Optimality of noisy sensory-motor decisions under risk

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The processing and coding of noisy sensory information plays a key role in understanding how the brain controls voluntary behavior. It seems that the remarkable precision and reliability of behavior is possible because the nervous system represents the uncertainty associated with the processing of information in the sensory and in the motor system. Little is known about how noisy sensory estimates and noisy motor responses interact, since previous work failed to separate the two.

I present experimental work in which we systematically vary the uncertainty associated with the processing of sensory information, as well as the variability of the motor response. We vary the sensory noise by manipulating stimulus parameters, such as stimulus onset, duration of stimulus presentation, luminance, and contrast. Variability of the motor output is manipulated by changing the overall time limit for the motor response, the movement kinematics, and the response mode (button press vs. hand movement). In most conditions of our experiments, monetary rewards and losses are assigned to the outcome of the movement. In parallel, we compare our subjects' behavior to a model of optimal (risky) performance based on statistical decision theory. The model is based on the idea that movements reflect a choice under the constraints of the perceptual and motor system.

I will present several experimental tests of the model. We find that subjects effectively acted so as to maximize gain, in good agreement with predictions of the model. Our experiments demonstrate that subjects optimally combine noisy sensory estimates and the noise associated with the motor output. Optimal performance can be disrupted by introducing uncertainty into the presentation of reward or object location.