

Strategic Information Search and Integration in Decision Making under Uncertainty

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Data & Code



Introduction

Most of our decisions violate the prescriptions of normative economic models—we don't maximize expected values (EV).

Rather, in decisions under risk (1A) or uncertainty (1B), we behave as if we are distorting the objective outcomes and probabilities.

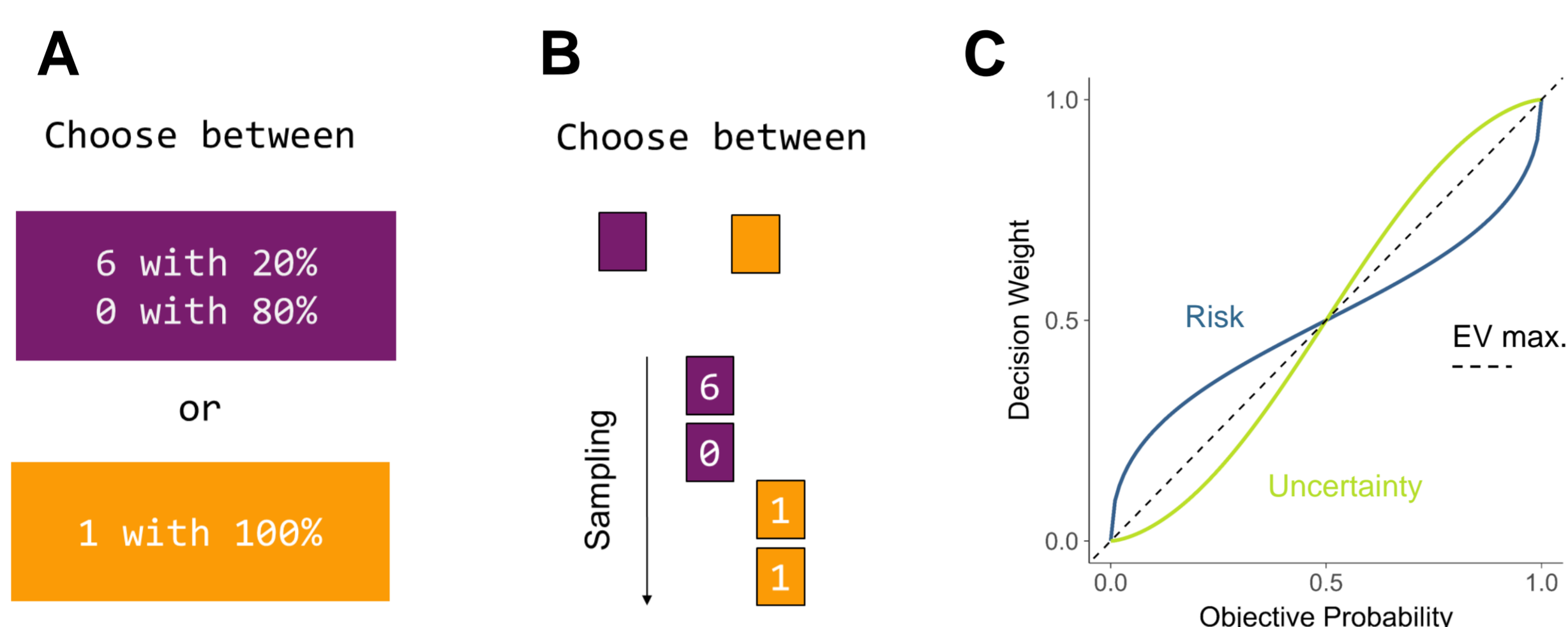


Figure 1. A) Risky choice: All outcomes and probabilities are explicitly stated. B) Uncertain choice: Outcomes and probabilities are initially unknown and must be inferred from a stochastic sampling process—people can sample as much as they want and in the way they want. C) Illustration of CPT's weighting function in risky and uncertain choice: In risky choice, small-probability outcomes are overweighted. In uncertain choice, small-probability outcomes are underweighted.

In a psychoeconomic approach, these distortions are modeled in terms of a value and weighting function, which transform outcomes and probabilities into subjective values and decision weights (1C).

Cognitive Modeling

Psychoeconomic models like cumulative prospect theory (CPT, Kahneman and Tversky, 1992) provide elegant descriptions of our choices—but they don't explain why we make them in the first place.

Here, we focus on decisions under uncertainty and showcase 2 cognitive models (2) that specify how the mind carries out the actual information-processing steps that lead to a choice.

We show that the interplay of simple, cognitive mechanisms of information search (sampling) and integration can explain commonly observed value and probability distortions and may shape CPT's value and weighting function.

Models & Simulations

We combined different sampling strategies (2A) with the summary and roundwise model (2B) to simulate a total of 1,200,000 decision processes and fitted the simulated choice data with CPT.

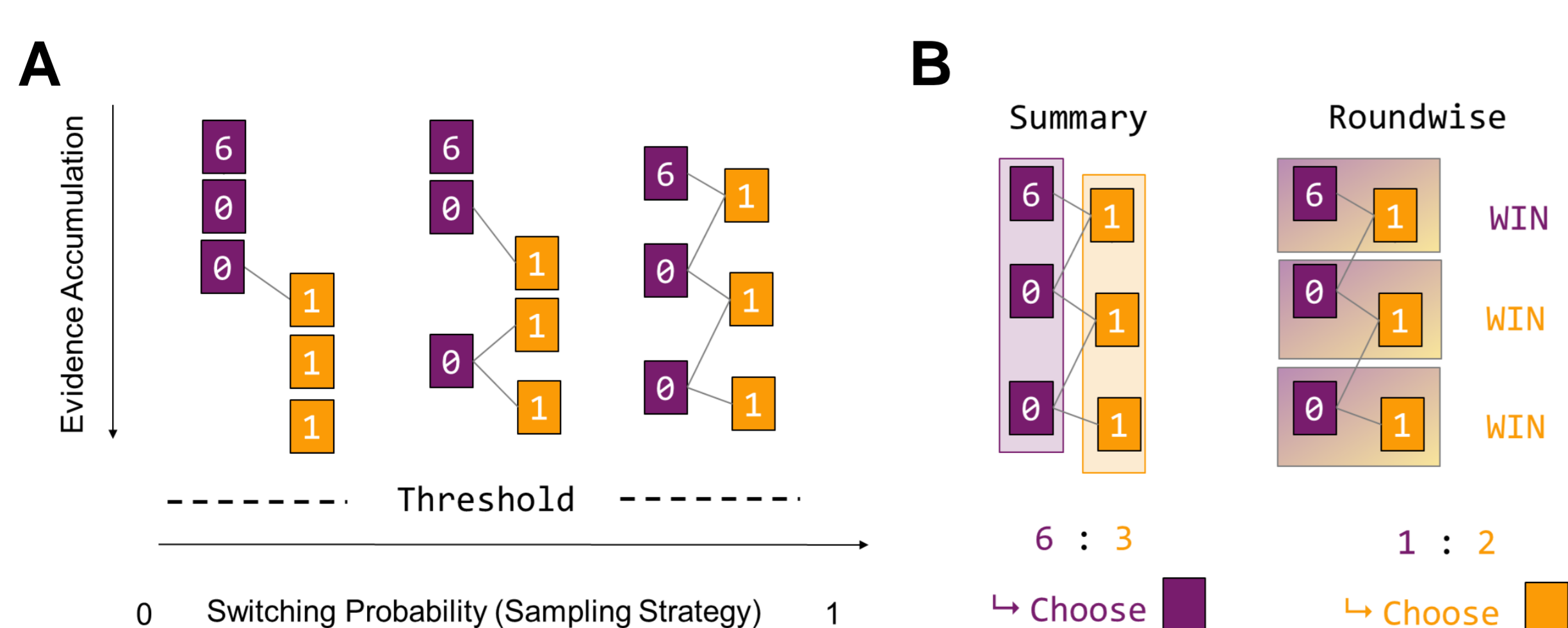


Figure 2. A) Sampling strategies: Decision makers may vary in the frequency with which they switch gambles during the sampling phase. In both models, sampling strategies are specified as the switching probability ψ . B) Integration strategies: Both models assume different outcome integration mechanisms: The summary model assumes that decision makers sum up all sampled outcomes. The roundwise model assumes that decision makers compare sampled outcomes over repeated rounds and sum up round wins. Both models assume that during the sampling phase, decision makers accumulate the evidence for and against the gambles until an evidence threshold θ is reached. In the summary model, θ is the outcome sum a gamble must reach to be chosen. In the roundwise model, θ is the required number of round wins.

Results

- The interplay of sampling and integration strategies can produce distinct choice patterns in decisions under uncertainty (3A).
- These model-implied choice patterns leave characteristic signatures in CPT's value and weighting function (3B).
- A roundwise integration of outcomes can cause the typical underweighting pattern in decisions under uncertainty (3C).

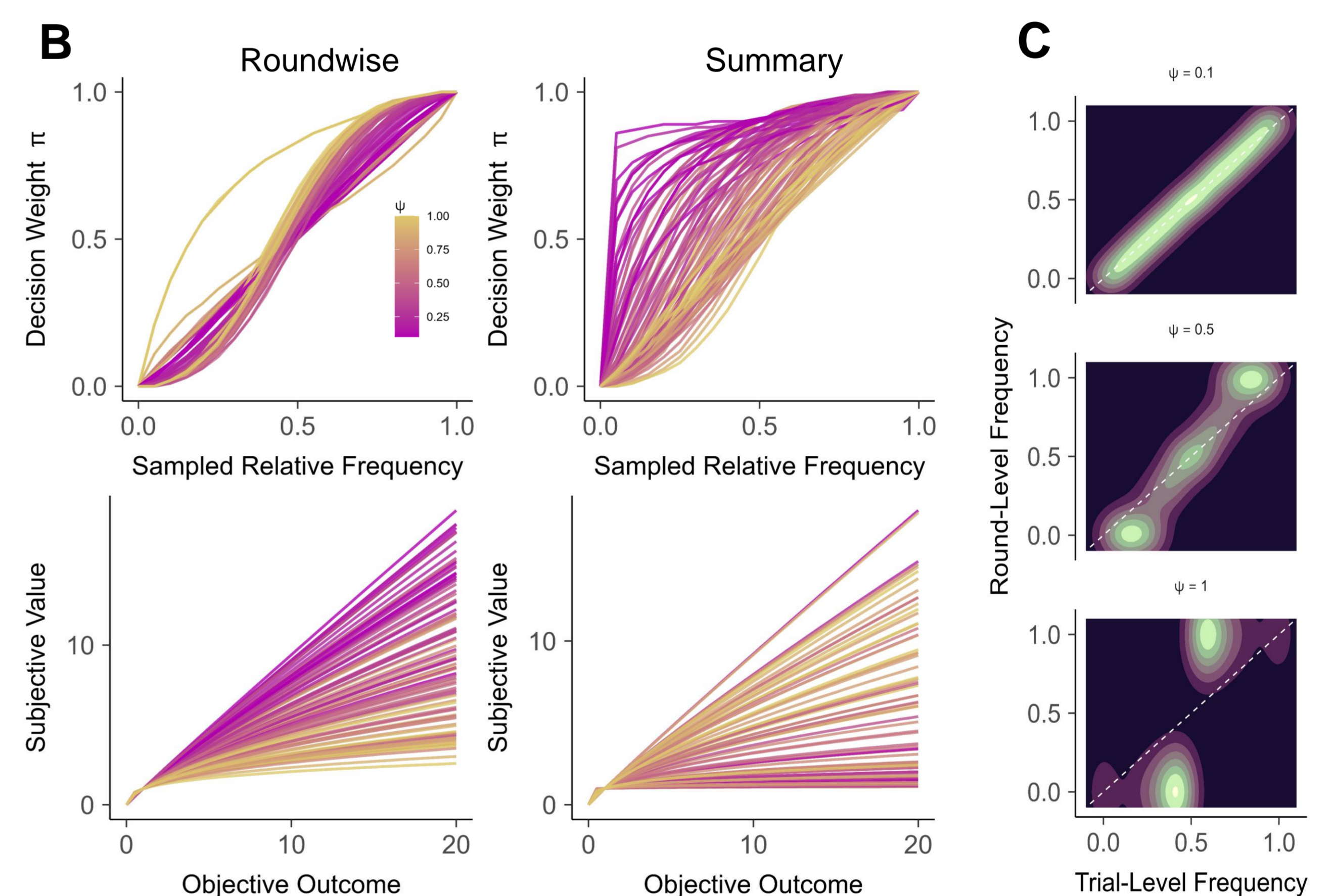
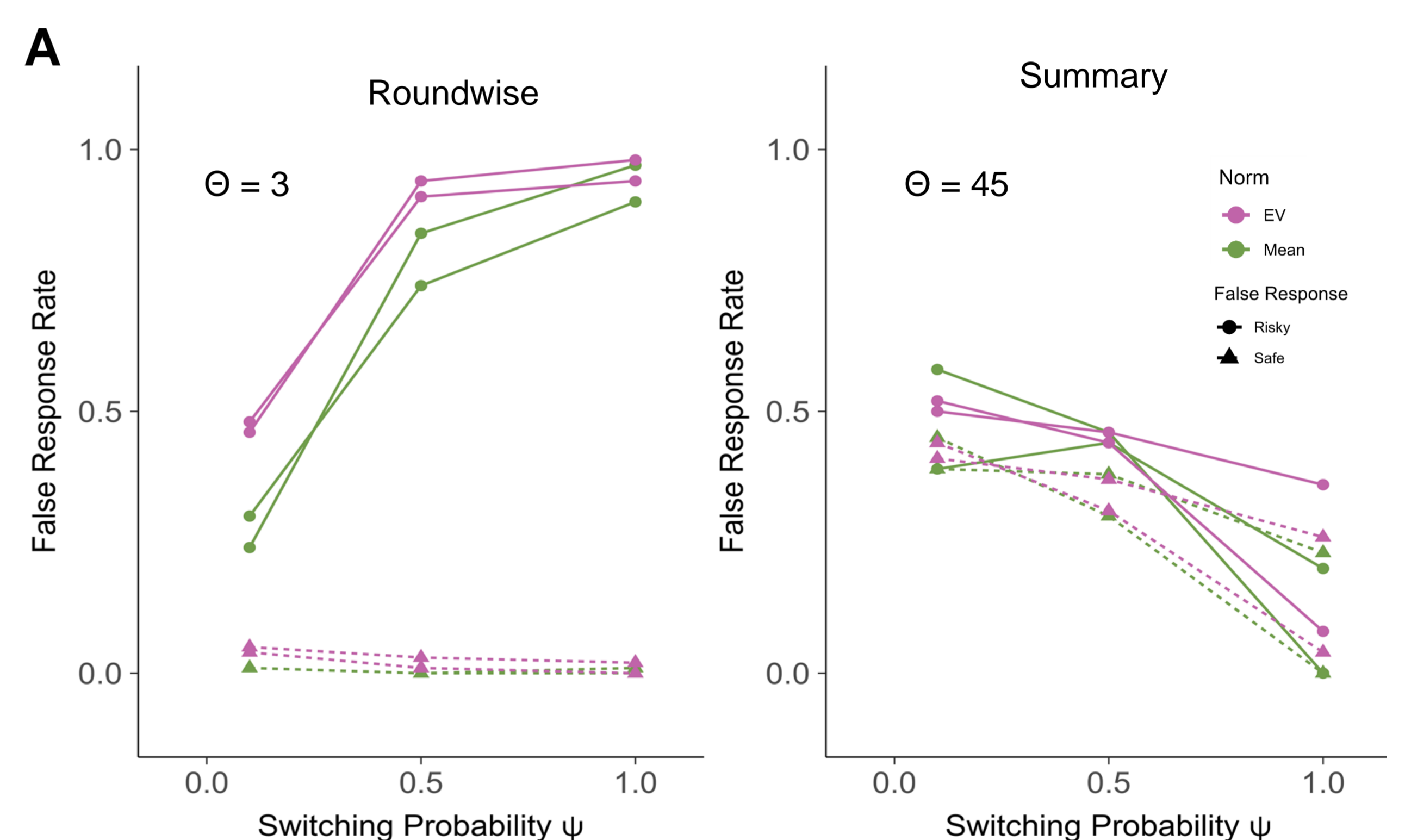


Figure 3. A) Rates of choices that did not maximize the EV or sampled mean (false response rates, FRR): In the roundwise model, increasing switching probabilities lead to higher FRRs. The opposite effect is observed in the summary model. Data stems from choice problems that included a safe gamble and a gamble with a rare unattractive outcome. B) Estimated graphs of CPT's weighting function (top) and value function (bottom): In the roundwise model, increasing switching probabilities lead to a S-shaped weighting function and a more compressed (concave) value function. In the summary model, both the weighting and value function become more linear with increasing switching probabilities. C) Density plot of the sampled relative frequencies of small-probability outcomes within roundwise model decision trials: With increasing switching probabilities, small-probability outcomes are not considered in the majority of comparison rounds, i.e., the round-level frequencies are lower than the trial-level frequencies. This underrepresentation of small-probability is the major cause for the roundwise model's choice patterns and psychoeconomic functions in A) and B).

Conclusion

Our models illustrate how decision makers might approach uncertain choices where economic optimization is out of reach.

The combination of simple cognitive sampling and integration strategies can produce complex choice patterns that are commonly observed in situations of uncertain choice.