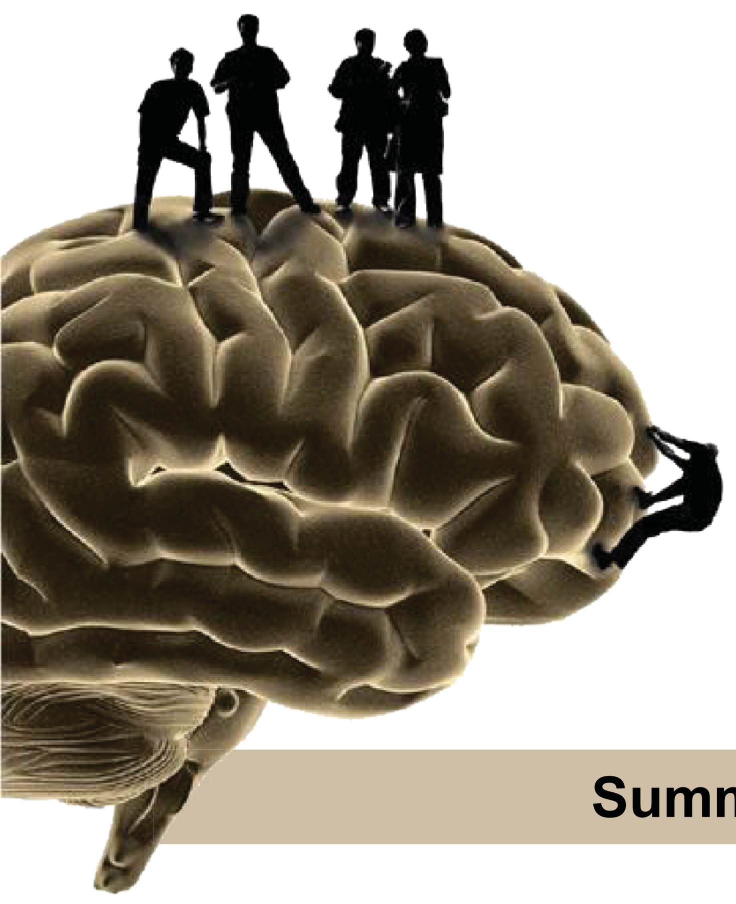

Visual motion processing and perceptual decision making

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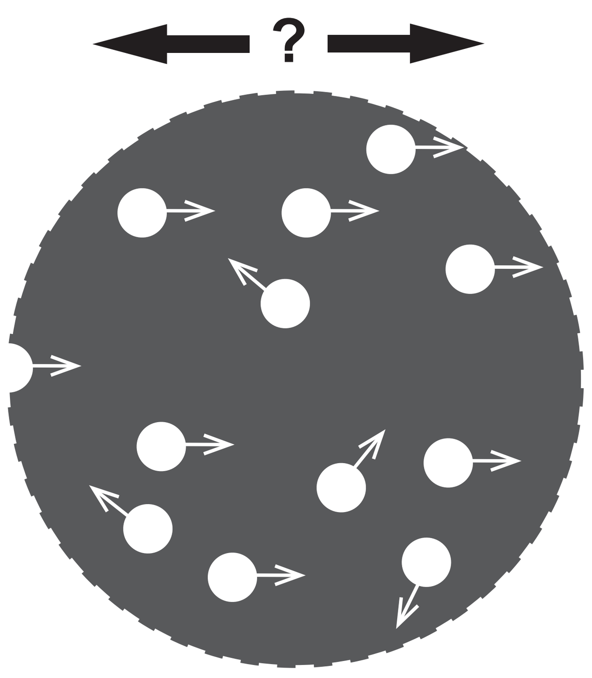
Summary

We present a biologically plausible spiking network model of visual motion processing and perceptual decision making, independent of the number of choice alternatives. As an application we simulate the two-alternative forced choice (2AFC) task.

The integration of local dot velocities over time produces a decision vector that depends on the nature of the sensory input, processing and integration mechanisms, and not the number of choices. As evidence is integrated, the vector grows in the 'decision direction' until a threshold or radius is crossed.

Our results capture the evidence accumulation aspects of single neuron and psychometric data from monkeys.

Method



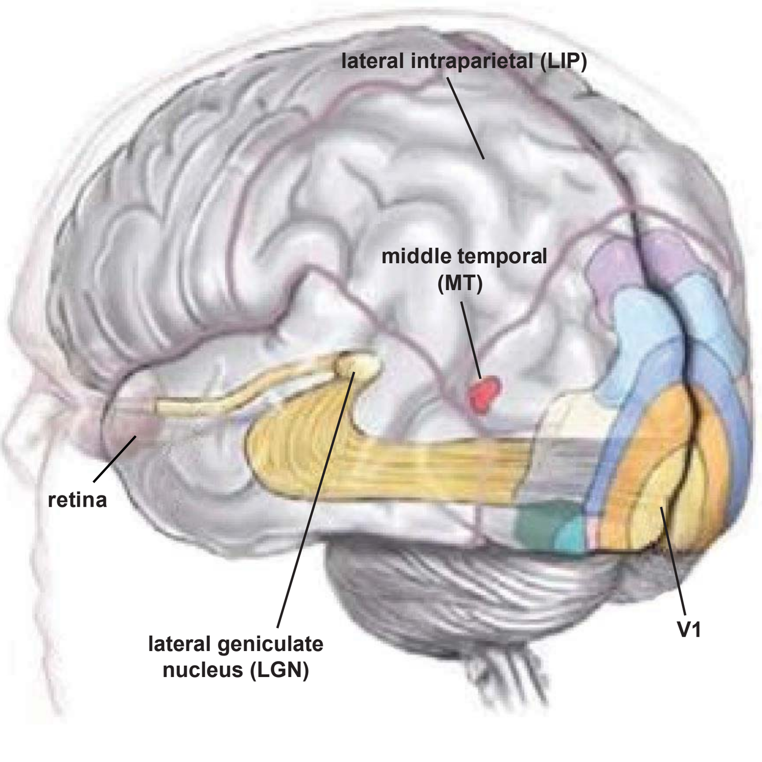
dot motion stimulus with net direction rightward

We used animal laboratory stimulus movies generated by Psychtoolbox-3 for Matlab.

10 tests were run for each noise level, lowered progressively.

Nengo simulation software was used to build the neural network according to the Neural Engineering Framework (Eliasmith & Anderson).

Our V1 used the principle of oscillator interference to extract local direction and speed for each point in a map of optical flow, represented in MT.

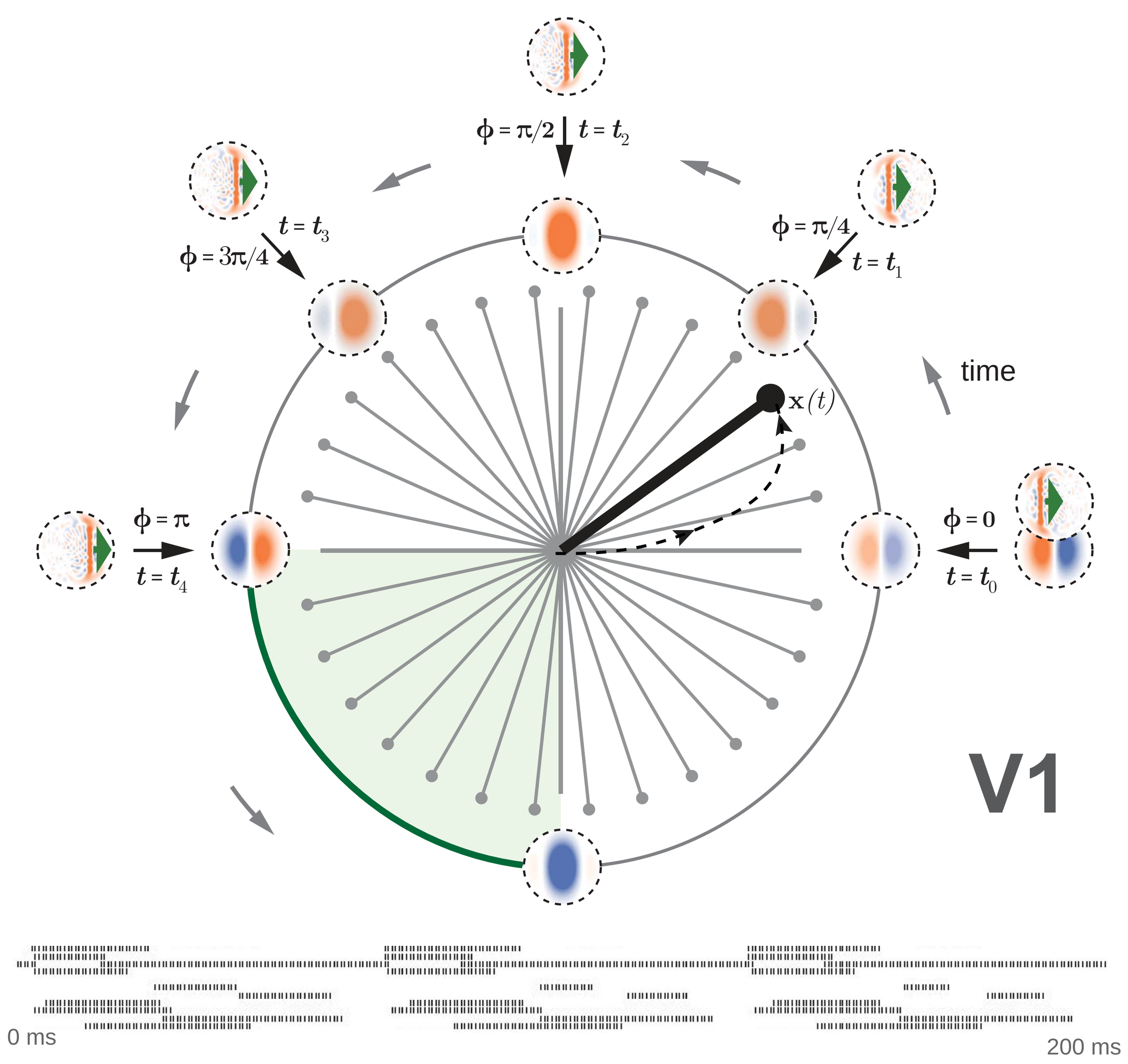


Subnetworks simulated include later geniculate nucleus (LGN), V1, middle temporal (MT) and lateral intraparietal (LIP) cortical areas.

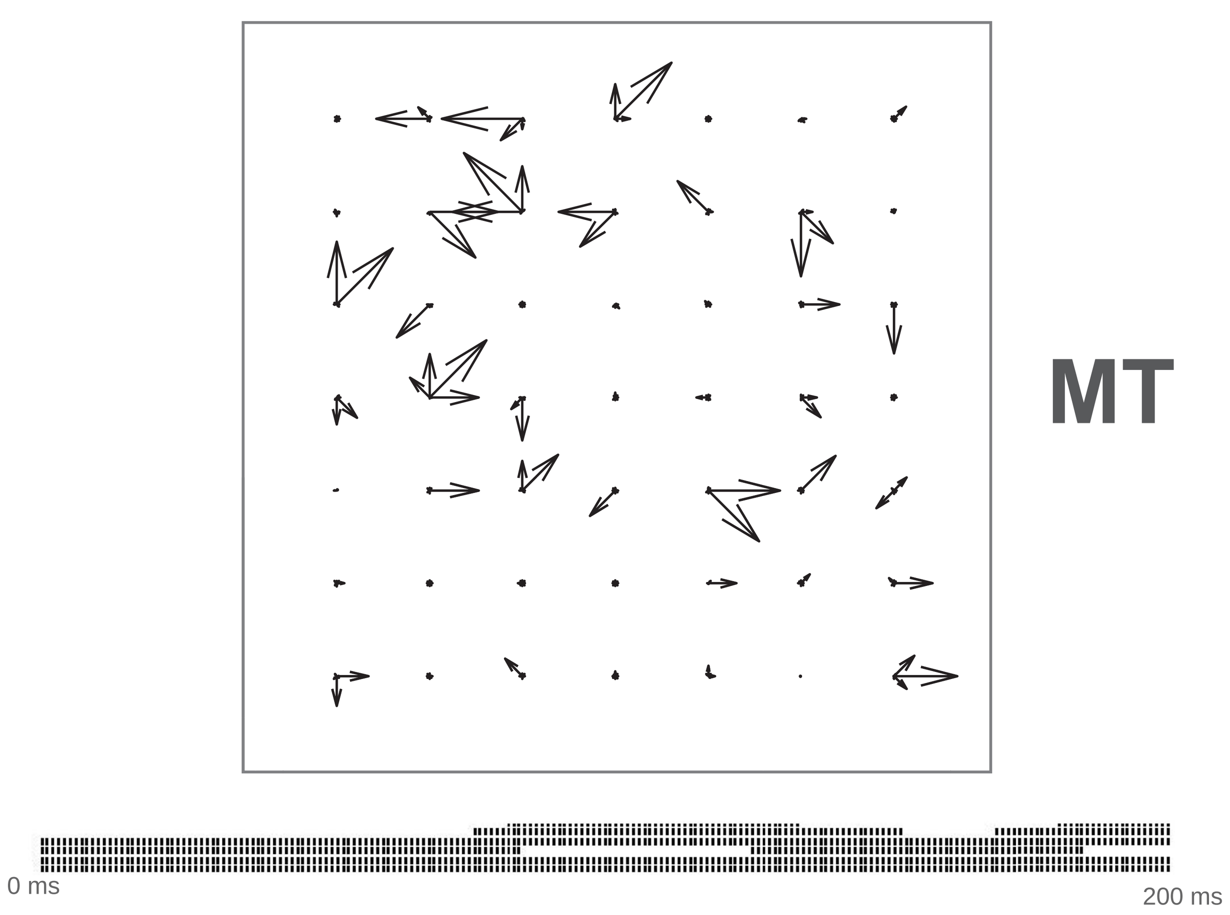
Adapted from <http://scien.stanford.edu/pages/labsite/2006/psych221/projects/06/cukur/intro.html>

Model

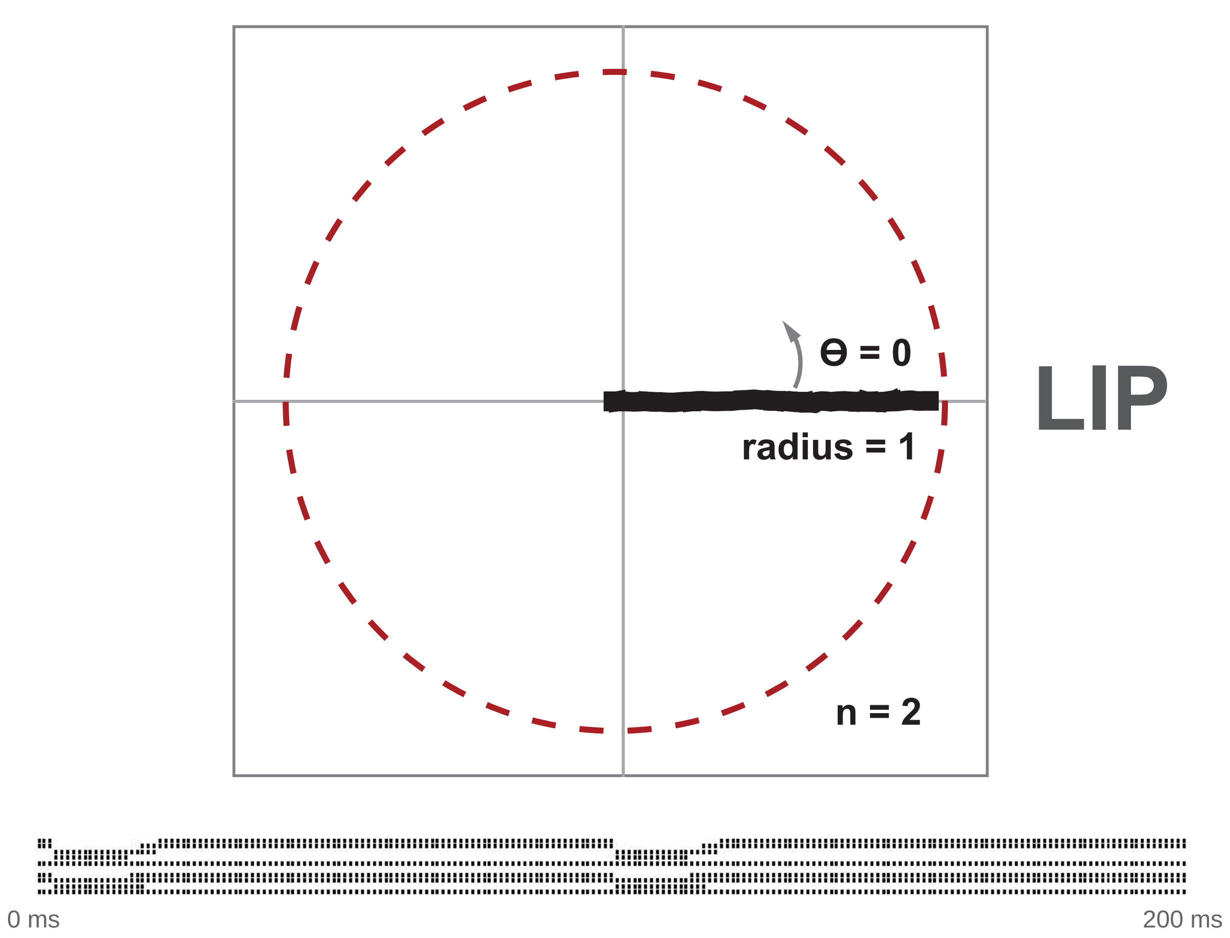
To simulate thalamic bursting (Butts et al.), an input filter extracts convolution peaks between the stimulus and the preferred orientation of each V1 oscillator. The bursts drive and interfere with simple cell oscillators arrayed by field location, speed and orientation selectivity.



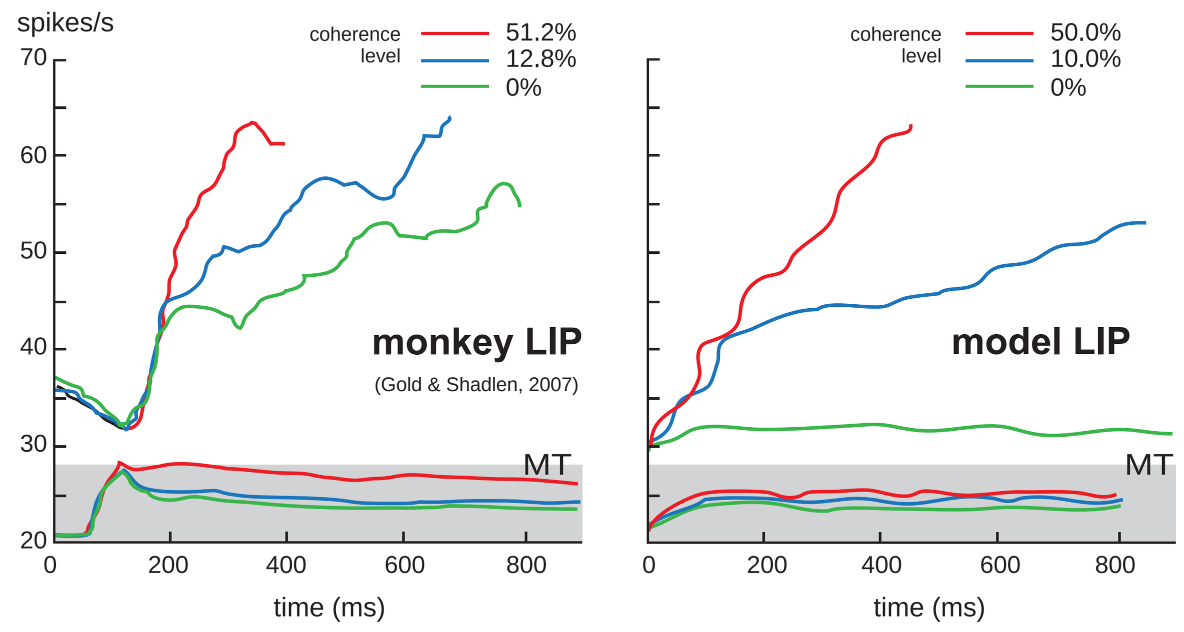
Each local response from V1 encodes the magnitude of a direction vector in MT. Shown below is a decoded evidence field at a particular time. Each point maps to a patch centre in the visual field.



Global, competition-less integration of the MT field over time gives a position in an *n*-dimensional perceptual space. No task structure (left vs right) is imposed. An average success rate of 80% determined the threshold.

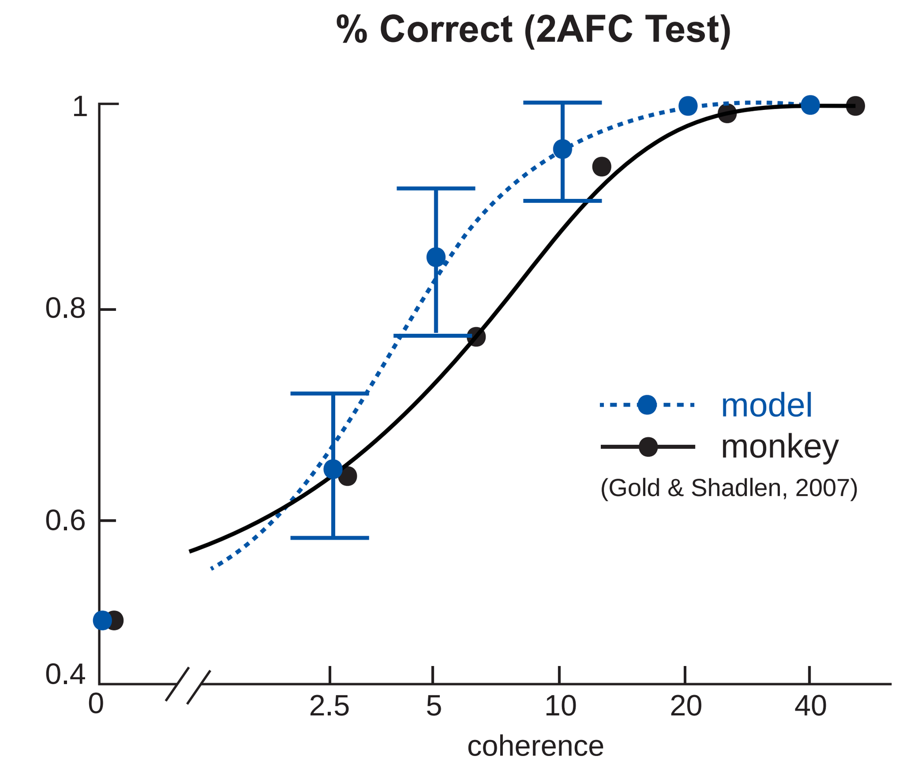


Single neuron results

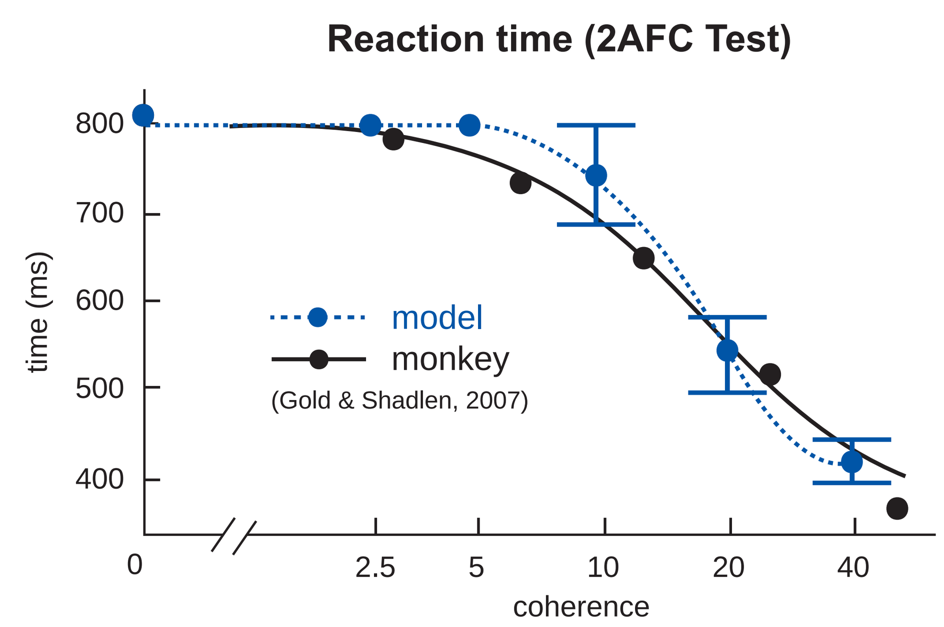


The monkey response at 0% coherence may indicate 'guess' formulation involving non-sensory mechanisms (Shadlen & Newsome).

Psychometric results



The model performs similarly well using 4- and 8-choice decisions.



The model has a 300ms constant motor response time added. The maximum trial length for both the experiment and model is 800ms.

Remarks

Fewer choices lead to faster decisions since the minimum detectable difference in signal among a few alternatives is greater vs distribution among many.

The model works with *n* dimensions, continuous choices and any integrate-to-threshold decision model.

Acknowledgments

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