Investor Memory and Biased Beliefs: Evidence from the Field

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  2. biased beliefs affect choice across many decision domains
     - individual trading, corporate investment, bank loans, ...
     - asset prices and the macroeconomy
- The underlying sources of biased beliefs are less well understood
  - psychological flaws, bounded rationality, informational frictions, ...

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  - additional lab evidence from economic settings (Enke et al., 2020; Bordalo et al., 2022b; Graeber et al., 2022)

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- But, there have been few studies that directly test this mechanism using field data

This paper

- We survey a nationally representative sample of $\sim 17K$ Chinese individual investors
  - two types of recall
    1. a market episode that first comes to mind: free recall
    2. own performance during pre-specific periods in the past: probed recall
  - investor expectations and other individual information
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- We use elicited recalls to document stylized facts about investor memory and the relationship between memory and beliefs.
- Our setting is different from those in existing studies
  1. **sample pool**: retail investors (some of which are rather affluent)
  2. **decision domain**: high-stake (trading of stocks)
  3. **cue**: market-based cues such as return
  4. **rational benchmark**: direct observations of actual trading records

Main results

We present and test a model of belief formation based on cued recall (Bordalo et al., 2022a)

1. *Recall*: present cues trigger recall of past experiences
2. *Simulation*: use retrieved experiences to make forecasts

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1. Market fluctuations affect investors' recall process
   - when recent returns have been high, investors tend to
     - think of episodes of a rising market
     - recall ther own past performances more positively
   - cued recall is stronger for more recent experiences

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1. Market fluctuations affect investors' recall process
2. Investors use retrieved memories to form expectations
   - a positive and robust relationship between memory and expected future returns.
   - recalled own return ≈ individual characteristics (including demographics) in their explanatory power for return expectations

Main results

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1. Market fluctuations affect investors' recall process
2. Investors use retrieved memories to form expectations
3. Cued recall *can* microfound return extrapolation
   - return extrapolation: good returns → optimistic expectations
   - cued recall: good returns → positive recalls → optimistic expectations
   - controlling for recalls drives out the positive correlation between recent returns and expectations
   - rule in a memory-based microfoundation for return extrapolation

A Conceptual Framework

Model setup

- In period T, an investor makes forecasts about the next period's market return, r_{T+1}, in two steps:
  1. *recall*: retrieve past experiences
  2. *simulation*: use retrieved experiences to forecast the future

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  - r_t consists of a continuum of numbers
- Assume that r_t is normally distributed: $r_t \sim N(\mu_t, \sigma_t^2)$
  - objective description of past experiences: in period t, she experienced a market return of x with probability $f_t(x)$

Cued recall

No cue

- Recall means taking random draws according to the original PDF f_t

With cue

- An external stimulus, q_T, affects recall according to the rule of similarity: experiences with attributes similar to q_T are more likely to be recalled

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With cue

- An external stimulus, q_T, affects recall according to the rule of similarity: experiences with attributes similar to q_T are more likely to be recalled
- Specifically:

$$f^*(r_t; q_T) = f_t(r_t) \times \frac{s(r_t, q_T)}{\int_{-\infty}^{+\infty} f(z) \times s(z, q_T) dz}$$

where $s(r_t, q_T)$ denotes the similarity between cue q_T and experience r_t

When $q_T = r_T$

- Assume that

$$s(r_t, r_T) = \exp\left(-\frac{(r_t - r_T)^2}{2\tau\sigma_\epsilon^2}\right)$$

  - $\tau = T - t$ is the time elapsed since the experienced return
  - σ_ϵ is the perceived relevance of the cue

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- Recalled returns follows a “cued” normal distribution

$$r_t | r_T \sim N((1-\alpha)\mu_t + \alpha r_T, \sigma_q^2)$$

where

$$\alpha = \frac{\sigma_t^2}{\sigma_t^2 + \tau\sigma_\epsilon^2}$$

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where

$$\alpha = \frac{\sigma_t^2}{\sigma_t^2 + \tau\sigma_\epsilon^2}$$

- This is equivalent to the investor using the current return r_T as a signal to infer r_t in a Bayesian fashion, by assuming that $r_T = r_t + \epsilon_\tau$

Model results: recall

Hypothesis 1. *(Cued recall) The mean of recalled returns,* $\mathbb{E}[r_t|r_T] = (1-\alpha)\mu_t + \alpha r_T$*, increases in today's market return* r_T*.*

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Hypothesis 2. *(Recency effect) The strength of cued recall, measured by* α*, is decreasing in* τ*.*

Model results: simulation

Step 2: Simulation

- Assume that her predicted distribution of r_{T+1} is a weighted average of recalled distributions of past experiences:

$$f_{T+1} = \sum_{t=1}^{T-1} w_t f_t^q$$

  - $w_t > 0$ and $\sum_{t=1}^{T-1} w_t = 1$

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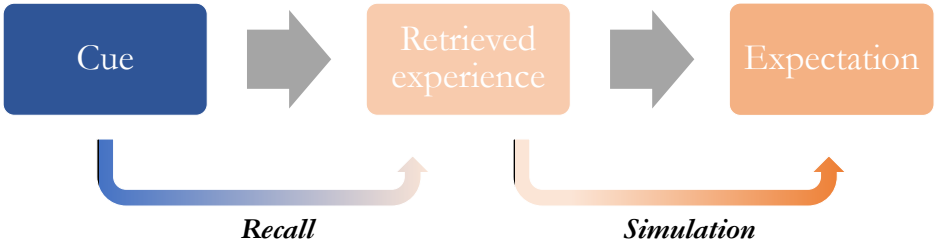
Hypothesis 3. *(Return extrapolation) Expected stock return for period $T+1$, $\mathbb{E}(r_{T+1})$, is increasing in the return cue r_T.*

Cued recall and belief formation



Survey Design

The *FreeRecall* block

FreeRecall

- Capture an episode of market movement that first comes to mind
  - motivated by the well-established experimental paradigm of free recall
- By “free,” we mean minimal guidance and conditions on what periods to be recalled
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  - an investor always starts the survey with this block
- Once an investor starts the block, we ask them to
  - "*first think about the overall stock market movement since you opened an account*"
  - then answer the following questions:
    1. "*What period of market movement first came to your mind?*"
    2. "*How much did the market (Shanghai Composite Index) move during this period?*"

The *ProbedRecall* block

ProbedRecall

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- When an investor starts the block, we ask "*to the best of your recollection, what was the cumulative return rate of your equity investment over*
  1. *last trading day?*"
  2. *last month?*"
  3. *last year (in 2021)?*"
  4. *last five years?*"

The *Expectation* block

Expectation

- We follow the literature on survey expectations and use a standard methodology to measure investor expectations (Greenwood and Shleifer, 2014; Giglio et al., 2021)
  - horizon: 1-month and 1-year
  - about market return or about their own return

Other issues

- At the beginning of the survey, investors are explicitly instructed to use their memory and **not** to check on their phone
  - however, we do not observe if an investor does
  - most investors finish the survey within ten minutes
  - checking their account would lead to an attenuation bias

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- We collect demographics and other information in a standard questionnaire
  - today we will mostly use them as control variables

Survey implementation

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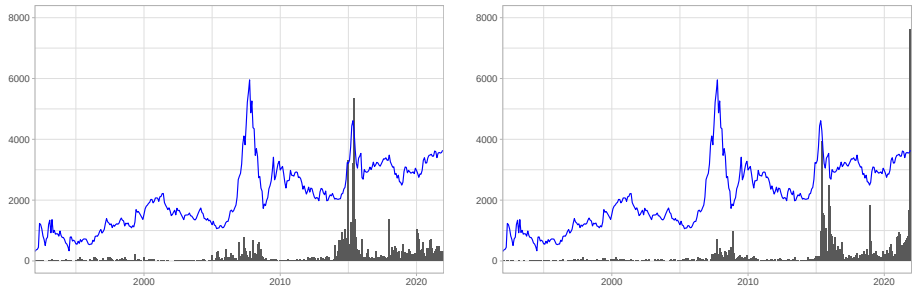
- We collaborated with one of the largest financial institution in China
  - randomized across 30 provinces and regions
- After basic filters, sample size ≈ 17K demo
  - geographic distribution proportional to financial development
  - well-educated, wealthy investor sample
- After merging with transaction data ≈ 5K investors

Stylized Facts

Fact I: Free recall exhibits both recency and salience effects

Figure: Distribution of start and end month



Blue line: Shanghai Composite index
Black bar: recall frequency

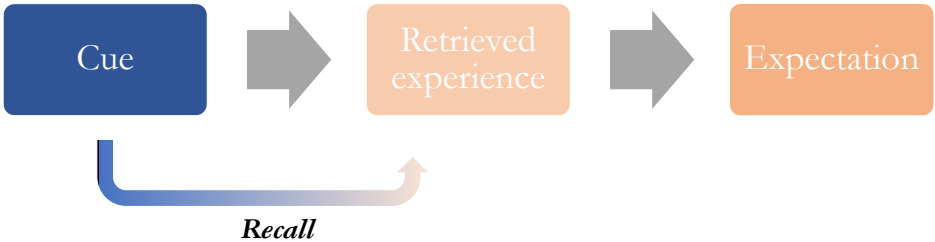
Fact II: recalled returns are highly correlated with actual returns

- In *FreeRecall*, recalled episode return highly correlated with actual episode return ($\rho = 0.53$)
- In *ProbedRecall*, recalled own return highly correlated with actual own return at all horizons ($0.07 < \rho < 0.40$)

Bottom-line

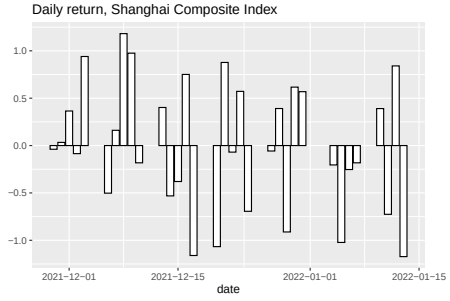
- Respondents are indeed making a conscious effort in recall tasks

Testing the Model


Cue
Retrieved experience
Expectation
Recall

Variation in returns

- The survey spans 6 weeks, during which the market exhibits mild yet still significant movement



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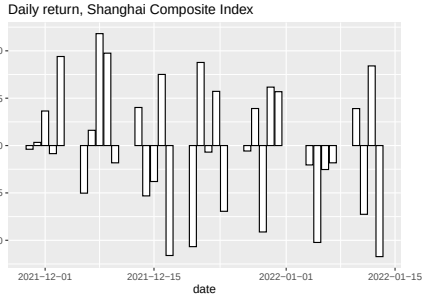

- Within a day, we record the precise time when an investor begins to take the survey
  - intraday movements → different cues
- We also consider portfolio-level return for the merged sample (see paper)

Cued recall in *FreeRecall*: full-sample results

$$\widehat{MktRet}_i^{Free} = \beta_0 + \beta_1 MktRet_{t \to t+t_i} + X_i + \epsilon_i,$$

	Recalled episode return		
	Full		
Market return, today	0.32		−0.21
	(1.35)		(1.49)
Market return, past month		−0.61	−0.57
		(0.53)	(0.58)
Observations	3,443	3,612	3,443
Adjusted R^2	0.01	0.01	0.01

Discussion: results in the full sample

Possible reasons

1. Recalled episodes in *FreeRecall* often capture dramatic events featuring large swings in asset prices
   - retrieving such events may require more dramatic cues
   - in a follow-up project, we ran a similar survey during more turbulent market periods and find stronger evidence of cued recall details

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   - consistent with Hypothesis 2
   - *temporal contiguity*: experiences that occur close together in time are associated to each other

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- We consider the subsample of investors recalling more recent episodes in *FreeRecall*

Cued recall in *FreeRecall*: subsample of recent recalls

$$\widehat{MktRet}_i^{Free} = \beta_0 + \beta_1 MktRet_{t \to t+t_i} + X_i + \epsilon_i,$$

	Recalled episode return		
	Recalled episode: within last 5 years		
Market return, today	2.08*		3.27***
	(1.21)		(1.16)
Market return, past month		0.86***	1.36***
		(0.41)	(0.44)
Observations	880	916	880
Adjusted R^2	0.02	0.02	0.03

- 1 pp ↑ in today's market return → 2.1 to 3.3 pp ↑ in recalled episode return

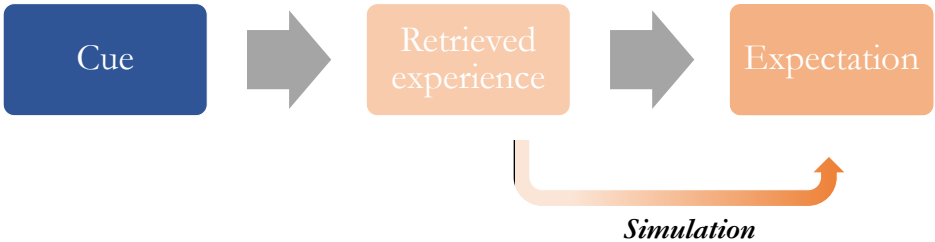
Cued recall in *ProbedRecall*

- We conduct a similar exercise for recalled own returns in *ProbedRecall*

$$\widehat{OwnRet}^{Probed}_{i,t-h\to t} = \beta_0 + \beta_1 MktRet_{t\to t+t_i} + X_i + \epsilon_i$$

	Recalled own return			
	Yesterday		Past month	
	(1)	(2)	(3)	(4)
Market return, today	0.68**	0.94**	0.99***	1.02**
	(0.28)	(0.31)	(0.37)	(0.47)
Actual own return, yesterday		0.27***		
		(0.09)		
Actual own return, past month				0.21***
				(0.02)
Observations	7,746	1,619	7,436	1,668
Adjusted R^2	0.03	0.03	0.04	0.10

- Today's market return affects recall of past own return up to a month ago


Cue
Retrieved experience
Expectation
Simulation

Recall and expectations in *FreeRecall*

- We examine how investors use retrieved experiences in their forecasts

$$\mathbb{E}_i[Ret_{t\to t+h}] = \beta_0 + \beta_1 \widehat{MktRet}_i^{Free} + X_i + \epsilon_i$$

	Expected return			
	Market return, 1M	Market return, 1Y	Own return, 1M	Own return, 1Y
	(1)	(2)	(3)	(4)
Recalled episode return	0.004**	0.02***	0.01**	0.05***
	(0.002)	(0.004)	(0.004)	(0.01)
Observations	3,968	3,864	2,805	2,952
Adjusted R^2	0.01	0.05	0.04	0.07

- a one-standard-deviation increase in the recalled episode return
  - 0.8% increase in expected market return next year
  - 1.6% increase in expected own return next year

Recall and expectations in *ProbedRecall*

$$\mathbb{E}_i[Ret_{t\to t+h}] \quad = \quad \beta_0 + \beta_1 \widehat{OwnRet}^{Probed}_{i,t-h\to t} + X_i + \epsilon_i$$

	Dependent variable:					
	Market return, 1M			Market return, 1Y		
	(1)	(2)	(3)	(4)	(5)	(6)
Recalled own return, 1M	0.08***		0.07***	0.11***		0.07***
	(0.01)		(0.01)	(0.02)		(0.02)
Recalled own return, 1Y		0.03***	0.01***		0.07***	0.05***
		(0.003)	(0.004)		(0.01)	(0.01)
Observations	8,000	8,312	6,567	7,759	8,123	6,415
Adjusted R^2	0.04	0.03	0.04	0.05	0.06	0.06

- a one-standard-deviation increase in the recalled own return
  - 0.9% increase in expected market return next year
  - 5.5% increase in expected own return next year

Additional properties

- Simulation exhibits horizon-dependence.
- Subjective recalled experience dominate objective actual experience in explaining expected future returns.
- A single variable based on recalled own return has similar explanatory power, measured by R-squared, than that of an

Discussion: alternative explanations

- We obtain very similar relationships between memories and forecast errors
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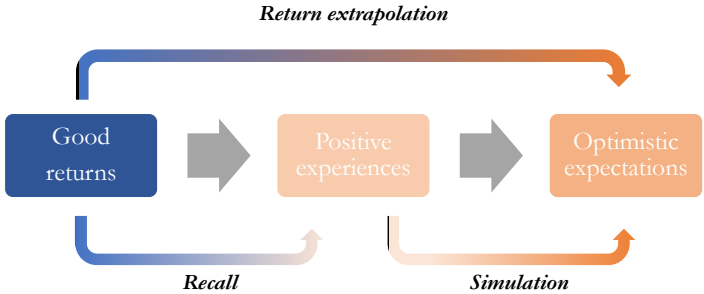
Discussion: alternative explanations

- We obtain very similar relationships between memories and forecast errors
  - memory does not only drive return expectations themselves, but also contribute to forecast errors at the individual level
- We do not claim causality
  - but the strong and robust correlation between memories and beliefs is highly suggestive of a memory-based channel of belief-formation
- We discuss several alternative explanations
  1. anchor effects ⏩ details
  2. click-through behavior ⏩ details
  3. motivated beliefs ⏩ details
  4. external validity ⏩ details

Cued recall and return extrapolation



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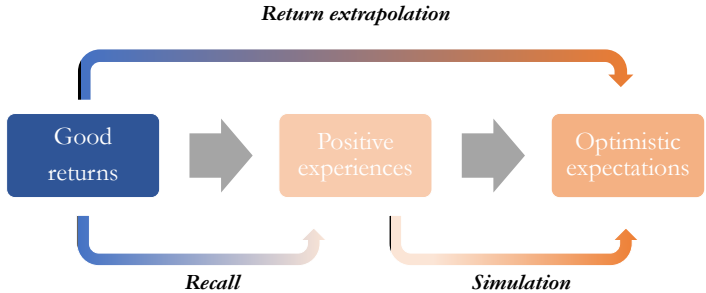

- *Key implication*: Controlling for memories should weaken or eliminate the positive correlation between past returns and expectations

Cued recall and return extrapolation, regressions

	Dependent variable:		
	Expected market return, 1M		
	(1)	(2)	(3)
Past market return, 1M	0.14^{**}	0.10^{*}	0.09
	(0.06)	(0.06)	(0.06)
Recalled own return, 1M		0.08^{***}	0.07^{***}
		(0.01)	(0.01)
Recalled own return, 1Y			0.01^{***}
			(0.004)
Observations	7,842	7,842	6,436
Adjusted R^2	0.02	0.04	0.04

Cued recall and return extrapolation, regressions

	Dependent variable:		
	Expected own return, 1M		
	(4)	(5)	(6)
Past market return, 1M	0.21***	0.09	0.06
	(0.07)	(0.06)	(0.08)
Recalled own return, 1M		0.30***	0.21***
		(0.02)	(0.02)
Recalled own return, 1Y			0.11***
			(0.01)
Observations	6,554	6,554	5,516
Adjusted R^2	0.05	0.11	0.14

Conclusion

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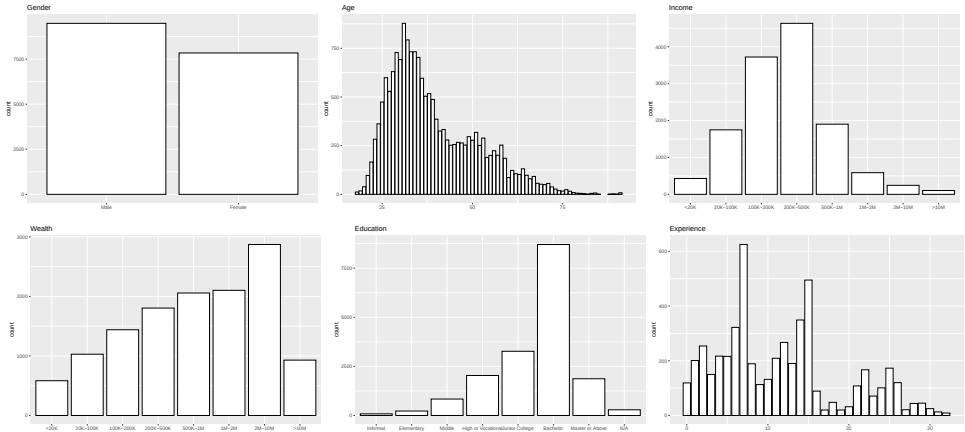
- There are growing interests in understanding the role of memory in driving beliefs and choices
- We contribute to this literature by bringing new evidence from the field
  - survey a large representative sample of retail investors to elicit their memories
  - merging the survey data with administrative data of transactions
- Main takeaways:
  1. what's on the mind of an investor is heavily influenced by what is going on in the market
  2. past experiences emerge at a given moment do affect belief formation
  3. return extrapolation can be microfounded by cued recall

Thank you!

Demographics of the investor sample

Figure: Distribution of demographic variables



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Distribution of recalled episodes in *FreeRecall* for experienced investors

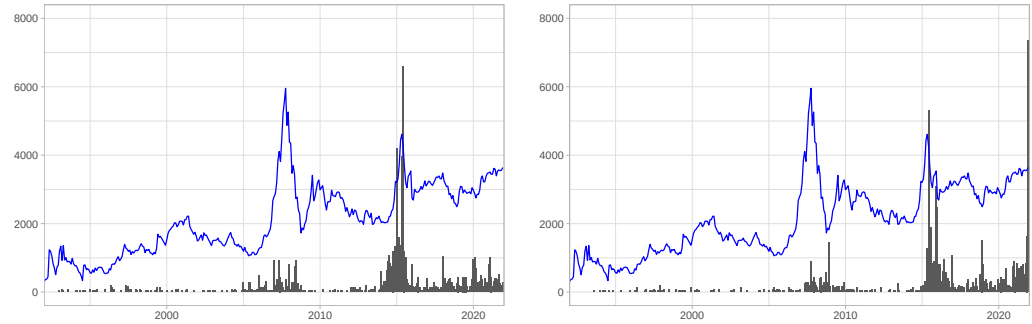

Figure: Distribution of start and end dates

back

Distribution of recalled episodes in *FreeRecall* for younger and older investors

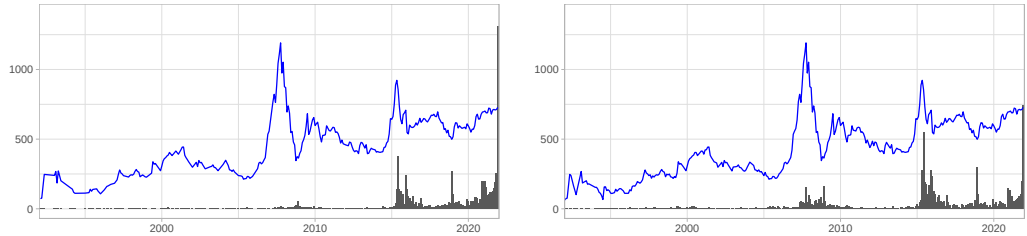

Figure: Distribution of end dates for younger and older investors

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Distribution of recalled episodes in *FreeRecall* under alternative phrasing

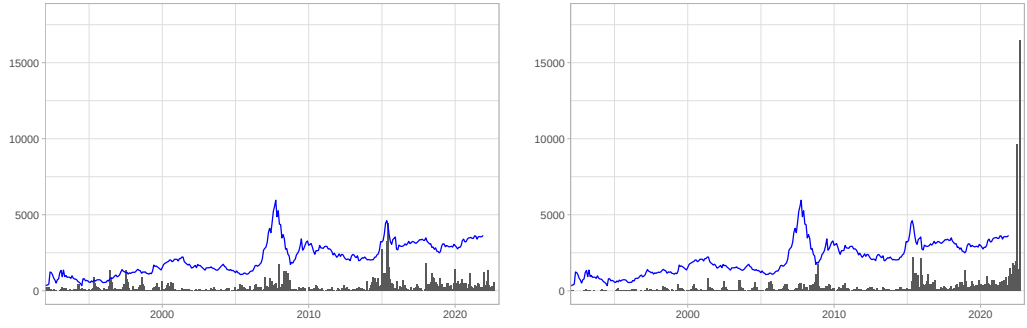
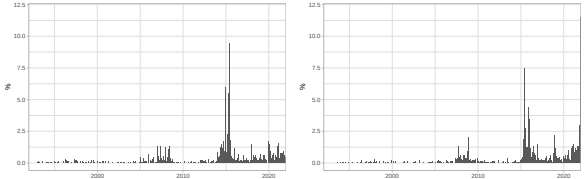


Figure: Distribution of start and end dates

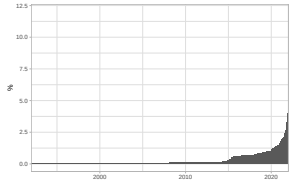
back

Distribution of recalled episodes in *FreeRecall* against counterfactual

Distribution of start and end dates



Counterfactual



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Distribution of actual episode returns and recall bias

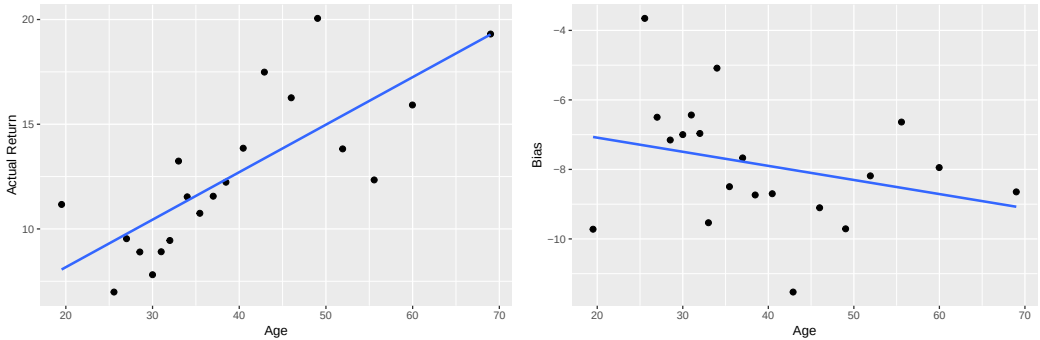

Figure: Distribution of actual episode return and recall bias

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Model details

- One particular formulation of the return-cued PDF is by assuming that the current return, r_t, is a noisy signal of recalled return in the simulation process:

$$r_t = r_t + \epsilon\sqrt{t-t} = r_t + \epsilon_{t,t}$$

where ϵ is normally distributed $\epsilon \sim N(0, \sigma_\epsilon^2)$

- The cued PDF of simulated returns is the conditional distribution of $r_t | r_t$, given by

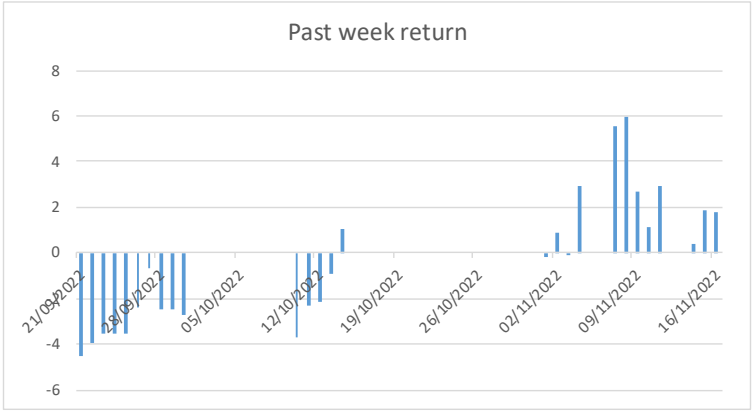
$$r_t | r_t \sim N\left(\frac{\sigma_\epsilon^2(t-t)}{\sigma_t^2 + \sigma_\epsilon^2(t-t)}\mu_t + \frac{\sigma_t^2}{\sigma_t^2 + \sigma_\epsilon^2(t-t)} r_t, \frac{(t-t)\sigma_t^2\sigma_\epsilon^2}{\sigma_t^2 + \sigma_\epsilon^2(t-t)}\right)$$

- This is when s^* takes the following form:

$$s^*(r_t, r_t) = \frac{\sigma_t}{\sigma_q} \exp\left(-\frac{1}{2}\frac{(r_t - r_t)^2}{(t-t)\sigma_\epsilon^2} + \frac{(\mu - r_t)^2}{2(\sigma^2 + (t-t)\sigma_\epsilon^2)}\right)$$

where $\sigma_q^2 = \frac{(t-t)\sigma_t^2\sigma_\epsilon^2}{\sigma_t^2 + (t-t)\sigma_\epsilon^2}$ back

Follow up: market conditions



Follow up: cued recall

$$\widehat{MktRet}_i^{Free} = \beta_0 + \beta_1 MktRet_{t \to t+t_i} + X_i + \epsilon_i,$$

	recalled episode return			
	Full		Less experienced	
	(1)	(2)	(3)	(4)
Market return, past week	0.780***		1.361***	
	(0.265)		(0.390)	
Market return, past month		0.957***		1.402***
		(0.220)		(0.295)
Observations	9,758	9,758	4,619	4,619
Adjusted R^2	0.04	0.04	0.03	0.03

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Anchor effects

Table: Relationship between recall and expectation as a function of time spent on the survey

	Dependent variable: Expected return			
	Market 30 day	Market 1 year	Own 30 day	Own 1 year
	(1)	(2)	(3)	(4)
Recalled own return, 1M	0.08***		0.32***	
	(0.01)		(0.01)	
Recalled own return, 1M * Time spent	−0.0002		−0.0001	
	(0.001)		(0.001)	
Recalled own return, 1Y		0.07***		0.44***
		(0.01)		(0.03)
Recalled own return, 1Y * Time spent		−0.0003		−0.002
		(0.001)		(0.001)
Time spent	0.001	0.01	0.01*	0.02**
	(0.003)	(0.01)	(0.01)	(0.01)
Observations	6,077	6,199	5,090	5,508
R^2	0.12	0.14	0.21	0.21

Anchor effects, cont'd

Table: Recalled return and expectations across treatments

		Recalled own return			
	Recalled episode return	Yesterday	Last month	Last year	Last five years
	(1)	(2)	(3)	(4)	(5)
FreeRecall	0.05	0.00	0.00	0.02	0.05
HappyRecall	0.23	0.00	0.00	0.02	0.05
PainfulRecall	−0.20	−0.01	0.00	0.02	0.03

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Click-through behavior

Table: Recall and perceived crash probability

	Dependent variable: Expected crash probability			
	One month		One year	
	(1)	(2)	(3)	(4)
Recalled own return, 1M	-0.10^{***}		-0.07^{***}	
	(0.02)		(0.01)	
Recalled own return, 1Y		-0.06^{***}		-0.04^{***}
		(0.01)		(0.01)
Observations	7,317	7,712	7,297	7,698
R^2	0.09	0.09	0.10	0.10

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Motivated beliefs

Table: Past actions and future recall

	Dependent variable: Recalled own return							
	Yesterday					Past month		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Holding change, yesterday	−0.02	−0.01			−0.001	0.002		
	(0.02)	(0.02)			(0.02)	(0.02)		
Holding change, previous week			−0.005	−0.002			−0.004	−0.001
			(0.01)	(0.01)			(0.01)	(0.01)
Actual own return, yesterday		0.35***		0.36***				
		(0.07)		(0.08)				
Actual own return, past month						0.22***		0.23***
						(0.02)		(0.02)
Observations	1,869	1,869	1,874	1,836	1,808	1,808	1,813	1,813
Adjusted R2	0.03	0.05	0.03	0.04	0.03	0.10	0.03	0.10

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External validity

Table: Expectations and future actions

	Dependent variable: Holding change					
	Previous week	Today	Following week	Previous week	Today	Following week
	(1)	(2)	(3)	(4)	(5)	(6)
Expected own return, 1M	−0.22	0.10**	0.28**	−0.40***	0.14**	0.48***
	(0.14)	(0.05)	(0.13)	(0.13)	(0.05)	(0.15)
Expected own return, 1Y	0.02	−0.03**	−0.07	0.03	−0.03	−0.10*
	(0.05)	(0.01)	(0.05)	(0.05)	(0.02)	(0.05)
Expected market return, 1M				−0.12	−0.09	−0.3
				(0.11)	(0.07)	(0.32)
Expected market return, 1Y				0.24	0.02	−0.08
				(0.22)	(0.06)	(0.17)
Observations	1,379	1,378	1,378	1,133	1,135	1,135
Adjusted R2	0.01	0.01	0.003	0.01	0.02	0.001

References

Bordalo, P., Burro, G., Coffman, K., Gennaioli, N., and Shleifer, A. (2022a). Imagining the future: memory, simulation and beliefs about covid. *Working paper*.

Bordalo, P., Conlon, J. J., Gennaioli, N., Kwon, S. Y., and Shleifer, A. (2022b). Memory and probability. Technical report.

Enke, B., Schwerter, F., and Zimmermann, F. (2020). Associative memory and belief formation. Technical report.

Giglio, S., Maggiori, M., Stroebel, J., and Utkus, S. (2021). Five facts about beliefs and portfolios. *American Economic Review*, 111(5):1481–1522.

Graeber, T., Zimmermann, F., and Roth, C. (2022). Stories, statistics, and memory. *Working paper*.

Greenwood, R. and Shleifer, A. (2014). Expectations of returns and expected returns. *The Review of Financial Studies*, 27(3):714–746.

Kahana, M. J. (2012). *Foundations of human memory*. OUP USA.

Wachter, J. A. and Kahana, M. J. (2021). A retrieved-context theory of financial decisions. Technical report.