BioE332 Lecture 4: Decision Making

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Direction discrimination task

• Reaction-time task: Monkey saccades to indicate motion direction as soon as it is certain.

• Other version of task had fixed viewing duration.

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After fixation, two choice targets appeared in the periphery. One of the targets was within the response field of the neuron, indicated by gray shading.

To evaluate the relationship between the ramp-slope and RT, we used a full second (Fig. 3), instead by setting RT = 0.

The monkey reported its judgment by making an eye movement to a choice target at any time after onset of random-dot motion to indicate the direction of perceived motion. A liquid reward was delivered to the monkey for its correct response. Reward magnitude was adjusted to maintain high RT performance across all conditions.

Performance accuracy on the RT and FD tasks depended on the speed and accuracy of direction judgments.

Speed and accuracy of direction judgments varied as a function of coherence level are included.

The monkey maintained fixation point was extinguished, the monkey reported its judgment by making an eye movement to a choice target at any time after onset of random-dot motion to indicate the direction of perceived motion. A liquid reward was delivered to the monkey for its correct response. Reward magnitude was adjusted to maintain high RT performance across all conditions.

Reaction time (RT) is deﬁned as the interval from motion onset to saccade initiation. Only correct T1 choices were included in this analysis. The monkey performed a direction discrimination task (Fig. 2). We will ﬁrst show how the speed and accuracy of the monkeys vary with stimulus motion strength.

One version of the task is that motion strength does not affect the saccade parameter (Fig. 4). Speed and accuracy of direction judgments varied as a function of coherence level are included.

The latter is obtained by inverting the 2 standard error. The null hypothesis, that there is no relationship between the neural activity and motion strength of the stimulus. Accuracy data from a single recording session are shown in Figure 3.
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stimulus was presented on a computer monitor with a frame

remaining motion was present by the second video frame (13 msec). The

randomization of the prestimulus interval in this fashion was essential for

activity to motion was estimated by plotting the probability (Fig. 7F

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RT was faster than in these experiments and varied less across the range

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neuron activity during the delay

neuron activity during the delay

[5211.0]

cue location

0

180°

270°

0°

90°

Goldman-Rakic '89

Schadlen '99

0.66

0.64

1.00

0.96

0.82

0.64

0.50

0.96

1.00
Random-dot display

100%

30%

5%

0%
**Psychophysics: Percent correct and reaction time**

- **Weibull function fits** with $\alpha = 7.11$ and $\beta = 1.4 - 1.7$

![Psychophysics graph showing percent correct vs. motion strength and reaction time vs. motion strength.](image-url)
LIP neuron responses (RT)

* Spike trains aligned to saccade; stimulus onset indicated by claret; only correct choices shown

* Spike rate builds up when target is in cell’s RF

* RT is longer when coherence is low

**Figure 4.** Response of an LIP neuron during the RT-direction discrimination task. Data were obtained from the block of RT trials (Materials and Methods), we expected neurons to respond to the corresponding target. On the basis of our selection criteria, we defined decision formation as the period of motion viewing (spike histogram binwidth 20 msec). This pattern of persistent activity during the delay period indicated the monkeys were in a state of decision formation, which could be differentiated from the immediate preparation of an eye movement. Decision formation was defined as the period of motion viewing during which the monkey judged the direction of motion as away from the RF, and this change in activity persisted through the delay period until the go signal. When the monkey judged the direction as toward the RF, the activity decreased and remained suppressed through the delay period.

**Figure 5.** The activity increased during the period of decision formation on each trial, before the monkey is committed to an eye movement response. In particular, when motion was strong, the monkey made its decision rapidly, and the response modulation was apparent for only a short time frame. However, when the task is more difficult, the monkey takes longer to decide the direction of the weaker (6.4% coherent) motion. This is consistent with previous studies reporting that RT is longer when coherence is low (Shadlen and Newsome, 1996, 2001). To test this, it is necessary to determine whether the monkey uses to reach a decision. This is not possible using the FD paradigm, which requires the monkey to initiate a saccade in a space-correlated manner.

**Figure 6.** The activity increased during the period of decision formation, before the monkey is committed to an eye movement response. In particular, when motion was strong, the monkey made its decision rapidly, and the response modulation was apparent for only a short time frame. However, when the task is more difficult, the monkey takes longer to decide the direction of the weaker (6.4% coherent) motion. This is consistent with previous studies reporting that RT is longer when coherence is low (Shadlen and Newsome, 1996, 2001). To test this, it is necessary to determine whether the monkey uses to reach a decision. This is not possible using the FD paradigm, which requires the monkey to initiate a saccade in a space-correlated manner.
Time course of activity

* Responses are aligned to stimulus onset (left) or saccade (right).

* Dotted lines are outside RF
Abstract model

Doesn’t specify how neurons achieve the key computations: difference, integration, and threshold.
There are two pyramidal cell populations (groups A and B) with strong recurrent excitatory connections that compete through feedback inhibition from interneurons.
At zero-coherence, either group could win, depending on random fluctuations in input strength as well as added noise.
Matches RT and % correct

\[ c' = 0 \% \]

\[ c' = 51.2 \% \]

- RT is longer and more variable when coherence is low. Neurometric threshold is 8.4 or 10.4% coherence for RT and 1s delay.

Wang '01
Next week

* Neurogrid tutorial!