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Bayesian Modeling
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The goal of my project will be to create a Bayesian model that can model data from a random dot motion task (RDM) as an alternative to the standard Drift-Diffusion model (DDM). I will integrate the work of Bitzer, Park, Blankenburg, and Kiebel (2014) as well as Fard, Park, Warkentin, Kiebel, and Bitzer (2017) who have shown how the standard and extended forms of the DDM can be rederived in a Bayesian framework with important benefits of modeling sensory input. While the model's end project will be able to model these type of data, I will run a simulation of various noise and boundary parameters to evaluate their overall effects see final paragraph for details.

This project will tie directly into to and integrate work that we have done in class. In particular, this will incorporate both the evidence accumulation and the classification/Signal Detection Theory lectures. In the cue combination lecture we learned how to integrate multiple pieces of evidences from a single stimulus over time. This is a crucial feature of the DDM, namely that one accumulates (noisy) evidence for a particular option over time. Secondly, SDT has been successful in discriminating between two options and with in this class when learn how to select optimally given specific noise parameters. On classic problem in measuring psychological experiments is determining whether one should use reaction time or accuracy in assessing behavioral data. The reason why the classic DDM model has been so popular in perceptual decision making tasks was because it, unlike SDT, integrated both accuracy and reaction time. As such, I will need to incorporate both lectures to complete this project.

I will adapt the generative model previously proposed Bitzer et al. (2014) and Fard et al. (2017) into a format more consistent with the structure that we have seen in this course. Specifically, I will have a generative model similar to fig. 1. There are several important features not explicitly stated in the generative model. First, there are only two classes $C = 1$ (dot coherence to the right) or $C = -1$ (to the left), while the stimuli are the actual coherence proportions. Second, there are two different CCSDs, this is because I will examine the effects of both distributions. The uniform distribution provides useful information about how the internal and stimulus noise will independently affect inference while the half Gaussian will be more similar to how most experiments are designed, so I wanted to explore both. Third, the inference of interest is the class of the stimulus (either left or right). Fourth, we will require a hidden variable λ by which we set our criterion (for completeness, I will use three different ones high, medium, and low). This mimics the case for SDT when we specified the criterion k for making a decision (optimal would be 0 for log odds, but we could have chosen another criterion value). And fifth and perhaps most importantly, there are two subtleties with the $x's$. First, as is the case with DDM these represent the participants sequential evidence accumulation steps in time of the same stimulus AND on the same trial. This means that we are proposing a situation where we predict multiple stages of cue combination over time even though the participant only provides one response per trial (the same goes for DDMs) and this is resolved by examining the reaction time for the given trial. The time it takes to respond yields critical information about the rate of evidence accumulation for the given stimuli type (in other words the difficulty of discerning class). Second, and again as with the case for DDMs, we will assume that these pieces of evidence are conditionally independent.

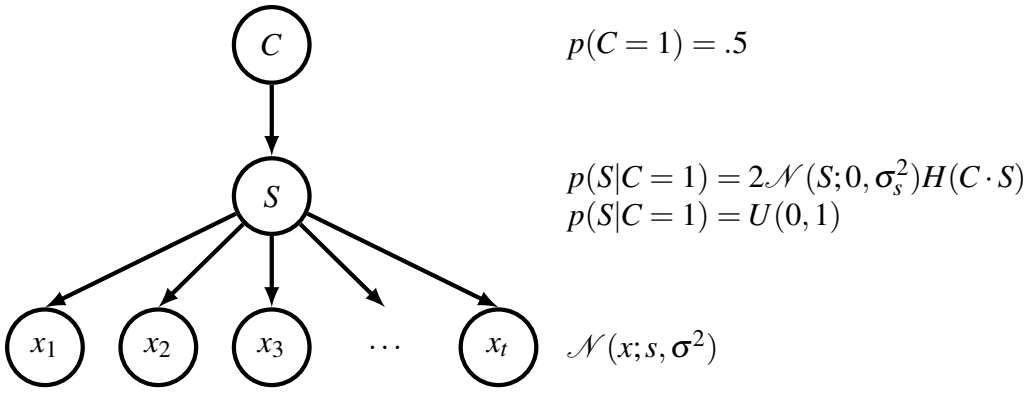

Figure 1: Generative Model.

The question I intend to answer with this project is three-fold: 1) what role do external (stimulus) and internal noise play in the amount of time it would take for a Bayesian observer to accumulate enough evidence to reach the thresholds (λ), 2) explore how the various levels of requested accuracy will influence time to accumulate sufficient evidence, and 3) evaluate the role of both noise and λ on predicted number of correct and incorrect (and non response) responses given a an experimenter implemented time limit. This is mostly experimentally relevant because most of these designs have a time limit, such that a Bayesian observer with enough noise might still be able to accumulate enough evidence, but sufficiently quick enough to make a response in time.

References

Bitzer, S., Park, H., Blankenburg, F., & Kiebel, S. (2014). Perceptual decision making: drift-diffusion model is equivalent to a bayesian model. *Frontiers in Human Neuroscience*, *8*, 102. Retrieved from https://www.frontiersin.org/article/10.3389/fnhum.2014.00102 doi: 10.3389/fnhum.2014.00102

Fard, P. R., Park, H., Warkentin, A., Kiebel, S. J., & Bitzer, S. (2017). A bayesian reformulation of the extended drift-diffusion model in perceptual decision making. *Frontiers in Computational Neuroscience*, *11*, 29. Retrieved from https://www.frontiersin.org/article/10.3389/fncom.2017.00029 doi: 10.3389/fncom.2017.00029

Appendix A

25-item General Decision Making Style Scale

Instructions: Please indicate the extent to which you each sentence captures how you are **CURRENTLY** make decisions.

I double-check my information sources to be sure I have the right facts before making decisions.	I make decisions in a logical and systematic way.
My decision making requires careful thought.	When making a decision, I consider various options in terms of a specific goal.
When making decisions, I rely up my instincts.	When I make decisions, I tend to rely on my intuition.
I generally make decisions that feel right to me.	When I make a decision, it is more important for me to feel the decision is right than to have a rational reason for it.
When I make a decision, I trust my inner feelings and reactions.	I often need the assistance of other people when making important decisions.
I rarely make important decisions without consulting other people.[a]	If I have the support of others, it is easier for me to make important decisions.[a]
I use the advice of other people in making my important decisions.[a]	I like to have someone to steer me in the right direction when I am faced with important decisions.[a]
I avoid making important decisions until the pressure is on.	I postpone decisions making whenever possible.[a]
I often procrastinate when it comes to making important decisions.[a]	I generally make important decisions at the last minute.
I put off making many decisions because thinking about them makes me uneasy.[a]	I generally make snap decisions.
I often make decisions on the spur of the moment.	I make quick decisions.
I often make impulsive decisions.	When making decisions, I do what seems natural at the moment.
I explore all of my options before making a decision.	

Note: [a] indicates elements that are only in the 25-item version. All other items will be assessed in both scales. All items will be assess on a 5-point Likert-type scale (1 = *Strongly disagree* to 5 = *Strongly agree*, as was used in the original scale).

Appendix B

Cognitive Reflection Task with new Sample Items

Old CRT	A bat and a ball cost $1.10 in total. The bat costs $1.00 more than the ball. How much does the ball cost? ____ cents. **Answer Format**: Open response
Old CRT	If it takes 5 machines 5 minutes to make 5 widgets, how long would it take 100 machines to make 100 widgets? ____ minutes. **Answer Format**: Open response
Old CRT	In a lake, there is a patch of lily pads. Every day, the patch doubles in size. If it takes 48 days for the patch to cover the entire lake, how long would it take for the patch to cover half of the lake? ____ days. **Answer Format**: Open response
CRT 2.0	If you're running a race and you pass the person in second place, what place are you in? **Answer Choices**: *First, Second, Third*
CRT 2.0	A farmer had 15 sheep and all but 8 died. How many are left? ____ sheep. **Answer Format**: Open response
CRT 2.0	Emily's father has three daughters. The first two are named April and May. What is the third daughter's name? ____ **Answer Format**: Open response
CRT 2.0	How many cubic feet of dirt are there in a hole that is 3' deep x 3' wide x 3' long? ____ cubic feet of dirt. **Answer Format**: Open response
New Sample	If one car take 100 minutes to travel 100 miles, how fast is the car traveling? ____ $\frac{miles}{hour}$ **Answer Format**: Open response
New Sample	Alice is looking at Bob, and Bob is looking at Charlie. Alice is married and Charlie is not married. Is a married person looking at an unmarried person? **Answer Choices**: *Yes, no, cannot be determined*
New Sample	A drawer has 10 black socks and 10 white socks. With your eyes closed you pull 3 socks from a drawer. Are you holding a pair of socks? **Answer Choices**: *Yes, no, cannot be determined*

Appendix C

CEFA Output to Assess for Unidimensionality

Appendix D

IRT Output Demonstrating I know the appropriate code to run (and that I do not have the sample size to estimate these parameters)