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Final Project Part 3: Essay

1. Provide a summary of your approach and findings in the first two assignments.

A separate new ACT-R model was used for the DM for each block and individual due to the large time gap between blocks. The number of trials, runs, and sessions, as well as the timing of the model, followed the guidelines of the paper or educated guesses were made. Within the trials of each block, the sampled intervals were converted to integer pulses using a logistic noise (as sensory noise) and stored as these in the DM. For the reproduction of the intervals, a blended trace was used to simulate the influences of the just presented interval and the previous perceived intervals/pulses at retrieving, and again converted to an interval time using a logistic noise. The modeling of feedback or additional motor noise was not considered further in this simulation due to the lack of necessity or meaningfulness.

In general, the simulated results were relatively close to Acerbi's collected data in terms of bias and standard deviation. Also, when comparing the non-parametrically estimated priors to the retrieval probabilities of the integer pulses (representing as a discrete prior) used for the blended trace, a similar pattern was qualitatively evident, apart from differences stemming mainly from the exact model choice and outliers in the data. However, the greatest systematic difference in the cognitive ACT-R model can be identified as the stronger regression of the reproduced intervals to the mean of the condition and the greater probability density around the maximum of the prior. Both can be explained by a probably somewhat too strong weighting of more often perceived pulses compared to the less perceived (or also to the last perceived) pulses in the calculation of the retrieval probabilities. This difference could accordingly be reduced by parameter changes, but thus also increase the danger of overfitting, if the cognitive model is to be used for more general modeling.

2. What are the implications of your findings for the various modelling paradigms you've come across in (or outside) this course (including the neural network approach)?

The cognitive model used here has two main limitations. One is that the blended trace ultimately determines and reproduces a weighted arithmetic mean of the perceived pulses. This provides suitable results for uniform or unimodal distributions of the presented intervals as in these experiments, but reaches its limits for bimodal or multimodal distributions where the posterior can no longer be suitably determined by a weighted arithmetic mean of the priors. Weighted sampling instead of the blended trace could presumably solve this problem, allowing regressions toward multiple modes. The other limitation of the model is storing the intervals in discrete units (pulses) and also calculating the activation in discrete time steps. This is a very strong simplification of the dynamic system of the brain. A Bayesian observer model, for example, can solve the problem of discrete units in the DM by modeling a continuous prior at a good model fit, but it does not allow any conclusions about more precise cognitive processes in the brain of a subject and, moreover, it is strongly dependent on distributional assumptions for prior and likelihood, the choice of which, in turn, should strongly depend on assumptions about cognitive processes. A dynamic spiking neural network, on the other hand, can steadily model neuronal activity of neurons for interval perception and also provide realistic, flexible and even multimodal results. Due to a high number of neurons with spikes and tuning curves, the cognitive process cannot be interpreted as easily as in the DM of the ACT-R model but it gives interesting insights into the more "low-level" biological processes of the brain.

3. **What do your findings mean for our understanding of timing and the influence of memory on timing?**

Despite conceptual differences, the various models just mentioned share two main assumptions. First, the perception of intervals and thus of timing is generally relative and dependent on the perception of other intervals. Accordingly, perceived intervals are not treated as independent facts in a DM, but e.g. based on 2 perceived intervals, one can also interpolate and reconstruct an interval in between in timing without it ever having been perceived. Secondly, for timing, however, as for facts in general in memory, the activation of the respective perceived time depends on the time since the perception itself. In interaction, these effects lead to relative and not strongly deterministic interval reproductions in timing, which is reflected in the different models and supported by Acerbi's results.