Effective adaptation to changing environments can account for reliance on small samples and underweighting of rare events

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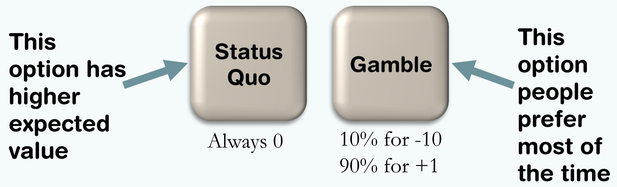
Introduction

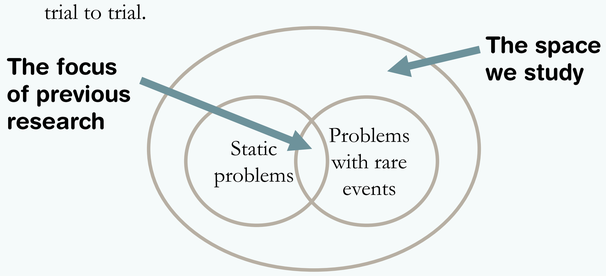
Underweighting of rare events is a robust phenomenon in human choice behavior. When making decisions from experience, people behave as if they believe that "it won't happen to me" (Barron & Erev, 2003; Hertwig, Barron, Weber, & Erev, 2004). For example, they prefer the bad gamble to the status quo in this repeated choice task:



A presumed **tendency to rely on small samples** of experiences explains underweighting of rare events and many other phenomena. Most explanations for the source of reliance on small samples focus on cognitive limitations (Hertwig et al., 2004; Hertwig & Pleskac, 2010). In this study, we show that reliance on small samples can also follow from an opposite mechanism: **cognitive (over)sophistication** (Gaissmaier & Schooler, 2008). If a certain environment can be in several states, and the state changes in time, then only some past experiences (that happened while the environment was in the same state) are relevant to the current decision. That is, reliance on small samples can be the result of a clever attempt to adjust to a changing environment.

The problems studied

Binary repeated choice tasks with a status quo option (payoff of zero with certainty) and a gamble option that has two possible outcomes (one gain and one loss). The outcome of the gamble in a certain trial is set by the "state of nature" in that trial. This state is set by a Markov chain, thus the probabilities for each outcome can change from trial to trial.



Adaptive choice strategies

Definition

Contingent Average (CA) rules sample from memory experiences with each alternative and select the alternative with the higher sample average. Yet, the sample that is taken is not random. Experiences enter the sample if they are relevant to the current decision. Here, an experience is relevant if it followed a sequence of k outcomes identical to the most recent sequence of k outcomes from the gamble.

Example (k = 2)

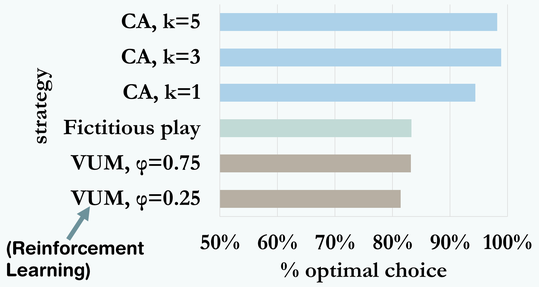
Assume this history of outcomes from the gamble:

Trial	1	2	3	4	5	6	7	8
Outcome	-3	-3	+1	-3	-3	+1	-3	-3

CA considers relevant all previous trials that followed "-3, -3" (the most recent sequence of k = 2 outcomes): Trial 3 and Trial 6. The gamble's sample average is thus +1, and the implied choice in Trial 9 is taking the gamble.

Results: These strategies…

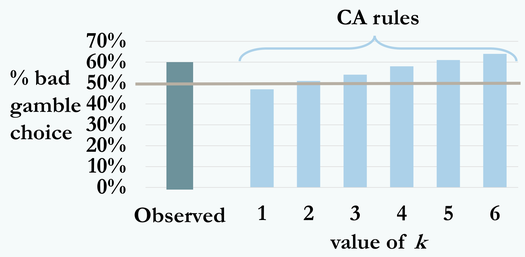
1. Are near optimal in the large space



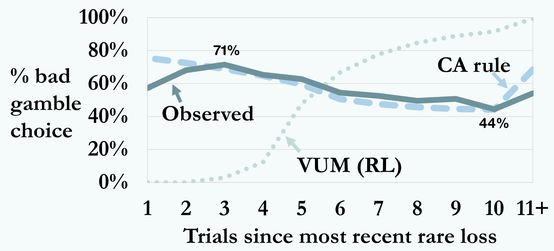
As seen on the left, the CA rules (with a single parameter k) **approximate the optimal performance** in the large space of changing environments that we study. The figure also compares the CA rules to other choice strategies: fictitious play and a 1-parameter version the value updating model (VUM; Hertwig et al., 2006). Results shown are for the long term (50,000 trials), but for small k, CA performs better than the other strategies also in the short term (100 trials).

2. Predict underweighting of rare events in static problems

CA rules are very effective in the large space of problems, and this result is robust to various changes to the environment. However, in the small set of previously researched static problems that include rare events, CA imply underweighting of rare events. This is a result of **reliance on small samples**. The figure on the right demonstrates that CA rules usually predict 50% or more choice of the bad gamble "10% for -10, 90% for +1" as the alternative for the status quo (always zero), as is observed in human data.



3. Predict a new phenomenon: Negative recency effect of rare events



CA rules use sequences of recent outcomes as basis for decisions. If people use them, we expect some interesting sequential dependencies. On the left are the observed and predicted choice rates of the bad gamble ("10% for -10, 90% for +1) contingent on the sequence of recent 10 outcomes with at most one appearance of a rare loss. People seem to choose the bad gamble soon after the large loss more than they do later on! CA nicely predicts this negative recency pattern.

Conclusions and discussion
(you can start here…)

- We suggest that decision making is based on the following two-stage process (cf. Skinner, 1953):
  1. Recall past experiences that are relevant to the current decision
  2. Choose the alternative that provided the best average outcome in these relevant experiences
- The number of relevant experiences can be small, which leads to behavior that appears as reliance on small samples
- In the space of problems we study, the sequence of outcomes that precede an experience determines how relevant it is to the current decision
- On one hand, such process leads to near-optimal performance in this space
- On the other hand, such process leads to underweighting of rare events in the set that was the focus of previous studies
- This process also has uncommon predictions regarding the effect of rare events: it predicts that the more recent a rare event is, the more people will underweight it
- Observed results confirm these uncommon predictions

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