Journal Club

A Cognitive Foundation for Perceiving Uncertainty

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Introduction

Paper

Bohren, J. A., Hascher, J., Imas, A., Ungeheuer, M., & Weber, M. (2024). **A Cognitive Foundation for Perceiving Uncertainty** (w32149; p. w32149). National Bureau of Economic Research. https://doi.org/10.3386/w32149

1. Research Question
2. Conceptual Framework
3. Experimental Design
4. Results
5. Discussion

Research Question

What is the cognitive foundation of perceiving uncertainty?

↓

How do cognitive constraints change people's perception of uncertainty in financial or economic decision making?

Conceptual FW I: Setup

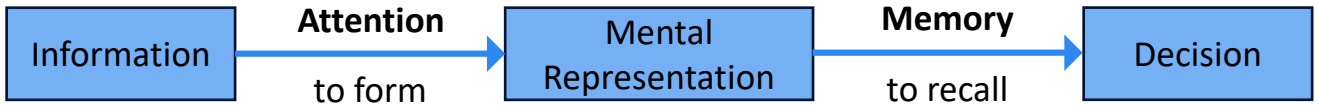
Setup

- A world with state space S where each state s occurs with a probability of π_s
- An assets A_i yields an outcome x_s^i for each state s $\in S$
- DM has a subjective value (utility) function $v(\cdot)$ for a given outcome

Rational DM: Expected Utility Theory

$$V^R(A^i) = \sum_{s \in S} \left(\pi_s * v\left(x_s^i\right)\right)$$

Cognitive Constraints



Conceptual FW II: Cognitive Constraints

DM with distorted attention & imperfect memory

$$V(A^i) = \sum_{s \in S} \left(\hat{\pi}_s * v(\chi_s^i) \right)$$

Attention

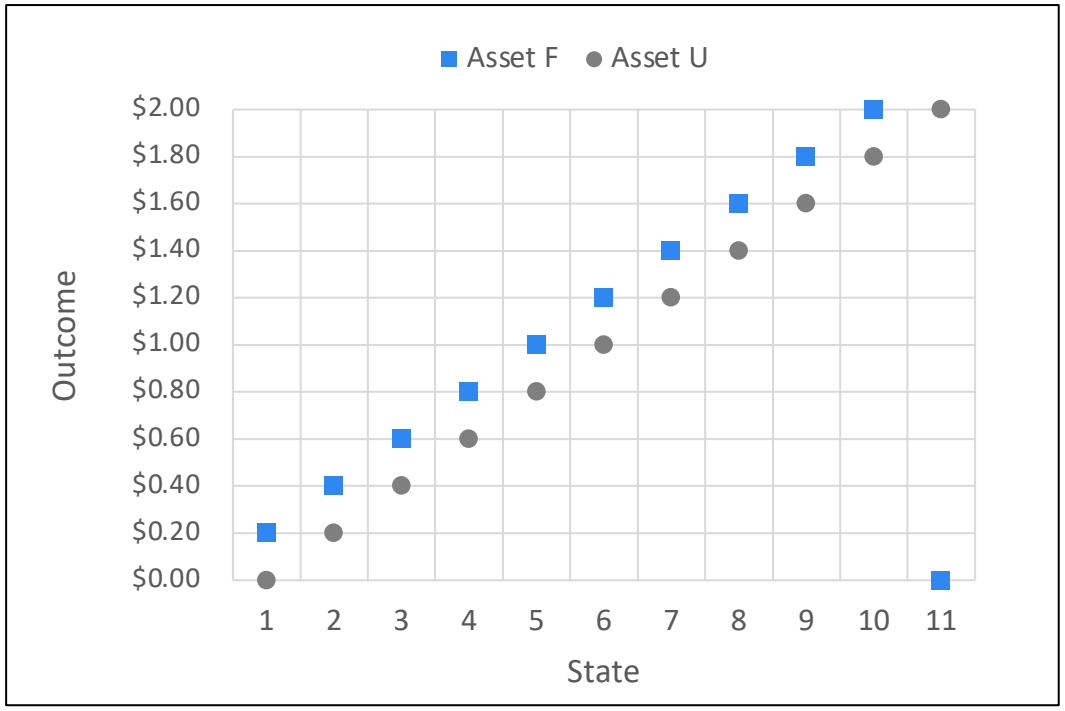
- Salient states attract more attention
- People tend to overweight the probability of salient states
- Weighted (perceived) probability: $\hat{\pi}_s = \omega_s \cdot \pi_s = \left(\delta^{k_s} \cdot \pi_s\right) / \left(\sum_{s' \in S} \delta^{k_{s'}} \cdot \pi_{s'}\right)$
  - $\delta \in (0,1]$, and k_s is the salience ranking of state s

Memory

- Similar states can lead to misremembering
- People tend to incorrectly recall the outcome of similar states
- Remembered outcome: $\chi_s^i = \begin{cases} x_s^i, & \text{with prob. } r(x_s^i) \\ \mu(x_s^i), & \text{with prob. } 1 - r(x_s^i) \end{cases}$
  - $r(x_s^i)$: a function of similarity (1) within asset and across states, (2) within a state but across assets
  - $\mu(x_s^i)$: mean of the most similar outcomes

Experiment Design I: Task

Asset F	Asset U
With state-dependent outcomes	
Exactly the same distribution, including mean and median	
Frequently outperform U, with marginal difference	Unfrequently outperform F, by a significant difference



Learn

- Two environments
  - Simultaneous learning
  - Sequential learning

Choice

- Choose one from assets F and U

Belief

- State belief about asset outcomes
  - For each asset
    - Average (expected) outcome $__
    - __% outcome < $1
    - __% outcome = $1
    - __% outcome > $1
  - __% F's outcome is > U
  - __% F's outcome is < U
  - __% F's outcome is = U

Experiment Design II: Treatments

Simultaneous Information
(D1) Baseline
(D2) No Salience Bias

D1

D2

Sequential Information
(E1) Baseline
(E2) No Recall Bias
(E3) Minimal Requirement
(E4.1) Interference (F)
(E4.2) Interference (U)

E1

E2

E3

E4.1

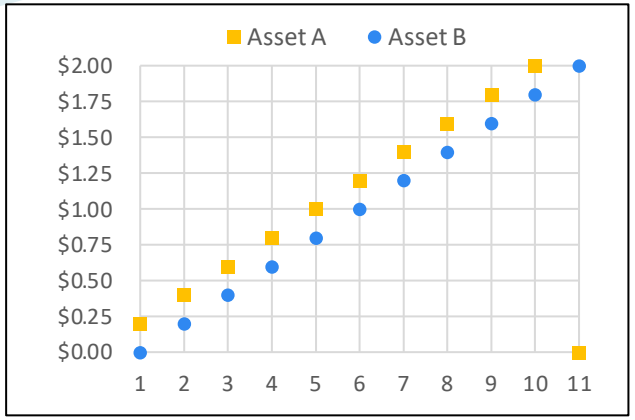
E4.2

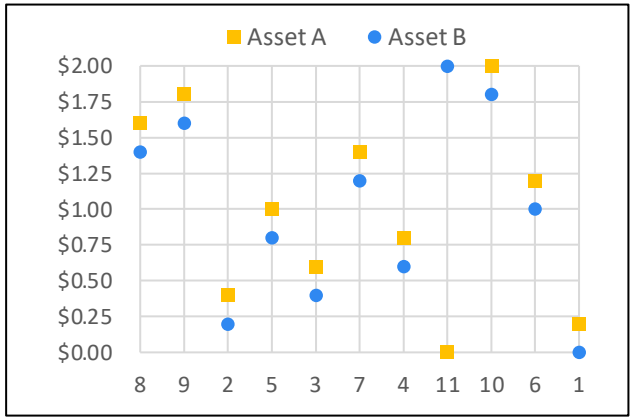
Experiment Design II: Treatments

Simultaneous Information

(D1) Baseline

(D2) No Salience Bias





Sequential Information

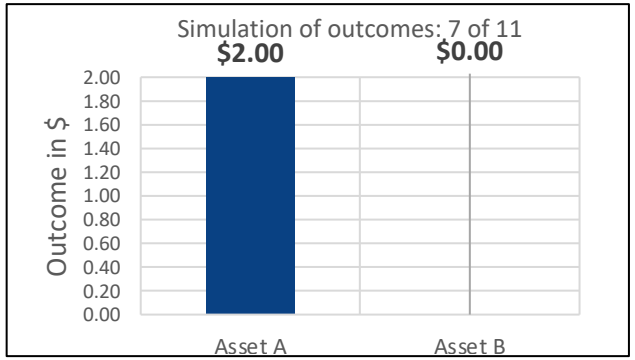
(E1) Baseline

(E2) No Recall Bias

(E3) Minimal Requirement

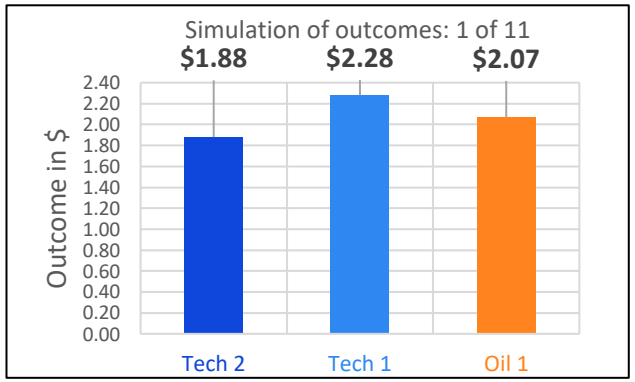
(E4.1) Interference (F)

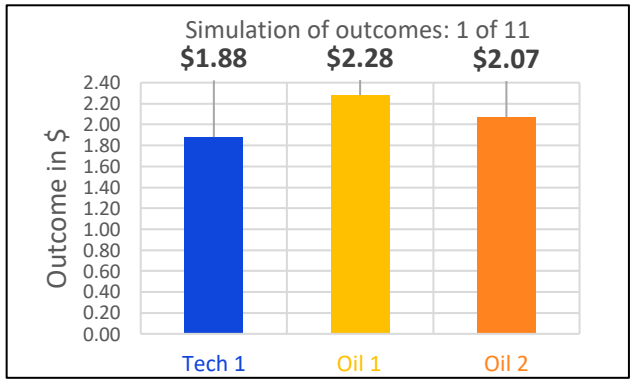
(E4.2) Interference (U)



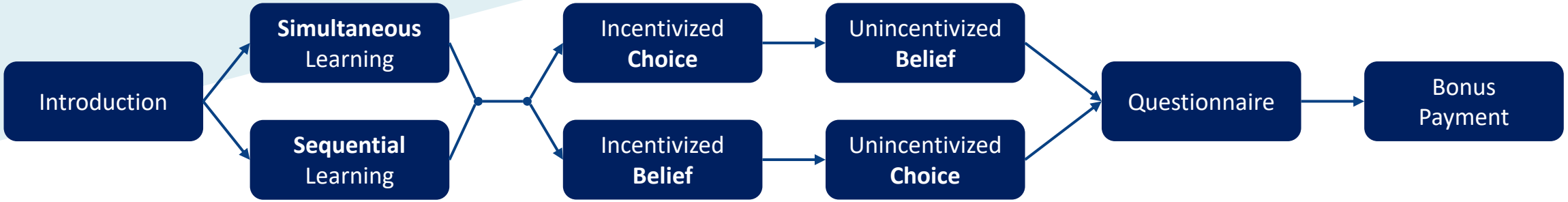
- Have pen and paper (etc.) ready
- Write down outcomes during the sequential sampling
- Incentivized with a potential bonus payment for correctly responding to a quiz at the end of round

- Reduce number of states from 11 to 3
- In 2 states, asset F “frequently” outperforms asset U by $1 (small)
- In 1 state, asset U “unfrequently” outperforms asset U by $2 (large)





Experiment Design III: Procedure



Participants

- 785 Baseline + 600 Manipulation
- All investors from US or UK, on Prolific
- Baseline Composition
  - Gender: 50% Female
  - Age: mean=38.68, median=36
  - Willingness to take risks: mean=3.23
- Manipulation Composition
  - Gender: 50% Female
  - Age: mean=37.00, median=34
  - Willingness to take risks: mean=3.31

Simultaneous Information	
(D1) Baseline	381
(D2) No Salience Bias	100
Sequential Information	
(E1) Baseline	404
(E2) No Recall Bias	100
(E3) Minimal Requirement	99
(E4.1) Interference (F)	102
(E4.2) Interference (U)	99

Incentives

- Base fee to make sure > $13 per hour
- Choice:
  - An outcome is randomly drawn from the distribution of selected asset and paid
  - $0-2, with an increment of $0.20
- Belief
  - One stated belief is randomly selected
  - $2 bonus, if within +-0.03 of the statistically correct value

Results I: Predictions

Prediction 1: salience-distorted attention → DM prefers U to F

- If DM's attention is attracted by salient state where asset U largely outperforms F,
- DM will overweight the salient state and be more likely to select U than F

Prediction 2: imperfect memory → DM prefers F to U

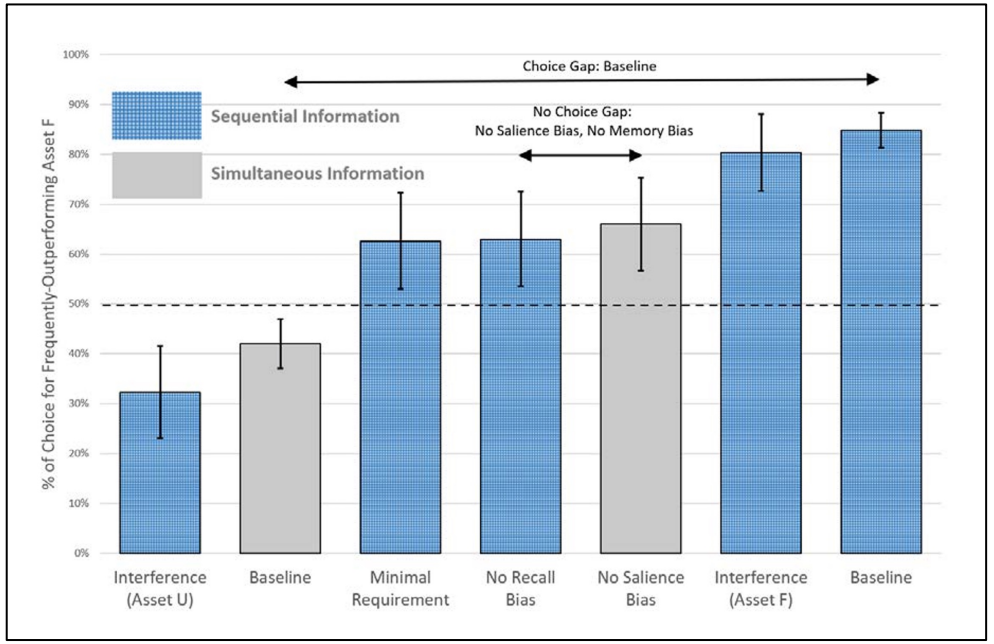
- If DM' memory doesn't allow them to perfect recall all states and outcomes,
- DM will be likely to forget the infrequent state where asset U outperforms F
- DM will be likely to select F than U due to its frequent outperforming the other

Prediction 3: imperfect memory + dominant decoy → DM prefers the more similar asset

- If there is a decoy asset D that consistently outperforms both asset F and U,
- If D is similar to F, then DM will be more likely to misremember F's outcomes by recalling D's and thus select F than U
- If D is similar to U, then DM will be more likely to misremember U's outcomes by recalling D's and thus select U than F

Results II: Choice

	Choice		Diff. vs. 50/50	Manipulation	Effect Direction
	Asset F	Asset U			
Simultaneous Information					
(D1) Baseline	42%	58%	-8%***	+ salience	U
(D2) No Salience Bias	66%	34%	16%***	- salience	F
Sequential Information					
(E1) Baseline	85%	15%	35%***	+ misremember	F
(E2) No Recall Bias	63%	37%	13%***	- misremember	U
(E3) Minimal Requirement	62%	38%	12%***	- misremember	U
(E4.1) Interference (F)	80%	20%	30%***	+ decoy F	F
(E4.2) Interference (U)	32%	68%	-18%***	+ decoy U	U



Results III: Belief

	Avg. Outcome			Prob. Outcome < or > $1					Manipulation	Effect Direction
	Asset F	Asset U	Diff.	Asset F<	Asset F>	Asset U<	Asset U>	DID		
Simultaneous Information										
(D1) Baseline	$1.00	$1.07	-$0.07***	44.27%	41.35%	39.09%	42.63%	6.46%***	+ salience	U
(D2) No Salience Bias	$1.09	$1.06	$0.03	42.39%	41.58%	41.71%	44.16%	3.26%	- salience	F
Sequential Information										
(E1) Baseline	$1.17	> $1.00	$0.16***	38.24%	< 50.76%	48.40%	> 35.04%	-25.87%***	+ misremember	F
(E2) No Recall Bias	$1.08	$1.08	$0.00	40.55%	41.02%	38.08%	37.87%	-0.68%	- misremember	U
(E3) Minimal Requirement	$1.25	$1.09	$0.16***	31.83%	37.42%	35.87%	32.08%	-9.39%**	- misremember	U
(E4.1) Interference (F)	$1.38	$0.99	$0.38***	37.38%	57.70%	47.98%	28.83%	-39.47%***	+ decoy F	F
(E4.2) Interference (U)	$1.08	$1.20	-$0.12***	49.67%	43.48%	34.88%	42.35%	13.66%**	+ decoy U	U

Discussion

1. Well-designed experiment
   - Exactly the same outcome distribution → rule out probability weighting (prospect theory)
   - Same information across learning environment → rule out sampling error
   - Explicit manipulation over factors of interest → test the proposed mechanism

2. Problems?
   - Participants were all “investors”, (and they were all from US or UK) – past experience, etc.
   - The incentive mechanism did not fully mimic real investing i.e. endowment in account, risk of loss etc.
   - …

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