PID *****2515

1. What is one key difference in the assumptions of signal-detection theory and sequential probability ratio test?

   Signal-detection theory (SDT) prescribes a process to convert a single observation of noisy evidence into a categorical choice (p538). Whereas Sequential Probability Ratio Test is a test under the sequential analysis (SA) framework, which accommodates multiple pieces of evidence observed over time (rather than just a single piece of evidence) (p539). SA assumes that the decision includes a stopping rule -- when to stop. Basically, in SDT, the decision requires the construction of a DV; by applying a criterion to the DV, we get a simple decision rule. The SPRT is comprised of DV (includes multiple pieces of independent evidence) and stopping rule.

2. Consider Fig 3C & 3D, Why does the data support the notion that S1 neurons encode sensory evidence, while neural response in the ventral premotor cortex reflects the final decision?

   Figure 3C shows S1 neurons response. We see that the firing rate encodes the vibration frequency similarly in the base and comparison period (brown and purple, respectively), but it does not reflect the monkey’s choice (black and white dots). The neuron is uninformative in the interval between base and comparison stimuli--no firing activity during interval. These evidence shows that S1 neuron activity only reflects sensory evidence. On the other hand, since the decision making (comparison) cannot be made until f2 is applied, in order to make the comparison, the neuron needs to incorporate information about f1 that has been held in working memory-- this is what’s shown in Figure 3D. In VPC neuron, continued firing activity is observed during interstimulus interval (blue), indicates the VPC neuron carries information about the base frequency. In the comparison epoch (purple), the VPC neuron is more active when f2<f1, which indicates a final decision making after the comparison (p543).

3. Using the example of the random-dot coherent motion task (Fig 5), identify the following elements of a decision: evidence, decision variable, priors, values, decision rule.

   Evidence (e): every dots' moving direction. **Neural activities in MT**
   Decision Variable: function of evidence, monkey’s judgement of how many dots are moving towards one direction vs. the other.
   Priors: the two direction choices monkey are trained to moved to. **And the relative frequency (1/2, 1/2)**
   Values: rewards for making the correct choice, or punishment for making the wrong choice.
   Decision rule: the monkey makes an eye movement towards one direction after deciding that the majority of dots are moving towards that particular direction. **When LIP activity (DV) hits a bound**

4. Consider Fig 5C. What two properties of the neural data in the figure indicates that neurons in the LIP do not only respond to the sensory properties of the motion stimuli, but actually reflect something of the final perceptual decision?

   First, even when the stimulus has zero coherence (the two blue lines), the firing rate differentiates in pattern between trials in which the monkey selects Tin (firing rate increases)
and those in which it selects Tout (firing rate meanders or decreases) (p548). So the neurons respond differentially depending on where the monkey’s final choice is at. Furthermore, when the data is lined up right before the eye movement is made, we can see that the firing rates on trials in which the monkey selects Tin reach the same threshold and behave almost identically before saccade initiation, a level of activity that is analogous to the decision rule that terminates the decision process (p548).

5. (Extra) Under what critical assumption is the overall evidence (cumulative log likelihood ratio) a sum of many additive terms, each representing the evidence (log likelihood ratio of each piece of sensory data) in each moment in time?

The assumption made here is that individual evidence (noise) is conditionally independent over time. Thus, we have: \( P(e1,e2 \mid h1) = P(e1 \mid h1) \cdot P(e2 \mid h1) \). We also assumed identical kind of noise. By doing so, we can now represent \( P(e1, e2, \ldots e(n) \mid h1) \) by multiplication of each \( P(e(i) \mid h1) \). Since log is a monotonic function, when we take the log on both side of the equation, the equation still holds.

6. (Extra) Consider the bounded random walk representation of the Sequential Probability Ratio Test in Fig 2b. If the accuracy became more important than speed, in which direction(s) would you expect the decision bounds (A and -A) to shift? If speed became more important than accuracy, what would you then expect?

If the accuracy became more important than speed, you would expect the distance between decision bounds A and -A gets farther apart. This is to increase the ratio of evidence for one hypothesis over the other. If speed became more important than accuracy, you would expect the distance between the decision bounds A and -A to decrease, as the accumulation of evidence for one hypothesis over the other will reach a less extreme threshold in a shorter amount of time.

7. (Extra). Why do the results related to Figure 4 indicate that “information flow from sensory neurons to motor structures is more or less continuous”?

The result in Figure 4 shows that the evoked saccade tend to deviate in the direction governed by the eye movement associated with the monkey’s ultimate choice. The amount of deviation is positively related to the motion strength, and to viewing duration. This indicates that “information flow from sensory neurons to motor structure is more or less continuous” because if this information flow is not continuous, we would see the monkey’s eyes move to the Fix (evoked saccade position) every time, rather than deviate from the Fix. This means while the evoked saccade caused a movement towards a specific point, the information from the sensory neurons that tells the monkey to go up or down continuous to affect the eye movement. The positive relationship between the motion strength, viewing duration and the amount of deviation also supports the continuous information flow, because that means the stronger the sensory input, the more effect it has on the motor response.