CS-134/PSY-141: Cognitive Modeling

Homework 2: Modeling Response Times

Due 11/12/2025, 23:59

Background

In this assignment, we are going to explore response times. You will download a .csv file with the response times of participant 1 from Experiment 2 described in Riest, Jorschick & De Ruiter, 2015, published in the Journal *Frontiers in Psychology*[1]. The authors were investigating whether people are *anticipating* the end of the turn of their conversation partner, or just wait until their partner stops speaking. So for comparison, they ran a control experiment in which people just responded to the stopping of a sound, and they could establish that the response distribution was much later than that of responding to the end of spoken turns. This provided evidence against the idea that people just wait for their interlocutor to stop speaking before they respond. For more details, please read the study cited above. We are going to work with a subset of the data from the control experiment, namely with the data from participant 1. So these are the response times of participant 1 who pressed a button as soon as they heard that the presented noise had stopped.

Exercise A: Fitting the half-normal model.

First, you are going to try to fit a so-called "half-normal" distribution to the data. That distribution has only one parameter, which is its standard deviation σ. Play with this distribution in Mathematica with the Manipulate command to see how it varies with different values of σ. The mean (expectation) of a Half Normal distribution is $1/\sigma$. Create a prior distribution for σ such that only positive values have nonzero probability (because standard deviations are always positive), and such that the values of $1/\sigma$ have a relatively wide range. Also, make sure that for values of $1/\sigma$ that are much larger than what you suspect is a plausible mean response time, the probability will quickly get very low; remember, it's the *mean* response time we are talking about here.

[1] See https://www.frontiersin.org/articles/10.3389/fpsyg.2015.00089/full

Generate combined plots of

I. The prior and posterior of the parameter of the model (in this case, σ).

II. The prior predictive, the posterior predictive, and the data, the latter in the form of a histogram.

Discuss the qualitative fit of the model with the data on the basis of the plot of the posterior predictive and the data.

Exercise B: Fitting a Gamma distribution

In this exercise, you are going to use a Gamma distribution for the likelihood function. Note that you can use the mean and standard deviation (μ and σ) in PyMC as parameters for the Gamma distribution instead of α and β, which is convenient. You need to define two priors, one for each parameter. Define a prior for the mean that corresponds with your intuition of what the mean of a response time would be likely to be. For the prior of the standard deviation σ, you are to define an *uninformative* prior that allows for a wide range of (only positive) values. This is necessary because the mean and the standard deviation of a Gamma distribution are not independent of each other. So if we set the mean to a "informed" value, we want to make the standard deviation prior vague and more free to vary.

Generate combined plots of

I. The prior and posterior of both μ and σ (two separate combined plots, one for each parameter).

II. The prior predictive, the posterior predictive, and the data, the latter in the form of a histogram.

Discuss the qualitative fit of the model on the basis of the plot of the posterior predictive and the data.

Exercise C – Comparison and Discussion

Discuss which of the two models fits the best from a qualitative (eye-balling) perspective. Then compute the Bayes Factor comparing the two models and compare their relative quantitative fit. Discuss what you find in this analysis, and report the Bayes Factor and what it means in terms of the relative probability of the data under both models. Report also whether the quantitative

evaluation (BF) matches your qualitative evaluation of the relative fit of both models, and why (not). They don't have to match, and they often mismatch, but if they do mismatch, you should discuss this and speculate why this could be. Finally, describe and discuss what you have learned about human response times to the stopping of a sound in this exercise.

What to Submit and How

For this assignment, you need to upload a **PDF** and a **Python script** to Gradescope. We strongly recommend using LaTeX for the PDF file. A good way to start with LaTeX is to use the Overleaf system (`https://www.overleaf.com`.

Please name your PDF file `<firstname>_<lastname>_HW2.pdf` and your script `<firstname>_<lastname>_HW2.py`.