Cognitive Modelling: Final Project

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0.1 How does your model work? Justify your modelling choices.

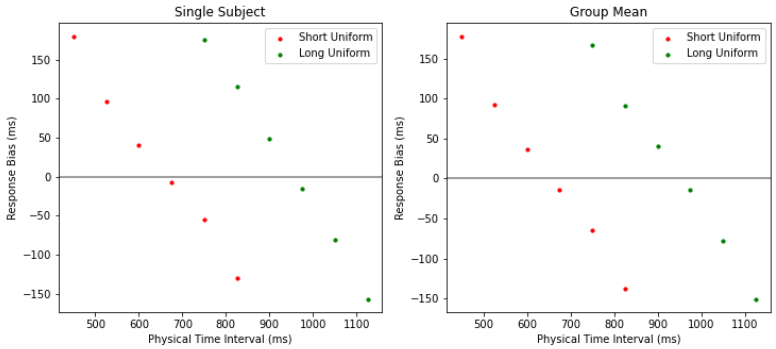
În order to replicate experiments 1 and 2 of Acerbi et al. (2012)[1], an ACT-R[2] model is created. The model takes account of the number of participants and conditions to recreate the experiment. For each participant, the conditions are looped containing several sessions of trials and testing where the former varied between 500 to 1500. In Acerbi[1], participants take breaks between switching conditions, so the model is reset after each condition with an empty declarative memory. Since Acerbi's participants are well trained before performing the experiment, they are mostly likely to distinguish the intervals even during the training phase. So resetting a model from one condition to another provides the participants to get introduced to a new condition without any traces of the previous condition.

Each condition consists of several sessions, where the intervals are shown to the participants after a random delay of 250ms - 1000ms. The interval time from a discrete distribution is presented followed by a yellow dot for 18.5 ms. The representation of time in ACT-R is given in pulses rather than time(seconds) to replicate human time perception. Time in seconds is converted to pulses using a prior (continuous uniform) and likelihood. Ts which is the initial interval is converted to Tm which is the measured time after observation using $f(Ts, w)$ where w is the prior. These pulses are stored in declarative memory with a pulse name. Whenever a pulse is stored, the activation of the particular pulse is increased. Participants wait at least 250ms before replicating the interval. The pulses are retrieved from memory using blended retrieval which calculates the probability of activation of each chunks stored in memory. The sum of the product of probability and values is given as output. Instead of retrieving the most active memory, the sum of probabilities are retrieved giving the highest activated memory a larger portion while also considering the lower activated memories by giving a chance to recall. Measured time (Tm) is converted to an output Tp (production time) using pulses to time which follows the same process mentioned above. The posterior is obtained using prior and likelihood.

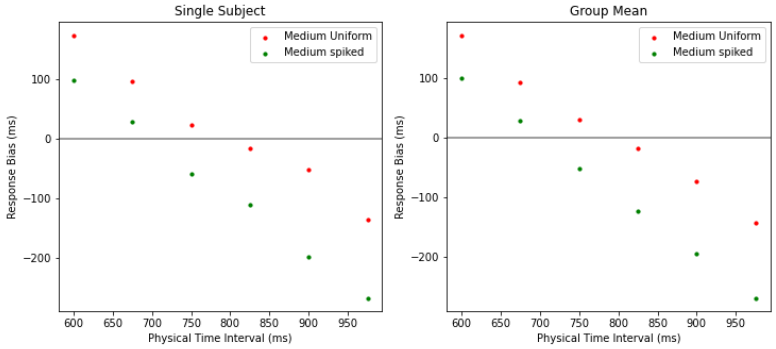
After the retrieval, a delay of 450ms - 850ms is provided before displaying the feedback. A skewed feed back is provided for both the blocks. The feedback is displayed for 62ms. In Acerbi et al. (2012)[1], participants observe the

feedback and tries to minimize the error at the preceding conditions, but ACT-R[2] model replicates the interval reproduction without taking the feedback into consideration. Participants move on to the next condition with a memory reset.

0.2 Show the behaviour of the model in a set of figures similar to Figs 3 and 4 in Acerbi's paper.



(a)



(b)

Figure 1: (a) Response Bias (ms) vs Intervals of Short Uniform and Long Uniform distributions. Single subject (left) and Group mean (right). (b) Response Bias (ms) vs Intervals of Medium Uniform and Medium Spiked distributions.

0.3 Compare your model to Acerbi's findings. Are there differences in behaviour? If so, what may be the cause of these differences?

Experiment 1 contains intervals from Short Uniform and Long Uniform distributions. Acerb[1] compares the experiment with Bayesian model as the baseline since it provides a normative account on how an observer should take action. Figure 1a shows the bias of the intervals from the mean. The graph (Figure 1a) is almost a replication of Figure 3 from Acerbi representing a regression of intervals with a little bias of the ones which are close to mean (637.5ms and 937.5ms). Also the participants tend to perceive shorter intervals with larger bias and longer intervals with shorter bias which is according to Acerbi, consistent with hypothesis of an ideal Bayesian observer.

Experiment 2 contains intervals from Medium Uniform and Medium Peaked. The second interval in medium peaked is presented with probability of 7/12 as opposed to other intervals. Figure 1b provides the results of experiment 2 performed using ACT-R[2]. Due to the peaked distribution, the peaked interval exhibits a shorter bias compared to it's predecessor making it slightly lower towards the zero bias. The same behavior is shown in Figure 1b where the second interval of medium peaked has lower bias compared to medium uniform. But the overall shift of intervals exhibited by medium uniform distribution is larger where the intervals has significantly lower bias compared to medium spiked. This behavior is different from Bayesian and Acerbi's experiments, which can be caused due to blended retrieval even though the probability density of second interval in medium spiked distribution is higher compared to uniform.

References

[1] L. Acerbi, D. M. Wolpert, and S. Vijayakumar, "Internal representations of temporal statistics and feedback calibrate motor-sensory interval timing," *PLOS Computational Biology*, vol. 8, no. 11, pp. 1–19, 11 2012. [Online]. Available: https://doi.org/10.1371/journal.pcbi.1002771

[2] A. J. R., B. D., M. D. Byrne, S. Douglass, C. Lebiere, and Y. Qin, "An integrated theory of the mind. psychological review," *APA PsycArticles*, 2004. [Online]. Available: ttps://doi.org/10.1037/0033-295X.111.4.1036