Sequential Sampling Models for DFE

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Basic model

The basic model is a sequential sampling model with two absorbing boundaries as shown in Figure **??**. Each trajectory (the colored curves) represents the process in time for choosing either option A or option B. It is continuous in time and does NOT represent the number of draws. The choice options are defined below.

For all model versions we assume at least two processes, one for choosing option A and one for choosing option B. The structure of the gambles is mapped onto the drift rate parameters μ_A and μ_B.

Structure of the gambles

I refer to Doug's output file.

Each of the gambles have a different expected value and a different variance.

- For the High (H) condition the expected value ranges from about 5.8 to 6.2 in the gain domain and from -4.8 to -5.2 in the loss domain.
- For the Low (L) condition the expected value ranges from about 4.8 to 5.2 in the gain domain and from -5.8 to -6.2 in the loss domain.
- The low variances range from about 10 to 30 and the high variance between 60 and 90.

- The difference in expected values between H and L ranges from .71 to 1.3.
- The values actually drawn vary between -24 and 24.

Except for the variances and the actual values the ranges are relatively small.

The question is what to map onto the drift rates. We want to weight the input (the parameters in the model) somehow. There are too many different expected values (altogether 166) to even consider this as an option. To consider the difference in expected values is not reasonable since both gambles are not directly compared (at least not for the low switchers but we will use that to construct the model for decisions from descriptions). And they would be too many as well (83). To use the actual values drawn could be one way to go. The ids for the set of outcomes are between 0 and 45 for the L condition and between 2 and 45 between the H condition. That is we have max 46 different values (hopefully less).

Specific models

Using the actual values drawn gives one possible input for the L condition to model:

$$\mu_{L_{id_n}} = (w_i L_{x1n} + w_j L_{x2n} + w_k L_{x3n})/\sqrt{Var(L_n)} \tag{1}$$

The same holds for the H condition. Implicitly we assume a zero input for H when L is considered and zero input for L when H is considered. w_i, w_j, and w_k are the parameters to be estimated from the data. With max 46 different values this results in 46 different w.

An alternative input is

$$\mu_{L_{id_n}} = (w_i L_{x1n} + w_j L_{x2n} + w_k L_{x3n})/para(Var(L)) \tag{2}$$

The difference between both inputs is that in Eq. 1 the standard deviation from the actual gambles are taken whereas in 2 low and high variances build two clusters and each is presented by an additional parameter. There are certainly more ways to set up the drift rate, e.g., by combining the values in the gambles in a reasonable way or by finding a different model input structure. We should discuss it.

Whatever the input to the drift is there are also various model architectures we have discussed briefly (there are certainly more, but let's start with these). For simplicity the processes are shown in the following without the trajectories.

Model 1

We assume one process for both options H and L with two subprocesses. In one subprocess H is considered and in the other subprocess L is considered.

t_1 indicates when the DM switched from H, say, to L. In the model t_1 is a RV (e.g., Uniform with small variance, i.e., almost fixed or with high variance which approaches a geometric distribution) and t_1 may be even related to the average number of draws. Low switchers switching happens once; f high switchers often. This is mapped one to one to the process: for low switchers we assume one switch and for frequent switchers the processes go back and forth. The sequence in which the processes are considered (first H and the L or vice versa) matters for the prediction (not for the choice probabilities but for the mean RT). We could also assume that the DM start randomly with H or L. Note that the starting process of the second process is not exactly as suggested in the figure. The trajectories are random (see **??** and so are the next starting positions.

Model 2

The second model assumes two separate processes, one for H and one for L. However, they are not directly interlinked. Note that the choice options are now accept/reject H and accept/reject H. Also note, that the boundaries may be different in size.

Both processes are combined by assuming a mixture of processes. With probability p H is processes and with probability $(1 - p)$ L is processed. p is a model parameter but may be directly linked to the number of draws taken from each option. I don't know yet how to model the switching behavior for this model.

Remarks

- Most importantly to get it started is to decide what features of the gambles should be map onto the model parameters.
- Risk attitude can be mapped onto a approach/avoidance parameter like in DFT (cf. forgetting). That is, the drift rate in Eqs. 1 and 1 are extended by $-\gamma x$, where γ is a model parameter and x is a state in the state space (roughly the evidence to accumulate).

Exploratory analysis

This exploratory analysis was conducted to answer the following questions:

- Are measures (sample size, number of switches) related to subject- and problem-level factors?
- Can trial-by-trial decisions (whether to continue sampling the same options, to switch to the other option, or to stop sampling altogether) be predicted by trial-level changes in the evidence accumulated?

Subject- and problem-level analysis

The following predictors were considered:

- Group (young/old)
- Session (1-21)
- Domain (gain/loss)
- Pairtype (HH-LL or HL-LH): all option pairs included one high-variance and one low-variance option. For HH-LL pairs, the H option had high variance (this was predicted to be a difficult problem); in HL-LH pairs, the H option had low variance (predicted to be an easy problem).
- EV-diff: difference in expected value between H and L option

Number of switches. Ran mixed effects linear regression on the number of switches, with the variables above as fixed effects, and a random effect term for sample size by participant. [1] However, there were no significant effects of any of these variables on the number of switches. This is consistent with earlier analysis that indicated 1) a bimodal distribution of switching rates, and 2) consistent switching rate within subjects. For following analyses, people are divided into two groups (FREQ and RARE switchers) using a median split on the average switching rate.

Sample size. The next question was whether the total sample size was related to the same set of predictors (now adding the switching group variable based on median split above). There was a highly significant effect of the switch group (FREQ/RARE; $p < .001$), with frequent switchers taking fewer samples than rare switchers. There was also an effect of session ($p < .001$), with the number of samples decreasing over time. However, there were no other effects of group or problem on sample size.

Number of switches.

Trial-by-trial analysis

This analysis used logistic regression

Stay vs. leave.

Switch vs. stop.

[1] The random effect means that a different coefficient is estimated for each participant describing the effect of the number of samples on the number of switches. For frequent switchers this value will be high, while for people who switch only once regardless of sample size it will be at zero.