{\mathrm{d}t} = -\omega_F F(t) + \omega_F \frac{G_F}{\sum G_F}$$

3. Combine the two streams into a common activation map

$$u(t) = \frac{(A(t))^{\lambda}}{\sum (A(t))^{\lambda}} - C_F \frac{(F(t))^{\gamma}}{\sum (F(t))^{\gamma}}$$

4. Add normalization and noise

$$u^*(u) = \begin{cases} u, & \text{if } u > 0 \\ 0, & \text{otherwise} \end{cases} \quad \text{and } \pi = (1 - \zeta)\frac{u^*}{\sum u^*} + (\zeta)\frac{1}{\sum 1}.$$

DFG
SFB 1294 Data Assimilation

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