Information Partitioning, Learning, and Beliefs

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Motivation

- Individuals and information providers decide how much information to consume / present at a time
  - Observe large batches of information infrequently

    $\rightarrow$ update beliefs once
  - Observe small batches of information at higher frequency

    $\rightarrow$ update beliefs multiple times

$\Rightarrow$ Does information partitioning (i.e., grouping individual information signals into sets) affect learning and beliefs?

- Not for a Bayesian agent
- But for any non-Bayesian updating rule $\rightarrow$ humans

Motivation

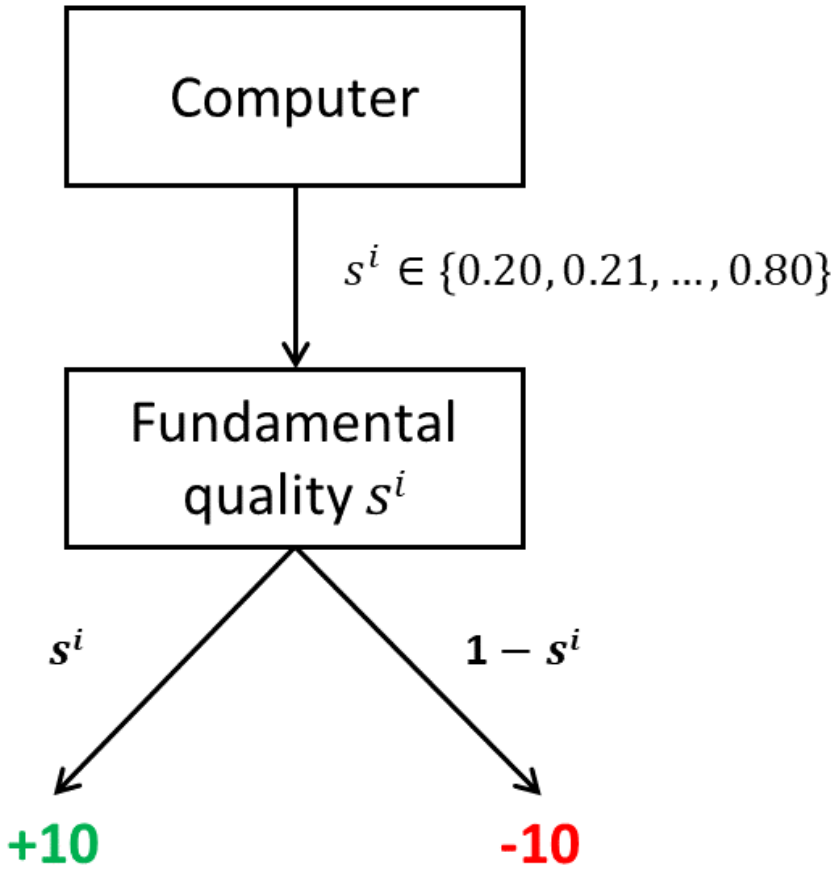
- Example: Diagnostic Expectations (Bordalo et al., 2016; 2018; 2019)
  - Expectations equal rational expectations plus surprise component
  - Surprise component depends on representativeness of recent news $\Rightarrow$ which news are *recent*?

Results Preview

- Experimental setting
  - Subjects form beliefs about asset's quality based on price signals
  - Exogenously assigned frequency of information

- Information partitioning matters
- Narrow information brackets lead to
  - $\rightarrow$ Increased sensitivity to recent information
  - $\rightarrow$ Less accurate beliefs
- Mechanism: attention shift towards recent information
- Applications: finance and consumer choice

Experimental Design



Experimental Design

- Subjects observe price development over 50 periods and estimate fundamental quality s^i (incentivized)

- 2 Treatments (between subject):
  - *Broad*: Entire price path at once, estimate only in period 50
  - *Narrow*: Price path ”builds” period by period, estimate every 10 periods

$\rightarrow$ Estimate in period 50 identical according to Bayes

Experimental Design

Experimental Design

Experimental Design

- Multiple trials (with a new i.i.d. s^i each trial)
  - 4 price developments in *Narrow*
  - 8 price developments in *Broad*
- Unannounced recall task (incentivized) after a randomly selected trial
  - Number of increases / decreases
  - Final price
  - Max. number of consecutive of increases / decreases

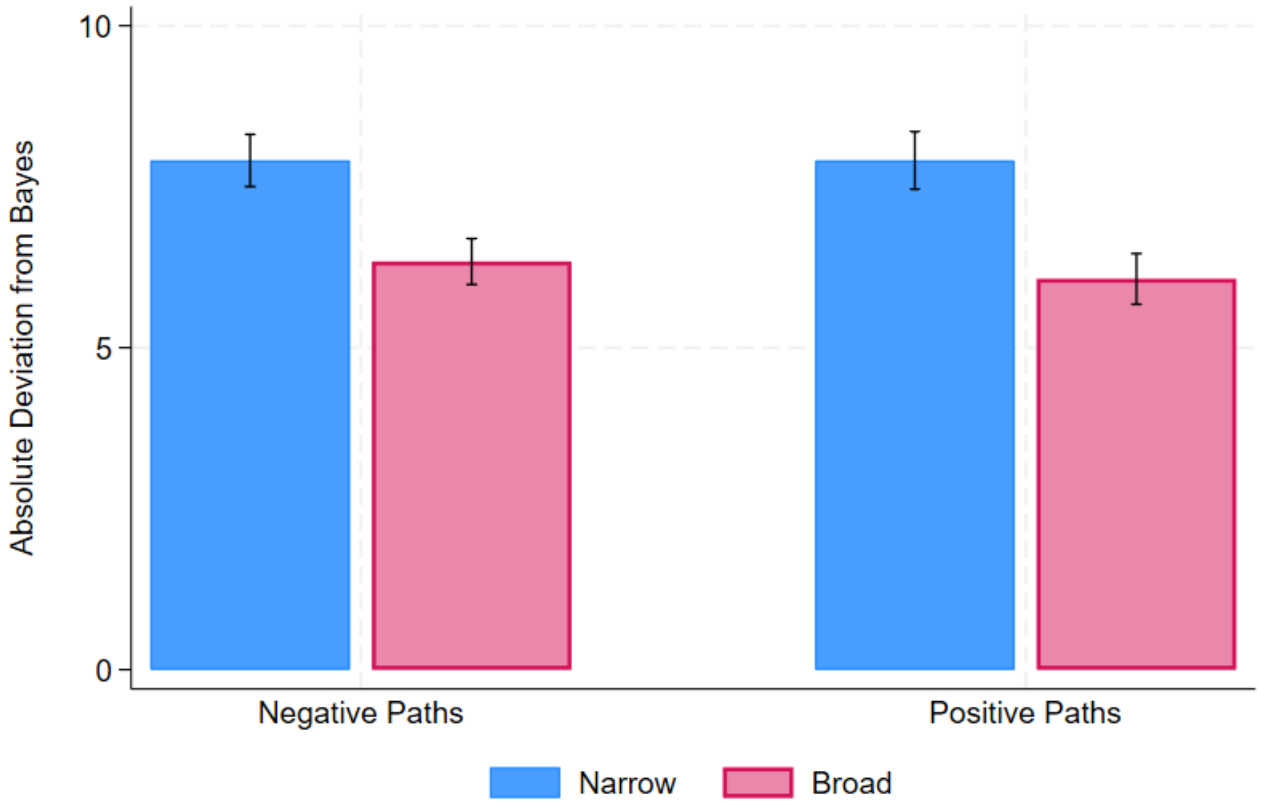
Recruitment Procedure

- Preregistered and IRB approved
  - `aspredicted.org/89ym-pqwn.pdf`

- N=713, recruited via Prolific
  - 2/3 in *Narrow*
  - 1/3 in *Broad*

▸ Summary Statistics

Information Partitioning – Belief Accuracy



→ Results symmetric for increasing/decreasing price paths

→ Estimation errors in *Narrow* roughly 25-30% higher

Information Partitioning – Belief Accuracy

Table: Estimation Error

	Overall	Overall	Negative	Positive
bayes	-0.07	-0.09	0.25***	-0.13***
	(0.49)	(0.49)	(0.04)	(0.04)
narrow	1.70***	1.67***	1.51***	1.82***
	(0.29)	(0.28)	(0.33)	(0.37)
controls	No	Yes	Yes	Yes
N	3,700	3,656	1,851	1,805
R^2	0.02	0.04	0.06	0.05

→ Holds in regression setting (with controls and clustered SE)

⇒ Beliefs in *Broad* more accurate

Information Partitioning – Belief Formation

Greenwood and Shleifer (2014) regressions ▸ Alternatives

$$p_i = a + b \cdot \sum_{j=0}^{k} \omega_j \Delta Price_{t-j} + u_t,$$

with

$$\omega_j = \frac{(\lambda_{broad} + \lambda_{narrow} \cdot Narrow)^j}{\sum_{l=0}^{k} (\lambda_{broad} + \lambda_{narrow} \cdot Narrow)^l}.$$

- λ measures how much weight is placed on recent versus past brackets of information

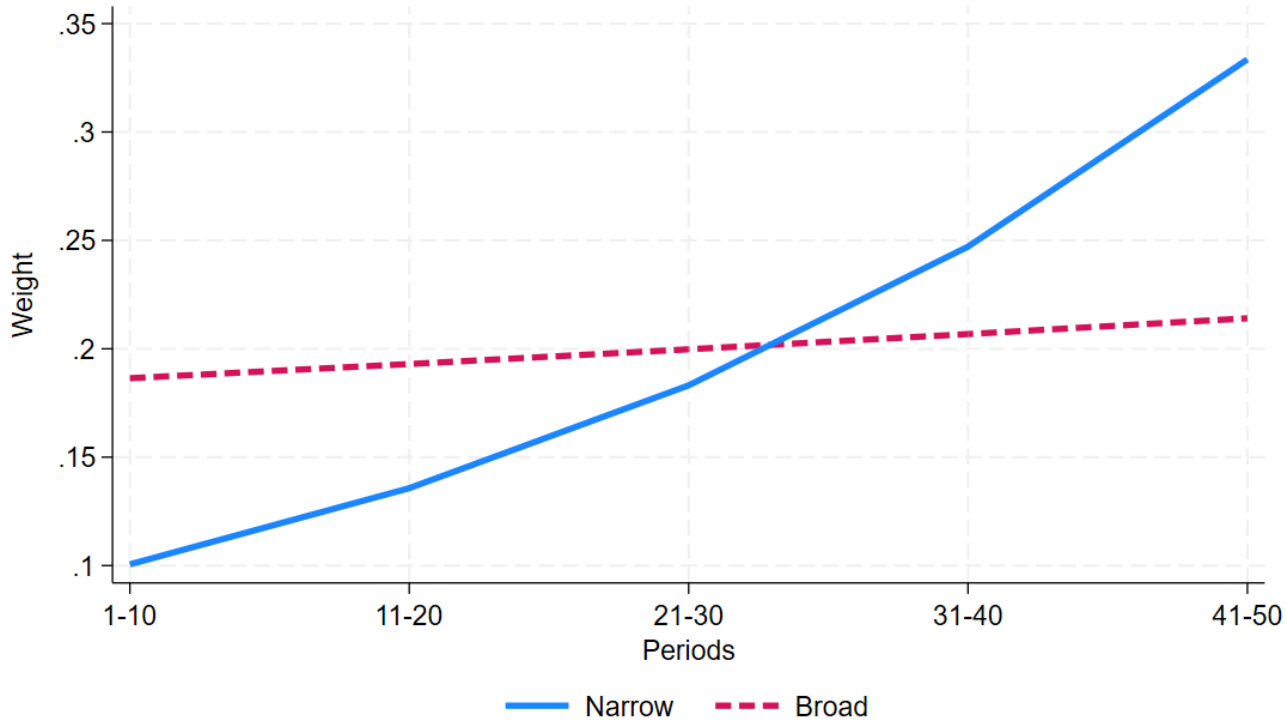
$\rightarrow$ Lower λ implies overweighting of recent information

Information Partitioning – Belief Formation

Table: Information Weights

	(1)	(2)	(3)
λ_{broad}	0.97***	0.97***	
λ_{narrow}	-0.23***		0.74***
a	48.60***	48.78***	48.44***
b	0.41***	0.43***	0.41***
N	3,700	1,696	2,004
R^2	0.82	0.86	0.79

Information Partitioning – Belief Formation



⇒ *Narrow* puts more weight on most recent information and less weight on earlier information

Mechanism – Memory

- Results inconsistent with Bayesian updating
- Cannot be explained by motivated beliefs, misattribution, or recency

$\Rightarrow$ Attention shift in *Narrow*

- Individuals overly focus on recent information, neglecting the "big picture"
- Affects which/how information is encoded into memory

$\rightarrow$ Increased sensitivity to recent information should lead to worse memory at the macro level (Schwartzstein, 2014)

Mechanism – Memory

Table: Memory

Panel A: Fraction	in %		
	Broad	Narrow	Difference
increases	19.81	13.57	6.24**
decreases	19.81	13.77	6.04**
final price	25.00	16.37	8.63***
streak up	16.04	17.96	-1.93
streak down	17.45	17.17	0.29
Panel B: Number			
	Broad	Narrow	Difference
memory score (all 5)	0.98	0.79	0.19*
memory score (first 3)	0.65	0.44	0.21***

→ Worse recall in *Narrow* ▸ Memory & Accuracy

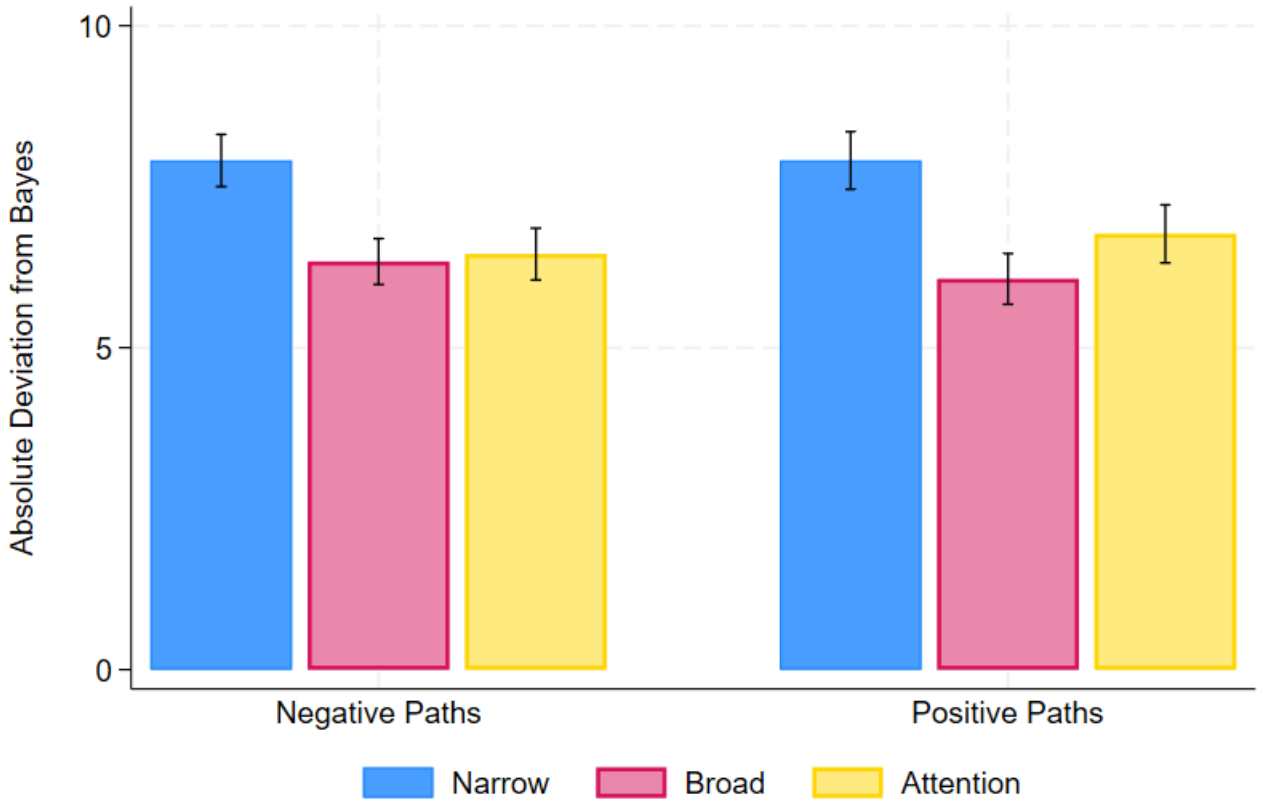
Mechanism – Attention Manipulation

- Exogenously manipulate attention in *Narrow*
- Before providing their estimate in period 50, subjects have to
  - Watch the price development rebuild
  - Identify 5 prices, covering each 10-period bracket ▸ Screenshot

→ Shift attention towards the big picture

- Preregistered
  - `aspredicted.org/78f9-p2zj.pdf`
- N=352, recruited via Prolific
  - only *Narrow*, 4 price developments each

Mechanism – Attention Manipulation



→ Attention manipulation closes gap in beliefs ▸ Information Weights

Mechanism – Attention Manipulation

Table: Attention - Memory

Panel A: Fraction			in %		
	Attention	Broad	Difference	Narrow	Difference
increases	23.58	19.81	3.77	13.57	10.01***
decreases	23.58	19.81	3.77	13.77	9.81***
final price	24.15	25.00	-0.85	16.37	7.78***
Panel B: Number					
	Attention	Broad	Difference	Narrow	Difference
memory score	0.71	0.65	0.07	0.44	0.28***

→ Attention manipulation also closes memory gap

Applications – Finance

- More recent information more informative in financial markets

→ Beneficial to observe information in narrow brackets

- Additional Experiment
  - 2 states determining the likelihood of price changes
  - Every 10 periods, the state can change

  → Bayesian overweights most recent signals

- Preregistered
  - `aspredicted.org/rp22-jwdt.pdf`
- N=998, investors, recruited via Prolific

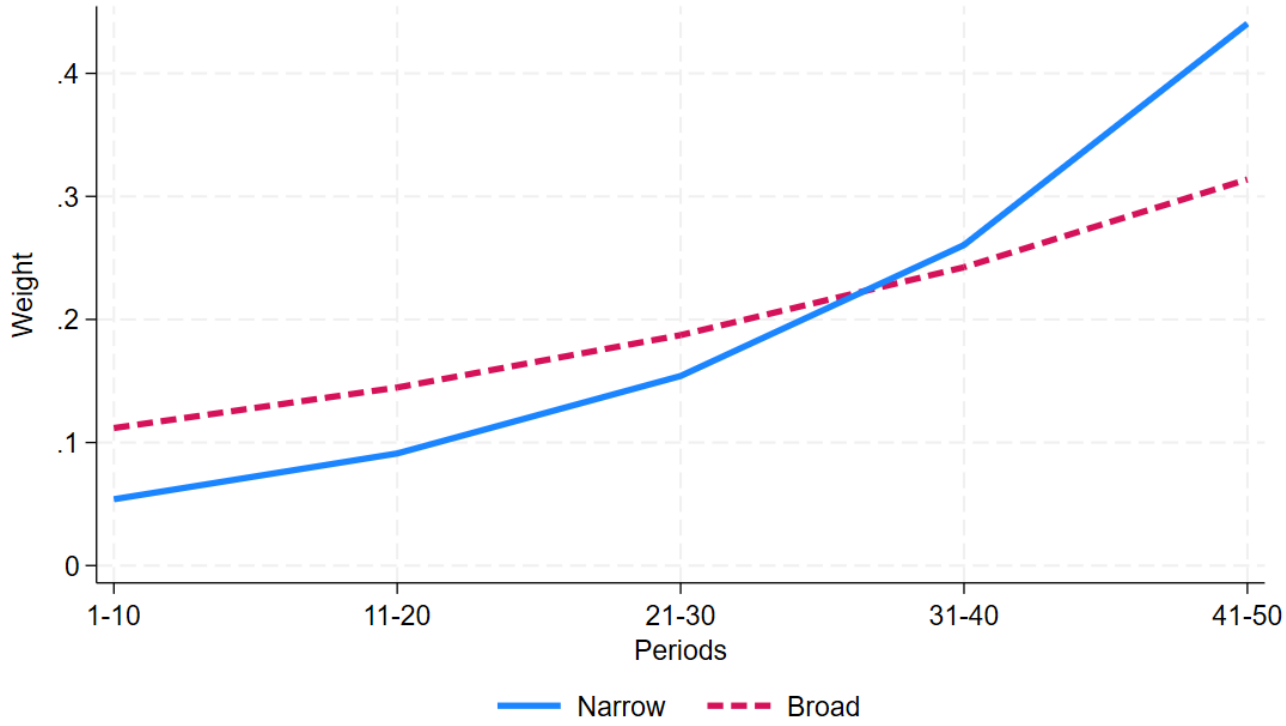
Applications – Finance

Table: Finance - Estimation Error

	Overall	Overall	Negative	Positive
bayes	-0.01	-0.01	0.18***	-0.18***
	(0.01)	(0.01)	(0.02)	(0.02)
narrow	-3.80***	-3.69***	-4.23***	-3.07***
	(0.91)	(0.91)	(1.17)	(1.07)
Controls	No	Yes	Yes	Yes
N	3,024	3,000	1,704	1,296
R^2	0.01	0.01	0.12	0.16

→ In line with the mechanism, *Narrow* now provides more accurate estimates

Applications – Finance



- More recent information generally more strongly incorporated

→ *Narrow* overweights recent information

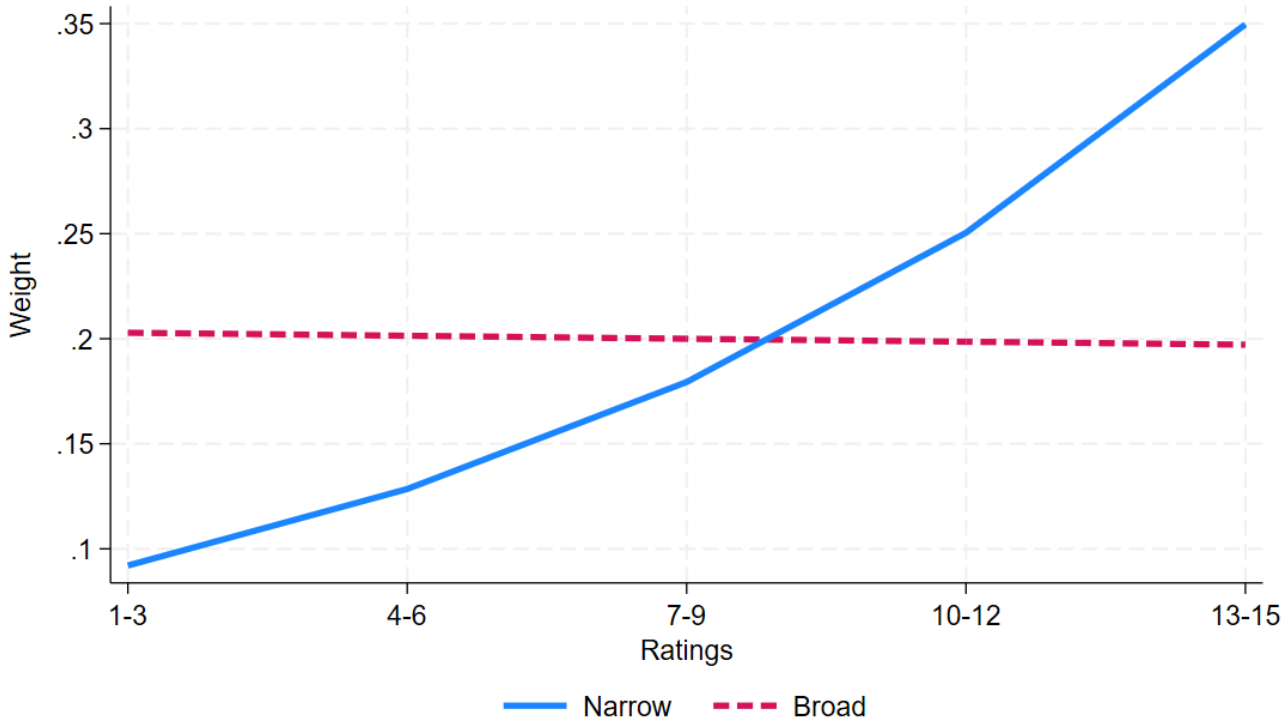
Applications – Consumer Choice

- Additional Experiment
  - Judge quality of fictional smartphone based on online reviews
  - Stable product characteristics
  - Qualitative rather than quantitative information

  ▸ Reviews

- Preregistered
  - `aspredicted.org/jhf2-wk5x.pdf`
- N=996, recruited via Prolific

Applications – Consumer Choice



- *Broad* places equal weight on all information

→ *Narrow* overweights recent information

Conclusion

$\Rightarrow$ **Information partitioning matters**

- Observing information in narrow brackets leads to increased sensitivity to recent information
  - Worse recall of information
  - Less accurate beliefs
- Information partitioning effect is driven by a shift in attention from macro- to micro-level
- Also applies to specific domains: finance and consumer choice

Thank you!

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Instructions

General Setting

In period 0 the stock price of a fictional stock amounts to $400. The stock price increases or decreases every period over 50 periods. The size of the price change is always $10, either up or down. The likelihood of a *price increase* is the same for these 50 periods and is randomly determined in period 0. It can be any percentage number between 20% and 80%. Since there are equally many percentage numbers above and below 50%, the average probability of a price increase is 50%.
But if, for example, 62% is drawn, the likelihood of a price increase is 62% in each period and the likelihood of a price decrease is 38% (100%-62%) in each period. As such, price increases and decreases are indicative of the drawn likelihood of a *price increase* for the fictional stock.

Task

You will observe the price changes of the fictional stock over 50 periods. From time to time you are asked to estimate the randomly determined likelihood of a *price increase* for this stock. In particular, you have to enter an integer percentage number between 20% and 80%.
The entire task is repeated up to 8 times for independent fictional stocks, i.e. each stock has its own randomly determined likelihood of a price increase.

▸ back

Information Partitioning – Summary Statistics

Table: Summary Statistics

	Full Sample	Broad	Narrow	Difference
Age	41.17	41.05	41.23	0.18
	(11.77)	(11.44)	(11.83)	
Female	0.48	0.46	0.49	0.03
	(0.50)	(0.50)	(0.50)	
Risk Aversion (1 – 7)	4.58	4.62	4.55	0.05
	(1.61)	(1.61)	(1.62)	
Statistic Skills (1 – 7)	4.06	3.99	4.10	0.11
	(1.38)	(1.33)	(1.40)	

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Information Partitioning – Alternatives

Table: Alternative Information Weights

	(1)	(2)	(3)	(4)
all50 × *narrow*	-0.02***			
last10 × *narrow*	0.08***			
first40 × *narrow*		-0.02***		
last10 × *narrow*		0.06***		
first30 × *narrow*			-0.04***	
last20 × *narrow*			0.05***	
first20 × *narrow*				-0.01**
middle20 × *narrow*				-0.02***
last10 × *narrow*				0.06***
FE	Yes	Yes	Yes	Yes
N	3700	3700	3700	3700
R^2	0.83	0.83	0.72	0.82

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Mechanism – Memory

Table: Memory & Accuracy

	Overall	Overall	Narrow	Broad
memory score	-0.92***	-0.93***	-0.91***	-0.93***
	(0.11)	(0.15)	(0.17)	(0.16)
narrow	1.53***	1.59***		
	(0.28)	(0.34)		
memory score × *narrow*		0.03		
		(0.23)		
N	3,700	3,700	2,004	1,672
R^2	0.05	0.05	0.02	0.04

→ Memory related to accuracy of beliefs

back

Mechanism – Attention Manipulation

Please identify the stock price for the following five periods:

Period 21

Period 50

Period 34

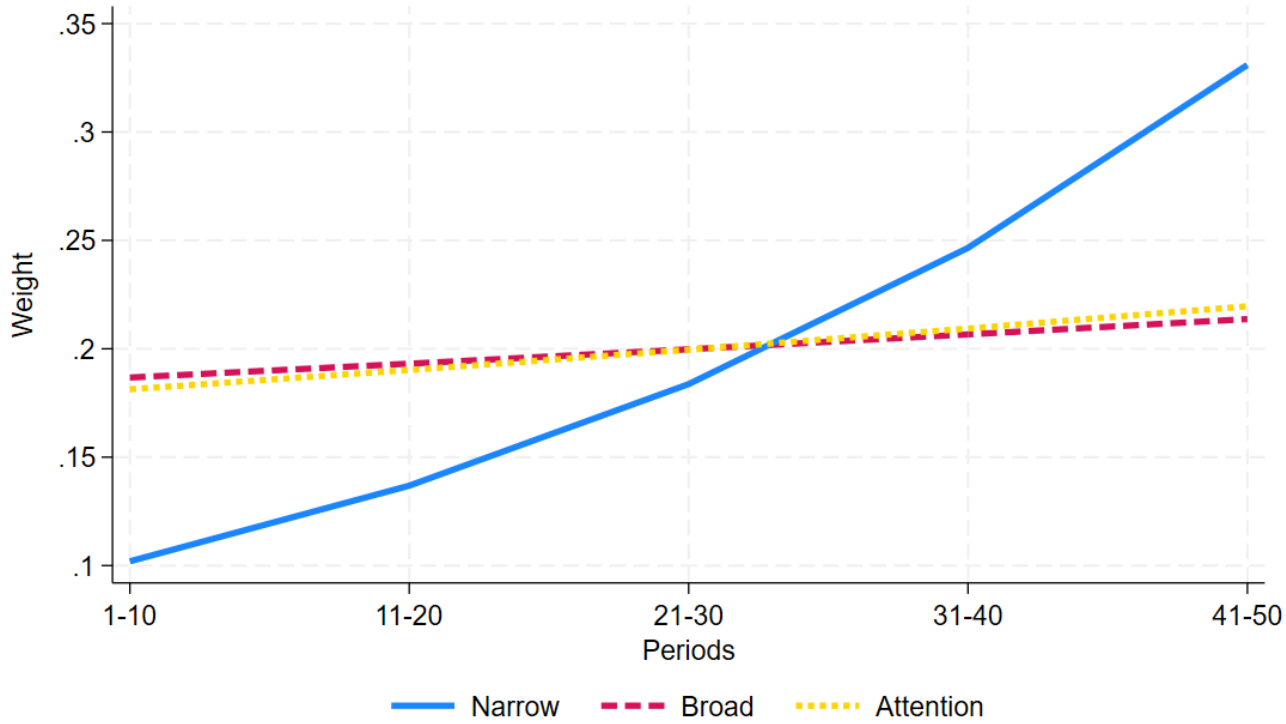
Period 7

Period 16

Next

back

Mechanism – Attention Manipulation



→ Attention manipulation leads to more equal weighting

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Applications – Consumer Choice

Ratings

New Ratings

Keeps you updated

Pro: Software updates are frequent, keeping the phone secure and up to date.
Con: Some updates introduce minor bugs that take time to be fixed.
Conclusion: A reliable phone with good software support, but occasional update issues are annoying.

Depends on how much you use it

Pro: The battery lasts all day under light use.
Con: Under heavy use, it drains quickly and struggles to keep up.
Conclusion: Battery life is decent, but power users will likely need to carry a charger.

Nothing for the fans of customisation

Pro: The phone's interface is user-friendly and easy to navigate.
Con: Customization options are limited compared to other brands.
Conclusion: A good phone for those who like simplicity, but not ideal for users who want more control over their settings.

Previous Ratings

Great phone and great camera in one device

Pro: The camera system is among the best in the market, taking sharp and detailed photos in any lighting.
Con: Some advanced features require manual adjustments to get the best results.
Conclusion: A powerhouse for photography lovers, as long as you don't mind tweaking settings occasionally.

The display is simply fun

Pros: Brilliant display with great colours, high brightness and smooth presentation.

Cons: Fingerprint-prone glass casing that smudges quickly and is slippery without a cover.

Conclusion: One of the best smartphones on the market if you can live with fingerprints and the high price.

Invest in no-wire headphones

Pro: The speakers deliver rich and clear audio.
Con: There's no headphone jack, forcing users to rely on adapters or wireless options.
Conclusion: If you're into great sound, this phone delivers—just be ready for the inconvenience of no headphone jack.

Press "Next" to evaluate the phone based on its ratings.

Next

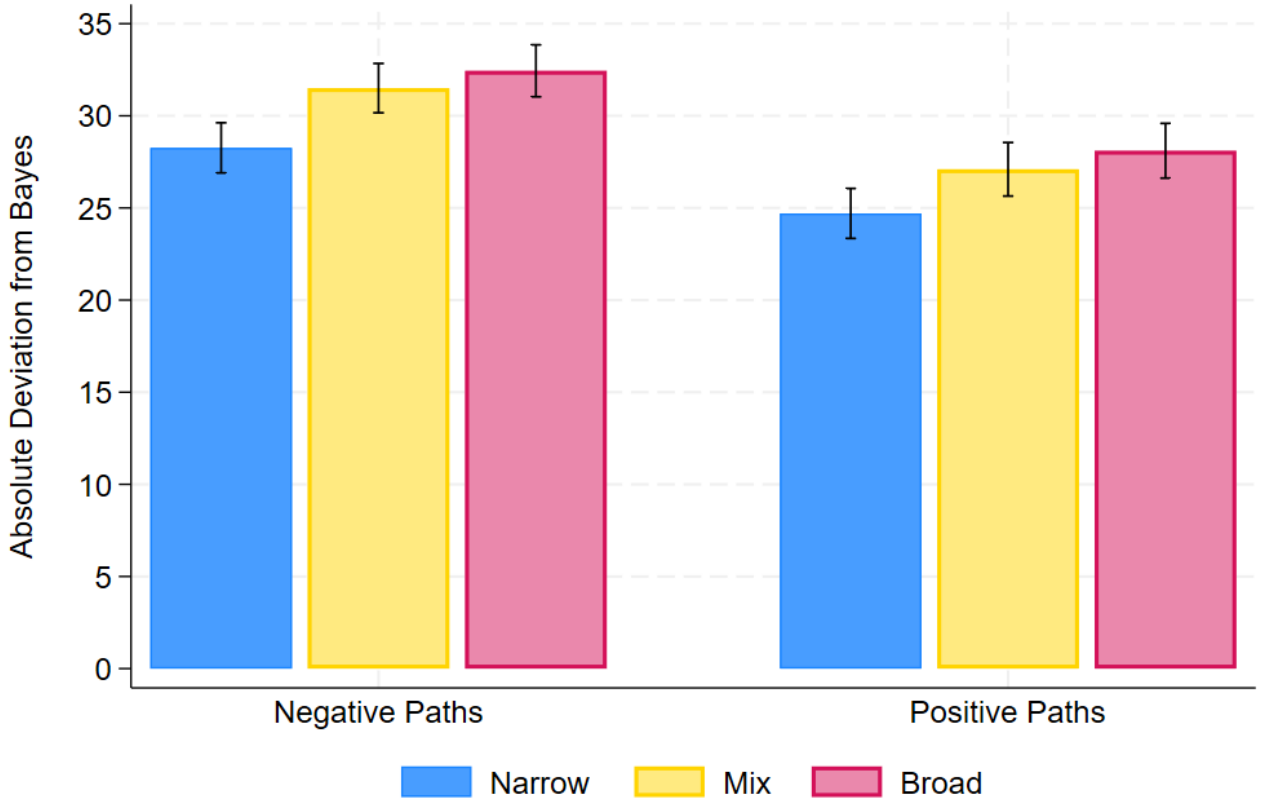
Robustness

- Information partitioning effect not driven by number of trials
  - No feedback
  - Results remain for each half of trials

- Information partitioning effect not driven by inattentiveness
  - Results remain for first half of trials
  - Results remain when excluding speeders

- Information partitioning effect also among sophisticated individuals
  - Comprehension questions ensure sufficient understanding
  - Results remain among subjects with high statistical skill

Robustness – Intermediate Updates



→ Estimation error between *Narrow* and *Broad*