Modeling perceptual decision making processes in the brain

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In the experimental neurosciences the brain function 'perceptual decision-making' is currently understood as the processes underlying the extraction and accumulation of evidence from noisy sensory input (stimulus). Then based on this evidence a decision is made. This process is found in everyday life situations like recognizing (and reacting to) a traffic sign in the rain or fog. This real world example is of course a complicated mixture of various cognitive processes and to investigate the basic mechanism for perceptual decision making, it needs to be abstracted. The most common experimental setup is a two-alternative forced choice task, like the random dot motion task. There the subjects have to decide whether a cloud of dots, subject to various levels of noise, is moving to the left or right.

To explain experimental data, the accumulation of evidence is often mathematically described by a drift-diffusion model, where the decision or state variable follows a trajectory of adding positive or negative evidence, subject to multiple sources of noise. Finally, 'making a decision' is represented by the state variable reaching a decision bound.

Recently, Brunton et al (Science, 2013) extended this very simple model by explicitly incorporating the stimulus and introducing several new parameters, to account for the quality of input processing, accumulation memory, stimulus impact and bias. This 'new' drift-diffusion model was then shown to yield good results for explaining behavioural data, which were the subjects' choices. We decided to use this model for our own behavioural experiment and extend it by adapting it to also describe the subjects' response times. To verify whether the model is adequate to describe this perceptual decision making task, the model parameters need to be determined by fitting to experimental data.

This model has several free parameters and so it can describe very different decision-making mechanisms, depending on the parameter regimes. Since the mechanism the brain actually uses is still unknown, finding evidence favouring one of them would be a benefit for cognitive neuroscience.

In my presentation, I will describe the procedure used to obtain the best-fit parameters, which is based on Fokker-Planck calculus and Bayesian statistics.