# Belief Disagreement, Instability, and Uncertainty under Stochastic Recall*

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**Abstract**

Using preregistered field studies, we show that even when individuals observe identical information, recall is highly heterogeneous across people and varies within the same person over time. Beliefs closely track recalled information and change even in the absence of new signals. Motivated by these findings, we develop a parsimonious model of stochastic recall in which agents store all observed signals but recall each past signal only probabilistically when forming beliefs, while updating optimally conditional on what they remember. This single friction generates cross-sectional disagreement, within-person belief instability, and heterogeneity in subjective uncertainty among ex ante identical individuals. The model yields sharp predictions for how disagreement, instability, and uncertainty vary with informational ambivalence, recall probability, and contextual cues. Large-scale preregistered experiments support these predictions, and survey evidence on macroeconomic and financial expectations is consistent with the model's implications. Our results identify stochastic recall as a foundational informational friction in expectation formation.

JEL classification: E31, D84, C83

Keywords: Belief Disagreement, Belief Instability, Ambivalence, Subjective Uncertainty, Contextual Cues

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# 1 Introduction

A central implication of Bayesian learning is posterior consensus and belief stability: when agents share common priors and observe the same information, their beliefs should converge and—absent new signals—remain unchanged (e.g., Aumann, 1976; Geanakoplos and Polemarchakis, 1982). This implication underlies many models of expectation formation in macroeconomics and finance (e.g., Sims, 2003; Mankiw, Reis and Wolfers, 2003; Coibion and Gorodnichenko, 2015). Yet in many settings beliefs remain widely dispersed across individuals and change over time even without new information despite identical information environments.

This paper proposes a simple explanation for these patterns: *stochastic recall*. Even when individuals observe and store the same information, the subset of information retrieved when beliefs are formed can vary across individuals and across time. If beliefs are based on recalled information, such retrieval randomness can generate disagreement across individuals and belief revisions over time even when agents share identical information histories and update optimally conditional on what they recall.

Our empirical design allows us to isolate stochastic retrieval from alternative explanations based on heterogeneous attention or information acquisition. Participants observe identical information histories, while interventions implemented only after the exposure stage—such as stop-and-think prompts and contextual cues—affect beliefs only by shifting which previously observed signals are retrieved from memory when beliefs are formed. In addition, we document systematic belief revisions in the absence of new information and show that these revisions closely track changes in recalled signals. Together, these features of the design provide direct evidence that variation in retrieval, rather than differences in information acquisition or new information arrival, drives disagreement and belief dynamics.

We begin by documenting a set of motivating facts that isolate this mechanism. In four large-scale preregistered two-wave online field studies, all participants are exposed to the same fixed sequence of real-world information. We elicit beliefs and recalled information immediately after exposure and again about 24 hours later, without providing any new information between waves. Five facts emerge.

**Fact 1: Recall varies across individuals.** Individuals recall strikingly different subsets of the same objective information history.

**Fact 2: Beliefs track recalled information.** Recalled signals strongly predict stated beliefs.

**Fact 3: Recall varies within individuals over time.** The same individual recalls different subsets of the same information when asked again about 24 hours later.

**Fact 4: Beliefs change without new information.** Despite no new signals between waves, beliefs revise substantially.

**Fact 5: Belief revisions track recall changes.** Changes in beliefs closely follow changes in recalled information.

Together, these facts show that beliefs move with recalled information even when the objective information set is fixed. While the motivating facts focus on beliefs and recall, the mechanism we propose also has implications for subjective uncertainty, which we analyze theoretically and test empirically later in the paper.

Motivated by these facts, we develop a parsimonious model of belief formation with *stochastic recall*. Agents observe the same signals, store them all, share a common prior, and apply Bayes' rule correctly conditional on recalled information. The only friction is memory retrieval: at the moment beliefs are formed, each stored signal is recalled with some probability. This minimal departure from standard learning isolates imperfect recall from heterogeneous information acquisition, selective attention, or biased updating. Stochastic recall alone generically breaks both posterior consensus and belief stability even among ex ante identical agents. Individuals exposed to identical information may retrieve different subsets of signals, generating cross-sectional disagreement, while the same individual may recall different subsets over time, generating belief instability even without new information.

Stochastic recall also has implications for *subjective uncertainty*. Because posterior uncertainty depends on the balance of recalled evidence, variation in recalled signals can generate heterogeneity in uncertainty even under identical information histories. The effect of improved recall depends on the composition of the underlying history, including settings—such as those we study experimentally—in which improved recall reduces uncertainty.

The model yields sharp and testable predictions. First, disagreement, belief instability, and subjective uncertainty are greatest when the information history is *ambivalent*—when positive and negative evidence are closely balanced—and vanish only in knife-edge cases of perfectly one-sided evidence or perfect recall. Second, increasing recall probability—through effort, incentives, repetition, or salience—reduces disagreement and stabilizes beliefs even without new

information, though its effect on subjective uncertainty depends on the underlying information history. Third, contextual cues can have non-monotonic effects on disagreement and uncertainty: cues that reinforce dominant signals reduce dispersion and uncertainty, while cues that prime minority signals can initially increase both before reducing them once cue strength becomes sufficiently strong.

This paper makes three contributions. First, we introduce stochastic recall as a new informational friction in belief formation. We show theoretically that imperfect retrieval of stored information generically breaks posterior consensus and belief stability even when agents share common priors and observe identical information histories. In contrast to models that rely on heterogeneous information acquisition or biased signal weighting, disagreement and belief instability arise here solely from stochastic variation in which stored signals are retrieved when beliefs are formed. The model further implies systematic heterogeneity in subjective uncertainty even under shared information, and it characterizes how this uncertainty depends on both the balance of the underlying signal history and contextual cues.

Second, we provide direct micro-level evidence linking recalled information to beliefs. In a series of large-scale preregistered experiments, all participants observe the same sequence of information while we vary informational ambivalence, recall effort, and contextual cues. By eliciting recalled signals alongside beliefs, we show that recalled information significantly predicts stated beliefs and that interventions affecting the retrieval process systematically shift both recall and beliefs.

Third, we document evidence consistent with the model's predictions in survey-based expectations data. Using data from the Michigan Survey of Consumers, we show that disagreement, belief uncertainty, and instability in expectations are systematically related to the degree of informational ambivalence in recent history. For stock market returns, belief dispersion, uncertainty, and instability are higher when households have lived through mixed sequences of stock value appreciation and depreciation, and lower following sustained run-ups or drawdowns. Consistent with this mechanism, disagreement in stock price expectations also covaries with salient recent market movements in the Michigan Survey of Consumers, suggesting that naturally occurring cues may affect which past signals households retrieve when forming expectations. For inflation, belief disagreement and instability are higher when households have recently experienced volatile inflation paths. By contrast, periods of sustained low and stable inflation,

such as the Great Moderation, are associated with more aligned and more stable beliefs.

Our findings have broad implications for economic theory. Models that assume posterior consensus under shared information implicitly rely on perfect recall. Relaxing this assumption provides a unified explanation for belief disagreement, belief volatility, heterogeneity in subjective uncertainty, and belief revisions without new information. More broadly, the results suggest that belief dispersion, uncertainty heterogeneity, and belief instability are natural features of environments with rich and ambivalent information histories.

The remainder of the paper proceeds as follows. Section 2 presents the motivating field evidence and summarizes the facts and their mapping to existing frameworks. Section 3 develops the stochastic recall model and Section 4 characterizes disagreement, instability, and uncertainty. Sections 5–7 present evidence from a series of experiments and quantitative estimation. Section 8 presents complementary survey evidence on stock price and inflation expectations. Section 9 discusses implications for models of expectations and belief formation. Section 10 concludes.

**Related Literature** This paper contributes to the literature on belief formation and expectations by identifying stochastic recall as a minimal and independent source of belief disagreement, belief instability, and heterogeneity in subjective uncertainty—even when agents share identical information histories. A large body of work studies learning under the benchmark implication that Bayesian agents with common priors and shared information reach posterior consensus and exhibit belief stability (Aumann, 1976; Geanakoplos and Polemarchakis, 1982). This implication underlies many canonical models of expectations in macroeconomics and finance. We show that this conclusion depends critically on an implicit assumption of perfect recall. Once retrieval is imperfect, disagreement and belief instability arise generically even when agents observe and store identical information and update optimally conditional on what they recall. Because posterior uncertainty depends on the balance of recalled evidence, stochastic recall also generates heterogeneity in subjective uncertainty across agents under shared information.

More broadly, our results speak to dynamic consistency in belief formation. In canonical models with common priors, once the relevant information set is fixed, beliefs are stable absent new signals. Our analysis shows that this benchmark can fail even under shared information if recall is imperfect: the same agent may retrieve different subsets of stored signals at different times and therefore form different beliefs without receiving any new information. In this sense,

stochastic recall provides a distinct mechanism through which beliefs can vary both across agents and within agents over time.

A prominent strand of the literature explains disagreement through informational frictions such as noisy information, sticky information, and rational inattention (Lucas, 1972; Woodford, 2003; Mankiw, Reis and Wolfers, 2003; Sims, 2003; Mackowiak and Wiederholt, 2009). These frameworks generate dispersion through heterogeneous acquisition or processing of information and can also produce heterogeneity in subjective uncertainty. In our setting, by contrast, agents share identical information histories and common priors. We abstract from heterogeneous acquisition and instead isolate stochastic variation in the retrieval of stored signals, showing that imperfect recall alone can generate cross-sectional disagreement, within-person belief instability, and heterogeneity in subjective uncertainty.

Our work is also related to models emphasizing memory, salience, and diagnosticity in belief formation (Bordalo, Gennaioli and Shleifer, 2020a; Bordalo, Burro, Coffman, Gennaioli and Shleifer, 2024; Gennaioli, Leva, Schoenle and Shleifer, 2024; Conlon and Kwon, 2025). These approaches study how particular signals become prominent or are differentially weighted in forming beliefs. Our mechanism is complementary but distinct: we abstract from distortions in signal weighting and instead focus on stochastic variation in which stored signals are retrieved when beliefs are formed. By maintaining Bayesian updating conditional on recalled information, we isolate retrieval randomness as a separate source of belief disagreement, instability, and uncertainty heterogeneity. Relatedly, Azeredo da Silveira, Sung and Woodford (2024) studies optimal decision-making under memory constraints in the spirit of rational inattention, whereas we model retrieval as probabilistic and study its implications for cross-sectional dispersion and belief dynamics.

Finally, our mechanism complements experience-based explanations of belief heterogeneity (Malmendier and Nagel, 2016; Kuchler and Zafar, 2019; Malmendier and Wachter, 2024). Related evidence shows that heterogeneous day-to-day exposure to price signals shapes macro expectations (D'Acunto, Malmendier, Ospina and Weber, 2021; D'Acunto, Malmendier and Weber, 2021). These works emphasize differences in individuals' information histories. By contrast, we show that substantial dispersion in beliefs and subjective uncertainty can arise even when information histories are identical once retrieval is imperfect. Empirically, our approach relates to experimental and survey-based studies of expectations formation (Coibion, Gorodnichenko

and Weber, 2022; Andre, Pizzinelli, Roth and Wohlfart, 2022; Giglio, Maggiori, Stroebel and Utkus, 2021). A distinctive feature of our design is that all participants observe the same information, allowing us to directly identify stochastic recall as a driver of belief disagreement, belief instability, and heterogeneity in subjective uncertainty.

## 2 Motivating Evidence: Five Facts about Recall and Beliefs

Perfect recall is a standard benchmark in many dynamic models of expectation formation: agents are typically assumed to retrieve the information in their information sets, such as historical data or past signals, when forming beliefs. To motivate relaxing this assumption, this section documents five empirical facts about recall and belief formation that emerge across financial, macroeconomic, policy, and firm-level settings. Using four pre-registered online field survey studies, we show that even when individuals are exposed to an identical information history, recalled information and beliefs are both heterogeneous across individuals and unstable within individuals over time. Because no new information is provided between survey waves, these patterns isolate a role for variation in retrieval under a common information history.

### 2.1 Design of Field Studies

**Overview** The four field studies share a common two-wave panel structure. In Part 1 (Day 1), participants are exposed to a fixed sequence of real-world information and subsequently report both their beliefs and their recall of the information. In Part 2 (Day 2), conducted approximately 24 hours later, the same participants report their beliefs again and complete an analogous recall task. Importantly, no new substantive information is provided between the two parts. The informational environment is therefore held fixed, allowing us to study the evolution of beliefs and recall in the absence of additional signals.

This structure allows us to study two central empirical margins. First, we measure cross-sectional heterogeneity in recall and beliefs immediately after exposure, even though all participants observe the same information history. Second, we measure within-individual changes in recall and beliefs over time under a fixed information set. Together, these objects allow us to examine how recalled information maps into stated beliefs both across individuals and within individuals when no new information arrives.

Across studies, we vary the substantive domain of the information while maintaining a

common informational architecture. Studies 1 and 2 present quantitative macro-financial data and elicit quantitative beliefs. Studies 3 and 4 present qualitative news content of mixed valence and elicit evaluative judgments. The domains include financial markets, macroeconomic outcomes, public policy, and firm-level performance.

**Information and Measurement** In Part 1 of each study, information is presented one item per screen in a fixed sequence. Participants cannot return to previous screens. Afterward, participants report their belief and then complete a recall task.

*Study 1 (Stock Market Returns).* Participants view the twelve monthly U.S. stock market returns for calendar year 2025 (January–December), each displayed as a percentage. They are then asked:

> "Based on the information you just received, what is your best estimate of the average monthly stock market return in 2025?"

Responses are entered as a numerical percentage. The recall task provides a blank entry field for each month, and participants are instructed to report any monthly returns they remember.

*Study 2 (Inflation).* Participants view the ten annual U.S. inflation rates for 2016–2025, each displayed as a percentage. They are then asked:

> "Based on the information you just received, what is your best estimate of the average annual inflation rate over the past 10 years?"

Responses are numerical percentages. The recall task again provides a blank entry field for each year, and participants are asked to report as many inflation rates as they remember.

*Study 3 (Tariff Policy Headlines).* Participants view a sequence of 11 opinion article headlines about recent U.S. tariff policy, consisting of five positive and six negative perspectives. They are then asked:

> "Based on the opinion article headlines you just read, how would you describe the overall sentiment of these articles?"

Responses are recorded on a four-point scale: *Very negative, Somewhat negative, Somewhat positive, Very positive*. The order of response options is randomly flipped. The recall task asks

participants to report how many positive and how many negative headlines they were shown; the order of the "positive" and "negative" response fields is randomly flipped.

*Study 4 (Electric Vehicle Company Headlines).* Participants view a sequence of 11 recent news headlines about a major electric vehicle company, consisting of six positive and five negative items. After exposure, they are asked:

> "Based on the news headlines you just read, how would you describe the overall sentiment of the news coverage?"

Responses are recorded on a four-point scale: *Very negative, Somewhat negative, Somewhat positive, Very positive*. The order of response options is randomly flipped across participants. The recall task asks participants to report the number of positive and negative headlines they observed, in the same way as in Study 3.

In Part 2 (Day 2), participants receive no additional substantive information. Instead, they receive a neutral reminder that the information shown in Part 1 is relevant for the follow-up questions and are asked the same belief question and the same recall task as on Day 1. This symmetry allows us to identify within-individual changes in beliefs and recall over time under a fixed information set, thereby isolating belief instability that arises in the absence of new information.

The information presented in the surveys is sufficient for participants to form beliefs and complete the recall tasks using the material provided in the study itself. This design substantially limits the need to draw on outside information, especially in the qualitative studies, while preserving a common information history across participants.

**Sample** Participants are adult U.S. households recruited through the online survey platform CloudResearch using its Connect participant pool.[1] In total, approximately 2,600 respondents were recruited across the four field survey studies. Each study includes approximately 600 valid participants in Part 1 (conducted on January 29, 2026), and participants were restricted to taking part in only one study. The average re-participation rate in Part 2 one day later is 84 percent. We pre-specified and implemented multiple data-quality screens, including an explicit

[1] Connect is a proprietary, managed panel of U.S. adults who enroll directly on the CloudResearch platform. We use CloudResearch's built-in quality assurance system (Sentry) to pre-screen respondents prior to survey entry based on historical response behavior, device-level checks, and automated bot-detection signals.

attention check and completion-time thresholds (excluding responses shorter than 2 minutes or longer than 20 minutes), resulting in the exclusion of approximately 8 percent of respondents. We additionally exclude participants who report taking notes during the information screens (approximately 2 percent). Appendix Table A.2 reports demographic characteristics by study.

**Incentives** Participants received fixed participation payments of $2 for Part 1 and $1 for Part 2. In Studies 1 and 2, belief reports in both parts were incentivized using accuracy-based bonuses: after data collection, responses were compared to the true average of the displayed series, and the top 10 percent most accurate respondents received a $1 bonus. In Studies 3 and 4, bonuses were tied to the accuracy of the recall task (correct counts of positive and negative headlines).[2] Incentives were structured to encourage careful attention and truthful reporting while preserving the informational environment across parts.

## 2.2 Five Facts

**Fact 1: Recall of the same information is highly heterogeneous.** Even immediately after exposure, individuals retrieve highly different information from the same objective information history. In other words, what comes to mind differs sharply across people despite identical exposure. Figure 1 shows substantial dispersion in recalled information across all four study domains on Day 1, with similar heterogeneity one day later on Day 2.

In Studies 1 and 2, recalled averages of stock market returns and inflation rates vary widely across individuals, despite all participants observing identical sequences of historical data. For example, the interquartile range (IQR) of recalled stock returns is approximately 1.6 percentage points around a true mean of 1.33 percent, while the IQR of recalled inflation rates is close to 1 percentage point around a true average inflation rate of 3.3 percent.

In Studies 3 and 4, which elicit evaluative judgments based on mixed-valence information, disagreement in recalled content is even more pronounced: the IQR of the recalled share of positive items is approximately 25 percentage points for tariff articles and 16 percentage points for electric-vehicle news, despite true positive shares of 45 and 55 percent, respectively. The support of the recall distributions spans nearly the full unit interval, implying that some individuals recall

[2] While these studies also have a correct overall sentiment, belief accuracy is less naturally scored on the four-point evaluation scale than in Studies 1 and 2, where responses can be compared directly to the true numerical average of the displayed series.

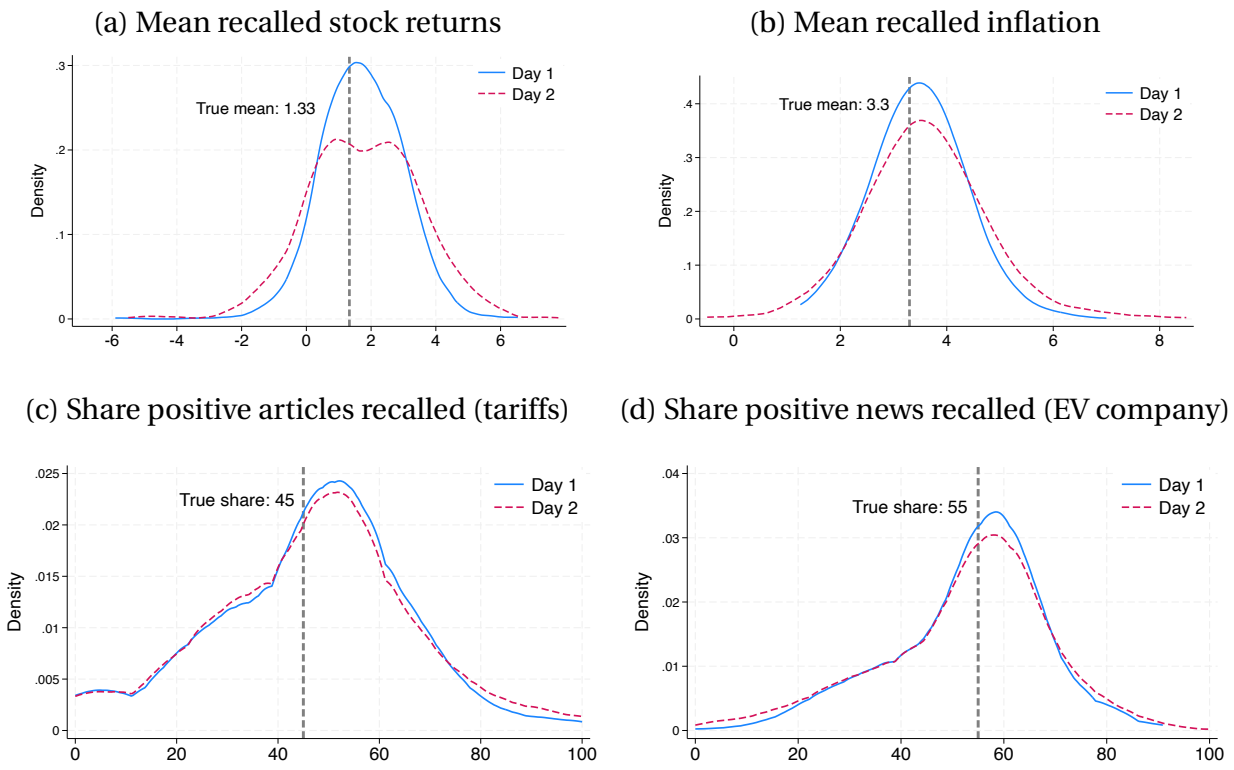



**Figure 1:** MEMORY RECALL OF THE SAME INFORMATION ARE HIGHLY HETEROGENEOUS (**FACT 1**)

*Notes:* The figure plots the cross-sectional distribution of retrieved information (memory recall) elicited immediately after exposure (Day 1, solid) and one day later (Day 2, dashed), holding the information history fixed. Panels (a) and (b) display the distribution of the mean recalled monthly stock returns over the past 12 months and the mean recalled annual inflation rates over the past 10 years. Panels (c) and (d) display the distribution of the percentage share of positive opinion headlines/news items recalled (out of all recalled items) for tariff policy and for the electric-vehicle company.

almost exclusively negative items while others recall predominantly positive ones from the same set of headlines.

**Fact 2: Recalled information strongly predicts stated beliefs.** Differences in recalled information translate into substantial disagreement in beliefs and opinions across domains. Appendix Figure A.1 documents wide dispersion in beliefs on both Day 1 and Day 2 across all four studies.

Figure 2 shows a tight cross-sectional link between Day 1 recall and contemporaneous beliefs across all four studies. Participants who recall higher stock returns (inflation) report higher expected returns (inflation), and those who recall a more positive mix of headlines express more favorable evaluations of tariff policy and the EV company. Appendix Table A.3 quantifies the magnitude of these relationships. In the quantitative domains (Studies 1–2), the elasticity of beliefs with respect to recalled averages is close to unity: coefficients are about 0.90 on Day 1

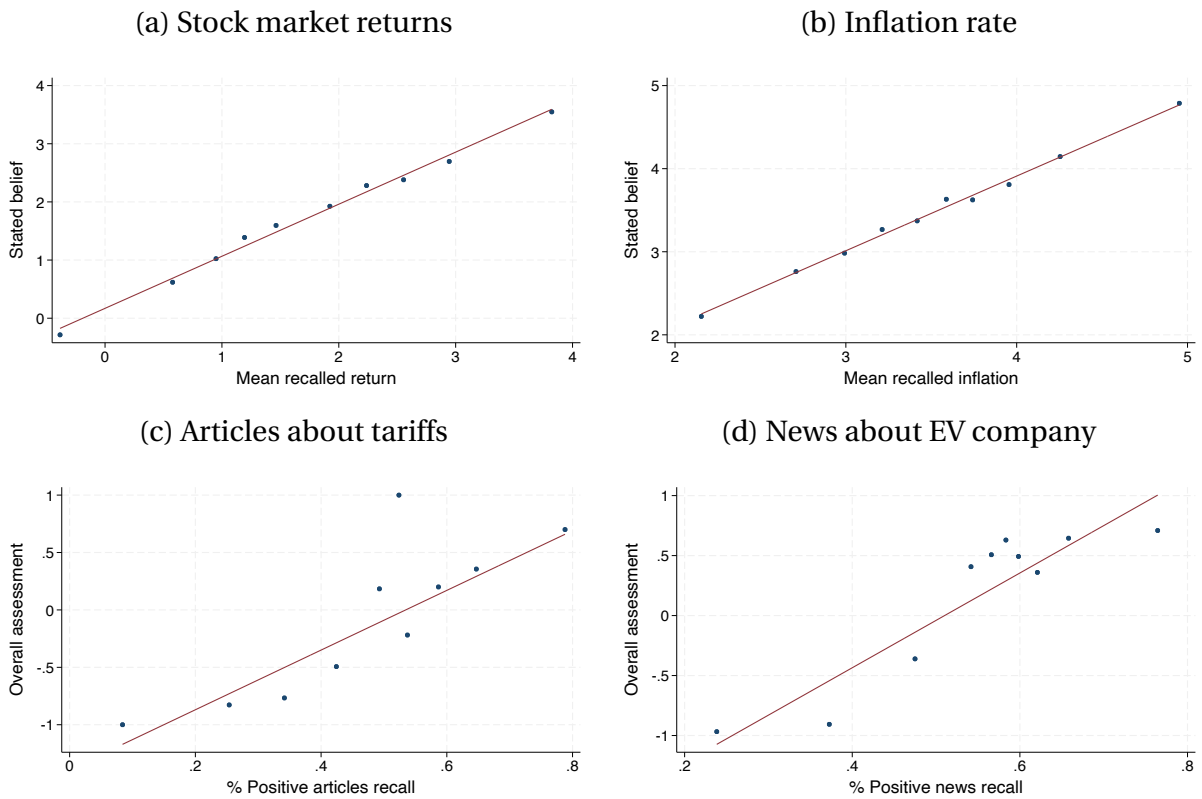



**Figure 2:** RECALLED INFORMATION STRONGLY PREDICTS BELIEFS (**FACT 2**)

*Notes:* Each panel reports a binned-scatter plot relating participants' Day 1 stated beliefs (y-axis) to their Day 1 elicited recall (x-axis), pooling across participants within each study. Dots plot mean outcomes within bins of the recall measure; the solid line is the corresponding linear fit. Panels (a) and (b) use the mean recalled monthly stock return over the past 12 months and the mean recalled annual inflation rate over the past 10 years, respectively. Panels (c) and (d) use the share of recalled items that are positive (out of all recalled items) for tariff headlines and for news about the EV company; the belief outcome in these panels is the binary evaluation index (+1 for positive, −1 for negative)

and 0.88–0.94 on Day 2, so a 1 p.p. difference in recalled returns or inflation maps into roughly a 0.9–1.0 p.p. difference in stated beliefs. In the evaluative domains (Studies 3–4), we summarize attitudes using a binary evaluation index that collapses the four-point response scale into its sign (+1 for positive and −1 for negative). A 10 p.p. increase in the recalled positive share predicts a 0.26 (tariffs) to 0.42 (EV company) increase in this Day 1 binary evaluation index and a 0.19 to 0.27 increase on Day 2. Since the outcome is coded $\{-1, +1\}$, these magnitudes correspond to roughly a 13–21 p.p. (Day 1) and 10–14 p.p. (Day 2) higher probability of a positive evaluation, and are robust to demographic controls. These patterns echo Andre, Pizzinelli, Roth and Wohlfart (2022) and Binder, Kuang and Tang (2025), who show that heterogeneity in recalled mechanisms is a first-order determinant of belief heterogeneity.

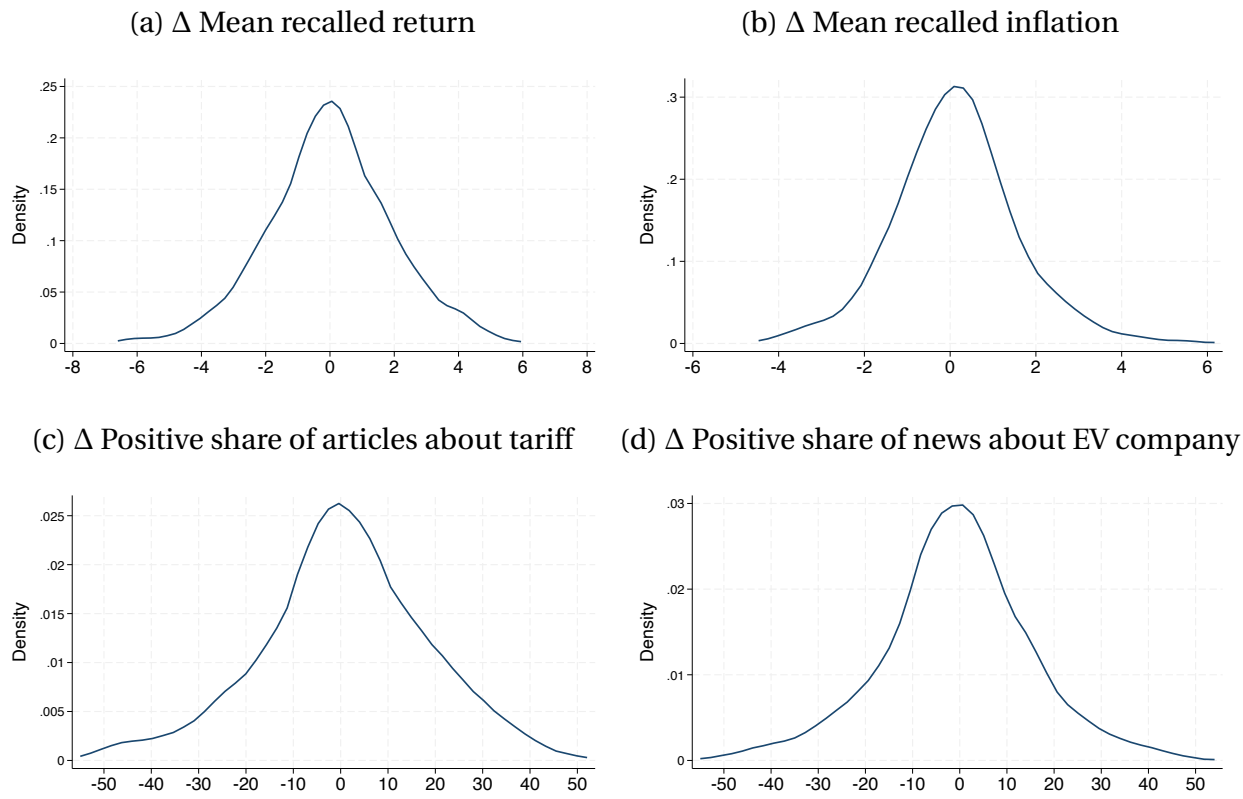



**Figure 3:** WITHIN INDIVIDUALS, MEMORY RETRIEVAL OF THE SAME INFORMATION VARIES SUBSTANTIALLY OVER TIME (**FACT 3**)

*Notes:* The figure plots the cross-sectional distribution of within-individual changes in memory retrieval between Day 1 and Day 2 across the four field studies. Panels (a) and (b) display the distribution of changes in mean recalled stock returns and mean recalled inflation rates between Day 2 and Day 1, respectively. Panels (c) and (d) summarize the distribution of changes in the share of positive recalled headlines between the two elicitations. No new information is provided between the two waves.

**Fact 3: Within individuals, recall of the same information varies substantially over time.** Recall is not stable within the same individual over time, even when the underlying information set is held fixed. Put differently, what comes to mind varies over time. Figure 3 plots within-individual changes in recalled information between Part 1 and Part 2, one day apart, and documents large, dispersed recall revisions across all four domains.

In Studies 1 and 2, many individuals recall substantially higher or lower average stock returns and inflation rates on Day 2 than on Day 1, despite receiving no new information. In Studies 3 and 4, the recalled share of positive items frequently shifts by tens of percentage points. These patterns indicate that the subset of information retrieved from memory fluctuates meaningfully over time in a systematic, nontrivial way. This finding is consistent with Andre, Haaland, Roth, Wiederholt and Wohlfart (forthcoming), who show that households' recalled causal narratives

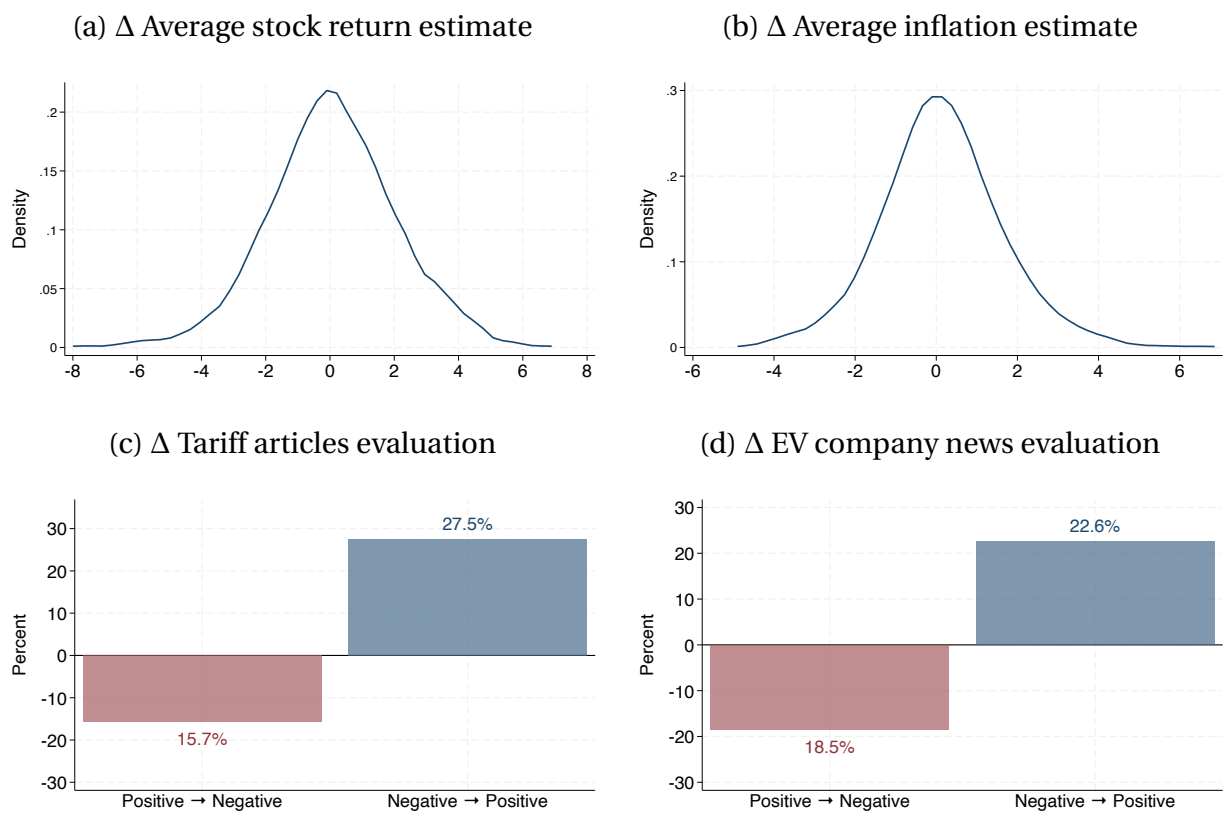



**Figure 4:** BELIEFS ARE UNSTABLE EVEN IN THE ABSENCE OF NEW INFORMATION (**FACT 4**)

*Notes:* The figure plots the cross-sectional distribution of within-individual belief changes between Part 1 and Part 2 across the four field studies. Panels (a) and (b) show the distribution of changes in reported beliefs, defined as the difference between Part 2 and Part 1 beliefs. For stock returns, beliefs are the reported average monthly return over the past 12 months; for inflation, beliefs are the reported average annual inflation rate over the past 10 years. Panels (c) and (d) summarize discrete belief revisions for evaluative judgments, reporting the percentage of respondents who switch from positive (somewhat or very) to negative (somewhat or very) assessments, and vice versa, between elicitations.

about macroeconomic developments substantially evolve over time.

**Fact 4: Beliefs are unstable even in the absence of new information.** Beliefs exhibit frequent and economically meaningful revisions even when no new information is provided. Figure 4 shows substantial belief changes between Part 1 and Part 2 across all four studies. In Studies 1 and 2, the interquartile range of belief revisions is approximately 2.3 percentage points for stock return expectations and 1.6 percentage points for inflation expectations.

In Studies 3 and 4, belief instability takes the form of discrete revisions: between elicitations, 43 percent of respondents reverse the sign of their tariff policy evaluation, and 41 percent reverse their evaluation of electric-vehicle company news. These patterns show that belief instability remains substantial even when the information environment is fixed. They are also consistent

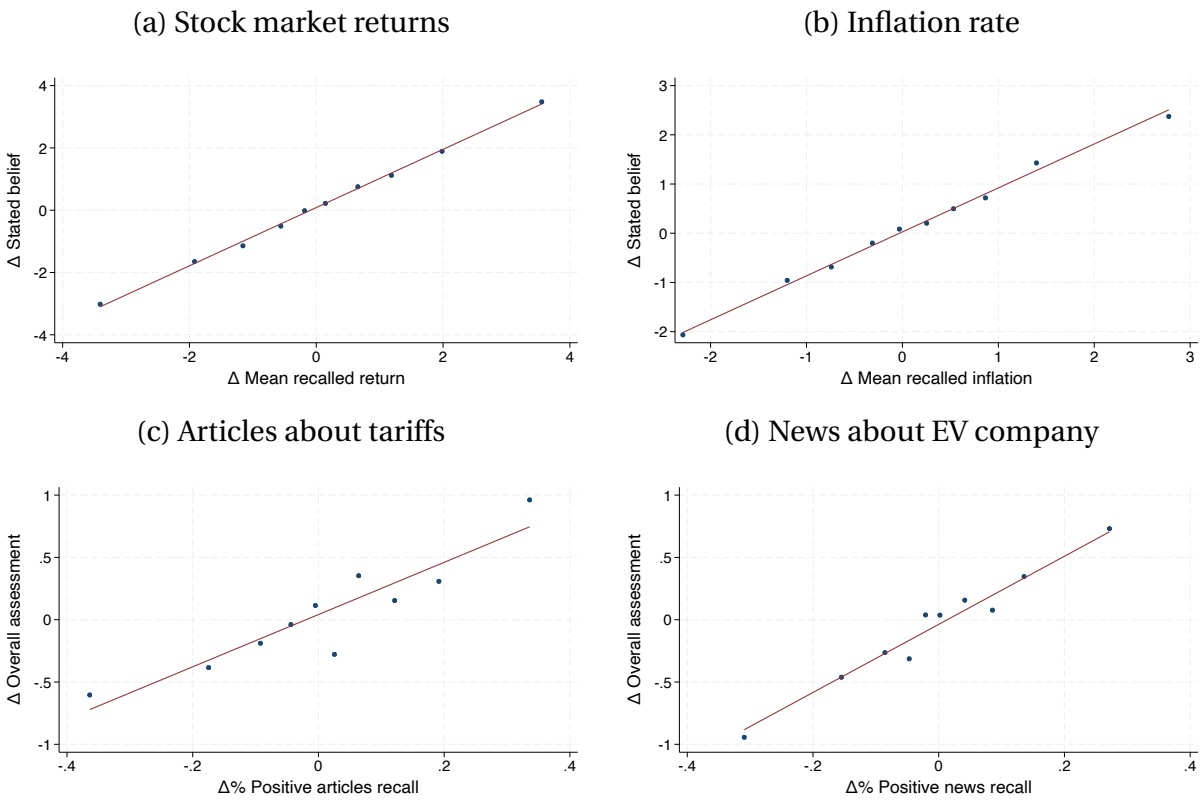



**Figure 5:** BELIEF REVISIONS CLOSELY TRACK CHANGES IN RECALLED INFORMATION (**FACT 5**)

*Notes:* Each panel reports a binned-scatter plot relating within-participant changes in beliefs from Day 1 to Day 2 (y-axis) to within-participant changes in recalled information over the same interval (x-axis), pooling across participants within each study. Dots plot mean changes within bins of the change in the recall measure; the solid line is the corresponding linear fit. Panels (a) and (b) use the change in the mean recalled monthly stock return over the past 12 months and the change in the mean recalled annual inflation rate over the past 10 years, respectively. Panels (c) and (d) use the change in the share of recalled items that are positive (out of all recalled items) for tariff headlines and for news about the EV company; the belief outcome in these panels is the change in the binary evaluation index (+1 for positive, −1 for negative).

with evidence that households' recall and interpretation of information vary over time (e.g., Graeber, Roth and Zimmermann, 2024), generating belief revisions even in stable information environments.

**Fact 5: Belief revisions closely track changes in recalled information.** Belief revisions are tightly coupled with revisions in recalled information. Figure 5 plots within-participant changes from Day 1 to Day 2 and shows a strong positive relationship between the change in recall and the change in beliefs or evaluations in each study. Appendix Table A.4 quantifies the magnitude of this within-individual mapping. In the quantitative domains (Studies 1–2), the slope is close to one: a 1 p.p. increase in recalled stock returns (inflation) between days predicts a

0.93 p.p. (0.89 p.p.) increase in stated expected returns (inflation). In the evaluative domains (Studies 3–4), a 10 p.p. increase in the recalled positive share predicts a 0.21 (tariffs) to 0.27 (EV company) increase in the binary evaluation index, indicating that changes in recall translate into economically meaningful within-person attitude revisions. These estimates are robust to demographic controls.

To summarize, Facts 1–2 establish substantial cross-sectional heterogeneity in recalled information and beliefs under a common information history, while Facts 3–5 establish substantial within-individual instability in both recall and beliefs even when no new signals arrive. These patterns motivate a framework in which beliefs depend on the subset of stored information that happens to be retrieved when beliefs are formed.

**Measurement error** Classical measurement error or random responding is unlikely to explain the central empirical patterns documented here. First, in both the motivating surveys and the subsequent experiments, stated beliefs are closely aligned with recalled information. For example, the Belief Disagreement Experiment described in Section 5 shows that in 98% of cases, beliefs constructed from recalled information coincide with stated beliefs. Such a high degree of alignment is difficult to reconcile with classical measurement error. See also **Fact 2**. Second, if belief and recall reports on Day 1 and Day 2 were driven primarily by random responding or classical measurement noise, belief revisions in the absence of new information should be weakly related to changes in recalled information. Instead, we document a strong and systematic relationship between recall changes and belief revisions (**Fact 5**). This relationship is also present in the Belief Instability Experiment in Section 6. Third, many of the paper's later findings take the form of structured comparative statics—for example, belief instability increases with informational ambivalence and decreases with recall probability (see **Facts 9, 10, 13, and 14** in Table 2). These systematic patterns are difficult to reconcile with unsystematic reporting error alone. Overall, the evidence points to stochastic retrieval as a primary source of belief revisions, rather than random responding or classical measurement noise.

**Scope and interpretation** The field surveys are intended to document motivating empirical patterns rather than to provide definitive causal identification. Although the survey information set is held fixed within each study, we cannot fully exclude the possibility that some participants draw on prior experience or preexisting beliefs, or seek outside information between elicitations,

particularly in Studies 1 and 2. Heterogeneity in numerical skills may also contribute to dispersion in quantitative beliefs in Studies 1 and 2, since forming average return or inflation estimates requires basic numerical processing. However, the substantial heterogeneity observed in recalled information itself emerges immediately after exposure and does not require advanced numerical ability. Moreover, in Studies 3 and 4, participants evaluate qualitative headlines constructed for the study and base their responses on the presented content, substantially limiting the role of outside information or numerical skills in generating belief disagreement. Thus, the field studies provide broad external-validity evidence that recall and beliefs are heterogeneous and unstable even under a common information history. The cleanest internal-validity evidence that stochastic recall drives disagreement and instability comes from the controlled Belief Disagreement and Belief Instability experiments presented below, in which the information environment, recall effort, and contextual cues are tightly regulated.

## 2.3 Existing Belief Formation Models

The facts documented above speak to mechanisms that operate even when agents share identical information histories. Our designs hold the objective information stream fixed within treatment cells, so disagreement and instability are measured conditional on a common information set. Two features are central: (**Fact 1**) individuals recall markedly different information from the same history, and (**Facts 3–5**) beliefs and recall vary within individuals even when no new information arrives.

**Informational frictions and dynamic consistency** A key benchmark in canonical informational-friction models is dynamic consistency conditional on a fixed information set: absent new signals, beliefs do not systematically revise. Rational inattention (Sims, 2003; Mackowiak and Wiederholt, 2009), sticky information (Mankiw, Reis and Wolfers, 2003), and noisy information (Lucas, 1972; Woodford, 2003) generate disagreement through heterogeneous attention, updating frequency, or imperfect signal extraction. These frameworks typically focus on differences in information acquisition or processing. Our evidence instead isolates a channel that operates even when information histories coincide and no new signals arrive. In addition, these models abstract from stochastic retrieval of stored observations and therefore do not directly address dispersion arising from variation in what is recalled from a shared history (**Fact 1**).

**Table 1:** EMPIRICAL PATTERNS IN THE FIELD STUDIES AND PREDICTIONS OF BELIEF-FORMATION FRAMEWORKS

| Empirical belief pattern | Informational frictions | Salience / diagnostic models | Stochastic recall |
|---|---|---|---|
| *Field studies 1–4 (Section 2)* | | | |
| **Fact 1:** Heterogeneous recall of identical information histories | Abstracts from retrieval heterogeneity under shared information | Retrieval typically deterministic conditional on cues | **Direct implication** |
| **Fact 2:** Recalled information predicts beliefs | Consistent with framework | Consistent with framework | **Direct implication** |
| **Fact 3:** Within-individual recall variation without new information | Not a primary focus under fixed information sets | Abstracts from stochastic retrieval | **Direct implication** |
| **Fact 4:** Belief instability without new information | Typically ruled out under dynamic consistency | Not directly implied under canonical formulations | **Direct implication** |
| **Fact 5:** Belief revisions track recall changes | Not directly modeled | Not directly modeled | **Direct implication** |

*Notes:* Entries indicate whether each framework delivers the empirical pattern under its canonical formulation. Descriptions such as "not directly modeled," or "not directly implied under canonical formulations" do not imply inconsistency; extensions of these frameworks could potentially generate some patterns. The table highlights that under shared information, the stochastic recall framework delivers all listed patterns as direct implications.

**Memory- and salience-based updating** Models of diagnostic expectations (Bordalo, Gennaioli, Ma and Shleifer, 2020b) and related approaches emphasize how salient or representative signals are weighted in forming beliefs. In these frameworks, conditional on the memory database and cue structure, the mapping from recalled information to beliefs is typically deterministic. Our evidence highlights an additional source of variation: stochastic differences in which stored signals are retrieved at the time beliefs are formed. By abstracting from weighting distortions and isolating retrieval randomness, we clarify how disagreement and belief instability can arise even under common priors and shared information. Stochastic recall is orthogonal to salience-based mechanisms and can operate jointly with them. Tables 1 and 2 summarize empirical findings from the motivating field studies and subsequent experiments and map them to leading frameworks, respectively. Motivated by **Facts 1–5**, the next section develops a parsimonious model of belief formation with stochastic recall. We then document systematic patterns in belief disagreement, instability, and uncertainty (**Facts 6–17**) that are naturally accommodated within this framework.

**Table 2:** EMPIRICAL PATTERNS IN THE EXPERIMENTS AND PREDICTIONS OF BELIEF-FORMATION FRAMEWORKS

| Empirical belief pattern | Informational frictions | Salience / diagnostic models | Stochastic recall |
|---|---|---|---|
| *Panel A. Qualitative disagreement experiment (Section 5)* | | | |
| *Disagreement* | | | |
| **Fact 6:** Disagreement increases with informational ambivalence | Not a central mechanism | Not a central mechanism | **Direct implication** |
| **Fact 7:** Disagreement decreases with recall effort | Outside canonical formulation | Outside canonical formulation | **Direct implication** |
| **Fact 8:** Asymmetric cue effects on disagreement | Not directly addressed | Partially related through salience amplification | **Direct implication** |
| *Subjective uncertainty* | | | |
| **Fact 9:** Recalled information predicts subjective uncertainty | Not directly addressed | Not directly addressed | **Direct implication** |
| **Fact 10:** Uncertainty increases with informational ambivalence | Not directly addressed | Not directly addressed | **Direct implication** |
| **Fact 11:** Asymmetric cue effects on uncertainty | Not directly addressed | Not directly addressed | **Direct implication** |
| *Panel B. Qualitative instability experiment (Section 6)* | | | |
| *Belief instability* | | | |
| **Fact 12:** Instability increases with informational ambivalence | Not a central mechanism | Not a central mechanism | **Direct implication** |
| **Fact 13:** Instability decreases with recall effort | Outside canonical formulation | Outside canonical formulation | **Direct implication** |
| *Panel C. Quantitative belief experiment (Section 7)* | | | |
| *Disagreement and instability under dynamic signals* | | | |
| **Fact 14:** Disagreement increases with volatility | Not a primary comparative static | Not a primary comparative static | **Direct implication** |
| **Fact 15:** Disagreement increases with persistence | Not a primary comparative static | Not a primary comparative static | **Direct implication** |
| **Fact 16:** Instability increases with volatility | Not directly addressed | Not directly addressed | **Direct implication** |
| **Fact 17:** Instability increases with persistence | Not directly addressed | Not directly addressed | **Direct implication** |

*Notes:* Entries indicate whether each framework delivers the empirical pattern under its canonical formulation. Descriptions such as "not directly addressed," "not directly implied under canonical formulations," or "outside canonical formulation" do not imply inconsistency; extensions of these frameworks could potentially generate some patterns. The table highlights that under shared information, the stochastic recall framework delivers all listed patterns as direct implications.

## 3 Stochastic Recall and Belief Formation

This section introduces a parsimonious model of belief formation under stochastic recall. The key modeling move is simple: we preserve Bayesian updating conditional on recalled information,

but relax the benchmark assumption that stored information is perfectly retrieved when beliefs are formed. This minimal departure from standard learning is sufficient to rationalize the five motivating facts above and applies to a broad class of settings in which individuals form opinions, judgments, and expectations. We first describe the basic environment and model setup and then introduce the stochastic recall mechanism. Section 4 characterizes the resulting cross-sectional distribution of beliefs and shows how informational ambivalence and imperfect recall jointly shape disagreement, instability, and uncertainty.

## 3.1 Model Setup

**Decision problem** We study settings in which a decision-maker forms a belief, opinion, or judgment on the basis of previously observed information. Two broad contexts are especially relevant.

*Context 1: Opinion formation and judgment-making.* A decision-maker forms an opinion or judgment about an object $Y$, such as a policy, issue, or political candidate. For example, the decision-maker may decide whether to support a policy proposal, whether to favor a particular firm, or which candidate to vote for. More generally, the decision-maker may form an overall qualitative assessment of the object, such as whether it is good or bad.

*Context 2: Qualitative and quantitative expectation formation.* A decision-maker predicts a variable $Y$ (e.g., inflation, house prices, or unemployment) or the effect of an exogenous change in $X$ on $Y$ (e.g., the effect of an unexpected interest rate hike on inflation), as in many surveys and experiments. In qualitative forecasting, the decision-maker predicts whether $Y$ will increase or decrease. In quantitative forecasting, the decision-maker reports a numerical expectation.

To isolate the core mechanism as transparently as possible, we first study a binary-state environment in which the decision-maker forms a qualitative belief about whether an asset is in a good or bad state. This formulation captures the logic of the qualitative experiments and provides a reduced-form representation of many opinion-formation and directional-forecasting settings. Section 3.3 discusses how the baseline model maps to opinion formation and qualitative expectation formation, while Section 7 studies quantitative expectation formation.

**Baseline environment** The model environment is closely related to Enke, Schwerter and Zimmermann (2024). Consider a continuum of decision-makers, indexed by $i$, who form beliefs

about the value of an asset $Y$. The asset can be in one of two states, $G$ (good) or $B$ (bad), which are not directly observable. All decision-makers share a common prior,

$$P(G) = P(B) = 0.5.$$

Each decision-maker observes the same realized history of independently and identically distributed binary signals

$$S = \{S_1, S_2, \ldots, S_N\},$$

where each signal is either positive ($pos$) or negative ($neg$). We code signals as $S_k = 1$ for positive and $S_k = -1$ for negative signals. Let $N^+$ and $N^-$ denote the numbers of positive and negative signals, with total signal count

$$N = N^+ + N^-.$$

The full collection of observed signals constitutes the decision-maker's memory database. We assume that all observed signals are stored; the friction studied in this paper operates only at the retrieval stage when beliefs are formed.

Signals are informative about the true state. Let $b \in (0.5, 1)$ denote signal diagnosticity, defined by

$$P(pos \mid G) = P(neg \mid B) = b,$$

so that a signal is more likely to match the true state than to contradict it. In applications, signals may be interpreted as news items, data points, observations, or considerations. Each decision-maker $i$ forms a qualitative belief about the asset value, denoted by $\widehat{Y}_i \in \{1, -1\}$, where 1 corresponds to state $G$ and $-1$ to state $B$.

The comparative statics below are derived conditional on a realized signal history $(N^+, N^-)$ shared by all decision-makers. This conditioning aligns the model with the empirical design, where all participants are exposed to the same objective information history and disagreement arises from differences in what is recalled from that common history.

## 3.2 The Stochastic Recall Approach

Under perfect recall, Bayesian learning implies posterior consensus and belief stability when decision-makers have common priors and common information. We separate Bayesian learning into two components: (i) perfect retrieval of stored information, and (ii) Bayesian updating conditional on the information that is brought to mind. Motivated by **Facts 1–5**, we relax the first

component while preserving the second.

Specifically, the only friction we introduce is stochastic recall: at the moment beliefs are formed, each stored signal is retrieved with some probability. Decision-makers then update according to Bayes' rule conditional on the recalled subset of signals. Thus, disagreement and belief instability arise here not from heterogeneous information acquisition or distorted signal weighting, but from stochastic variation in which stored signals are retrieved from a common memory database. Belief formation proceeds in two stages: a recall stage and an information-processing stage.

**Recall stage** Decision-maker $i$ recalls a random subset of the stored signals through a probabilistic sampling process. As a tractable baseline, we assume that each previously observed signal is recalled independently with probability $p \in (0,1)$. Let $X_i^+$ and $X_i^-$ denote the numbers of recalled positive and negative signals. The independence assumption is meant as a minimal benchmark that isolates retrieval randomness, not as a literal claim about all psychological processes governing memory.

**Information-processing stage** The decision-maker applies Bayes' rule to the recalled signals. Under the symmetric prior and signal structure described above, posterior log odds are proportional to the excess of recalled positive over recalled negative signals. Appendix Appendix C shows that optimal updating therefore implies a majority rule: if recalled positive signals outnumber recalled negative signals, the decision-maker believes the asset is good; otherwise, the decision-maker believes the asset is bad.[3] Formally,

$$\widehat{Y}_i = \begin{cases} 1 & \text{if } X_i^+ - X_i^- > 0, \\ -1 & \text{otherwise.} \end{cases} \tag{3.1}$$

The departure from the standard benchmark therefore operates entirely at the retrieval stage and is orthogonal to mechanisms that distort signal acquisition or signal weighting. This simple setup already implies the paper's core logic: disagreement and belief instability are strongest when the stored information history is ambivalent and decline as recall becomes more complete.

[3]When $X_i^+ = X_i^-$, the decision-maker is exactly indifferent between the two states. Throughout, ties may be broken by any fixed convention or ignored when their probability is negligible; none of the main qualitative results depends on the tie-breaking rule. For concreteness, we assume that the decision-maker classifies the asset as bad whenever $X_i^+ - X_i^- \leq 0$. All main comparative statics are unchanged under alternative fixed tie-breaking conventions.

**Remarks** *Baseline versus extensions.* The analysis in Section 4 focuses on the baseline model with common recall probability, independent recall across stored signals, and Bayesian updating conditional on recalled information. These assumptions provide the cleanest benchmark for isolating the role of imperfect retrieval.

*Richer recall processes.* The assumption of a constant recall probability serves as a tractable baseline and can be relaxed in several directions. Recall probabilities may depend on cues (see Section 4.6), recency, rehearsal, primacy, similarity, or interference. Recall can also be endogenized to depend on effort or incentives, and can vary systematically across individuals, for example by political affiliation, expertise, or personal experience.

*Interaction with other belief-formation mechanisms.* Stochastic recall can be embedded in models that also feature informational frictions, such as rational inattention, sticky information, or noisy information. Likewise, the Bayesian updating rule in the information-processing stage can be replaced by alternative updating rules, such as diagnostic expectations. The key distinction in our framework is that the friction enters through retrieval of stored information rather than through signal acquisition or weighting.

## 3.3 Model Interpretation and Extension

**Model interpretation** The baseline model provides a unified framework for opinion formation and expectation formation in macroeconomics, finance, and political economy. In these environments, decision-makers evaluate an object or forecast an outcome based on a stock of past signals stored in memory.

*Example 1 (Context 1).* A decision-maker decides whether to vote for a Democratic or Republican candidate in a presidential election. The memory database consists of signals such as the economic performance of the incumbent administration, media coverage, expert assessments, and salient policy outcomes.

*Example 2 (Context 1).* A decision-maker forms an overall assessment of a tariff policy as positive or negative. The memory database includes signals such as opinion pieces, expert commentary, and economic statistics describing the effects of the policy.

*Example 3 (Context 2).* A decision-maker forecasts whether an aggregate stock price index will increase or decrease. The memory database consists of signals such as recent realized returns, earnings news, and other observations that are coded mentally as favorable or unfavorable for

future performance.

More generally, the memory database can be interpreted as a collection of considerations. In opinion formation, a consideration is a reason favoring one side of an issue over another. Under this interpretation, the model provides a formal representation of the consideration-based framework of Zaller and Feldman (1992): when surveyed, individuals do not draw deterministically on all stored considerations, but on the subset that happens to be retrieved at the time of response. Stochastic recall therefore provides a simple microfoundation for variation in which considerations are brought to mind.

The memory database may also include perceived economic mechanisms relevant to expectation formation—for example, mechanisms used to predict the effect of an interest rate hike on inflation. In this sense, the model also provides a formal representation of the empirical framework in Andre, Pizzinelli, Roth and Wohlfart (2022): heterogeneity in beliefs can arise because different mechanisms or narratives are retrieved from memory.

**Model extension** The baseline analysis focuses on binary belief formation under a common uninformative prior in order to isolate the role of stochastic recall. A separate Online Appendix (Kuang, Tang and Weber (2026)) extends the framework along several dimensions, including: (i) continuous-signal and recency-weighted environments, (ii) probabilistic belief reports, (iii) repeated memory sampling, and (iv) biased priors. Across these cases, the key comparative statics continue to be governed by informational ambivalence interacting with imperfect recall.

## 4 Theoretical Implications of Stochastic Recall

We now derive the implications of stochastic recall. Even with common priors and identical information, probabilistic retrieval generates cross-sectional disagreement, within-individual belief instability, and heterogeneity in subjective uncertainty. We proceed in five steps. First, we characterize the cross-sectional distribution of binary beliefs. Second, we derive comparative statics for disagreement. Third, we analyze within-individual instability across repeated elicitations with no new information. Fourth, we study subjective uncertainty. Finally, we show how contextual cues shape disagreement and uncertainty.

## 4.1 The Cross-Sectional Distribution of Beliefs

We begin by characterizing the cross-sectional distribution of beliefs and the resulting disagreement across decision-makers. Throughout this subsection, disagreement is measured as the cross-sectional variance of realized binary beliefs, $\mathsf{Var}(\widehat{Y}_i)$, where $\widehat{Y}_i \in \{1,-1\}$. Under perfect recall, common priors and shared information imply identical posterior beliefs and therefore zero disagreement. Under stochastic recall, by contrast, each decision-maker's recall of the same signal history is idiosyncratic, consistent with **Fact 1**. Heterogeneous recall of signals therefore generates heterogeneous realized beliefs and positive disagreement, consistent with Figure A.1 and **Fact 2**.

For decision-maker $i$,

$$X_i^+ \sim \text{Binomial}(N^+, p), \qquad X_i^- \sim \text{Binomial}(N^-, p).$$

When $N^+$ and $N^-$ are large, these binomial recall distributions can be approximated by normal distributions:

$$X_i^+ \sim \mathcal{N}(N^+ p, N^+ p(1-p)),$$
$$X_i^- \sim \mathcal{N}(N^- p, N^- p(1-p)).$$

This normal approximation yields a tractable closed-form approximation for the cross-sectional distribution of beliefs.

Let

$$q = P(\widehat{Y}_i = 1) = P(X_i^+ > X_i^-).$$

Under the normal approximation, Proposition 1 summarizes the approximate distribution of beliefs and its cross-sectional moments.

**Proposition 1.** *1.* ***Approximate distribution of beliefs.***

$$\widehat{Y}_i = \begin{cases} 1 & \textit{with probability } q, \\ -1 & \textit{with probability } 1-q, \end{cases}$$

*where*

$$q = \Phi\left(\frac{(N^+ - N^-)p}{\sqrt{p(1-p)N}}\right).$$

*2.* ***Cross-sectional moments.***

$$E(\widehat{Y}_i) = 2q - 1, \qquad \mathsf{Var}(\widehat{Y}_i) = 4q(1-q).$$

The proof is provided in Appendix E. The expression inside $\Phi(\cdot)$ has a simple interpretation: the numerator captures the imbalance in stored positive versus negative signals, while the denominator captures recall-induced sampling noise. Intuitively, $q$ is the probability that a decision-maker recalls more positive than negative signals. When decision-makers form binary beliefs and the population is large, a fraction $q$ believe the asset is good, while a fraction $1-q$ believe it is bad.

First, $q$ increases with the share of positive signals in the memory database. A higher proportion of positive signals makes it more likely that recalled samples contain a majority of positive signals, thereby increasing the fraction of decision-makers who believe the asset is good. Second, when $p$ is small, recall is noisy and idiosyncratic, so $q$ is close to $\frac{1}{2}$. As $p$ increases, recalled samples more accurately reflect the underlying signal imbalance, shifting beliefs toward the majority signal type.

Disagreement under binary beliefs equals $4q(1-q)$. It is maximized when half of decision-makers believe the asset is good and the other half believe it is bad. Disagreement declines as $q$ moves away from $\frac{1}{2}$.

**Remark on memory size** Holding the recall probability $p$ and signal proportions fixed, disagreement converges to zero as $N \to \infty$. As the memory database grows large, recalled samples almost surely reflect the underlying signal imbalance, and all decision-makers' beliefs align with the dominant signal type.[4] In practice, disagreement may be more persistent once additional memory mechanisms are taken into account. First, recency effects may increase persistence by reducing the effective memory size, thereby amplifying the impact of stochastic recall fluctuations. Second, if DMs rehearse different subsets of the signal history, heterogeneous rehearsal can further amplify and prolong disagreement.

## 4.2 Cross-Sectional Disagreement: Comparative Statics

We summarize signal composition using the degree of informational ambivalence,

$$A = 1 - \left| \frac{N^+ - N^-}{N} \right|, \tag{4.1}$$

where $N^+$ and $N^-$ denote the numbers of positive and negative signals, respectively. Ambivalence is maximal when signals are evenly split and minimal when all signals point in the same direction.

[4] This follows directly from Proposition 1.

As an illustration, consider two environments that differ only in signal composition. Each environment features a large population of decision-makers who share the same prior and observe the same sequence of signals. In Environment A, 50 percent of signals are positive and 50 percent are negative. In Environment B, 90 percent of signals are positive and 10 percent are negative. Under perfect recall, disagreement is identically zero in both environments because all decision-makers retrieve the same information. Under stochastic recall, however, disagreement depends sharply on ambivalence. In Environment A, recalled samples are balanced on average, so roughly half of decision-makers recall more positive than negative signals and disagreement is maximal. In Environment B, most decision-makers recall more positive than negative signals and disagreement is small.

The next result formalizes how disagreement depends on ambivalence and recall probability.

**Proposition 2.**

1. ***Ambivalence.*** *Holding $N$ and $p$ fixed, belief disagreement $\mathsf{Var}(\widehat{Y}_i)$ is increasing in informational ambivalence $A$.*

2. ***Recall probability.*** *Holding $(N^+, N^-)$ fixed, belief disagreement is decreasing in the recall probability $p$.*

The proof is provided in Appendix F. Belief disagreement vanishes when $A = 0$. If all stored signals have the same sign, every recalled sample implies the same belief. Disagreement is maximized at the knife-edge case $A = 1$, when the stored signal history is perfectly balanced, because small recall fluctuations are then most likely to overturn the recalled majority. The role of recall probability is analogous. When $p$ is low, recalled samples are small and noisy, leading to substantial heterogeneity in recalled evidence across decision-makers. As $p$ increases, recalled samples become larger and more representative of the underlying history, increasing overlap across decision-makers and compressing disagreement. These comparative statics yield sharp empirical predictions: interventions that raise recall probability through effort, incentives, repetition, or salience reduce disagreement even when the underlying information set is held fixed.

## 4.3 Within-Individual Belief Instability: Comparative Statics

We now turn to belief instability within individuals over time. Cross-sectional disagreement compares different decision-makers at a given date; by contrast, instability compares the same

decision-maker across repeated elicitations. Consider a single decision-maker whose belief is elicited at two dates, $t$ and $t+1$, with no new information arriving between elicitations. At each date, the decision-maker independently recalls each stored signal with probability $p$ and applies the same majority rule to the recalled subset. Because recall is stochastic, the retrieved subset may differ across dates, consistent with **Fact 3**. Since the decision-maker updates optimally based on recalled signals, the decision-maker's belief may change over time even in the absence of new information, consistent with **Facts 4 and 5**.

Let $\Pi(N^+, N^-, p)$ denote the probability that beliefs differ across the two elicitations. Under the normal approximation,

$$\Pi(N^+, N^-, p) = 2q(1-q), \qquad q = \Phi\left(\frac{(N^+ - N^-)p}{\sqrt{p(1-p)N}}\right).$$

This expression follows because the two recall draws are independent across dates, so instability is the probability of opposite belief realizations:

$$q(1-q) + (1-q)q = 2q(1-q).$$

**Proposition 3.** ***(Within-individual belief instability)*** *Holding $N$ fixed, belief instability is increasing in informational ambivalence $A$ and decreasing in the recall probability $p$.*

The proof is provided in Appendix G. The logic mirrors the cross-sectional case. When evidence is ambivalent, small differences in recall draws across time are likely to flip the recalled majority, generating belief revisions. Increasing $p$ raises overlap in recalled information across elicitations and stabilizes beliefs. In the limit as $p \to 1$, belief instability vanishes whenever the stored signal majority is strict. This symmetry implies that environments generating high cross-sectional disagreement should also exhibit high within-individual belief instability, and that interventions increasing recall probability stabilize beliefs both across agents and over time.

In a large population of decision-makers, belief instability $\Pi(N^+, N^-, p)$ also corresponds to the proportion of decision-makers who revise their beliefs between two elicitation dates. This proportion increases with informational ambivalence $A$ and decreases with the recall probability $p$.

## 4.4 Subjective Uncertainty: Comparative Statics

The same mechanism also generates heterogeneity in subjective uncertainty. Even when decision-makers observe the same information history and apply the same updating rule,

stochastic recall implies that different subsets of signals may be retrieved when beliefs are formed. Because posterior beliefs depend on recalled evidence, different recall realizations can generate different degrees of confidence. This implication is important empirically because recall-based variation may affect not only the direction of beliefs, but also how certain decision-makers feel about those beliefs.

Let $X_i^+$ and $X_i^-$ denote the numbers of positive and negative signals recalled by decision-maker $i$. Under Bayesian updating, the posterior probability that the state is good is

$$\mu_i = \left[1 + \left(\frac{1-b}{b}\right)^{X_i^+ - X_i^-}\right]^{-1},$$

where $b > 1/2$ denotes signal accuracy. We measure subjective uncertainty as the posterior variance of the state indicator,

$$U_i = \mu_i(1-\mu_i).$$

Equivalently, subjective uncertainty is highest when the posterior is closest to $1/2$ and lowest when posterior beliefs are most extreme.

Define recalled net evidence as

$$D_i \equiv X_i^+ - X_i^-.$$

The following proposition characterizes the relationship between recalled evidence and subjective uncertainty at the individual level.

**Proposition 4.** ***(Subjective uncertainty and recalled net evidence)*** *Subjective uncertainty $U_i$ is a strictly decreasing function of the absolute recalled net evidence*

$$|D_i| = |X_i^+ - X_i^-|.$$

*Equivalently, subjective uncertainty is maximized when recalled positive and negative signals are balanced, and decreases as recalled evidence becomes more one-sided.*

The proof is provided in Appendix I. The intuition is immediate. When recalled positive and negative signals are nearly balanced, the posterior lies close to $1/2$, so subjective uncertainty is high. When recalled evidence is more one-sided, the posterior becomes more extreme and subjective uncertainty falls.

We now turn to comparative statics for expected subjective uncertainty across informational environments. Define informational ambivalence in the underlying signal set as

$$A = 1 - \frac{|N^+ - N^-|}{N},$$

where $N^+$ and $N^-$ denote the numbers of positive and negative signals and $N = N^+ + N^-$.

**Proposition 5.** ***(Expected subjective uncertainty)*** *Under the normal approximation, holding $N$ and $p$ fixed, expected subjective uncertainty across decision-makers, $E[U_i]$, is increasing in informational ambivalence $A$.*

The proof is provided in Appendix J. Informational ambivalence determines how balanced the stored signal history is. When positive and negative signals occur in similar numbers, stochastic recall more frequently generates realizations in which recalled evidence is nearly balanced. Since balanced recalled evidence produces posterior beliefs closer to 1/2, environments with higher informational ambivalence exhibit greater subjective uncertainty on average.

The effect of recall probability on expected subjective uncertainty is more subtle. When the stored history has a clear majority of one signal type, increasing recall probability tends to make recalled evidence more representative of the underlying history, which typically reduces subjective uncertainty. However, this effect is not globally monotone. In particular, if the stored history is exactly balanced, then more complete recall can increase subjective uncertainty by making recalled evidence more balanced with greater probability. For this reason, unlike disagreement and instability, expected subjective uncertainty is not in general monotone in $p$ without additional restrictions on the underlying signal composition.

These results parallel the earlier comparative statics for disagreement and instability. Informational ambivalence increases disagreement, instability, and subjective uncertainty because it increases the likelihood that recalled evidence is balanced. More generally, stochastic recall generates heterogeneity not only in the direction of beliefs, but also in the confidence with which those beliefs are held.

## 4.5 Posterior Consensus, Uncertainty Heterogeneity, and Stability under Imperfect Recall

We now summarize the implications of imperfect recall for three benchmark properties often associated with shared information: posterior consensus, common subjective uncertainty, and belief stability.

**Theorem 1** (Posterior Consensus, Uncertainty Heterogeneity, and Stability under Imperfect Recall)**.** *Suppose decision-makers share a common prior, observe and store the same finite signal history containing at least one positive and one negative signal, and recall each signal indepen-*

*dently with probability $p \in (0,1)$ at each belief-formation date. Decision-makers update optimally based on recalled information. Then:*

1. *with strictly positive probability, realized binary beliefs disagree across agents;*
2. *with strictly positive probability, subjective uncertainty differs across agents;*
3. *with strictly positive probability, a given agent's realized binary belief differs across two elicitations with no new information.*

*Moreover, if the stored history has a strict majority, disagreement, uncertainty heterogeneity, and instability all converge to zero as $p \to 1$, and are identically zero when $p = 1$.*[5]

**Proof intuition** With both positive and negative signals present, any recall draw has strictly positive probability of yielding different realized balances of recalled positive and negative signals. Because realized binary beliefs depend on recalled net evidence, independent recall across agents implies that different agents may form different realized beliefs, generating disagreement. The same logic applies across time for a given agent, so fresh recall draws can generate belief revisions even when no new information arrives.

The same recall variation also generates heterogeneity in subjective uncertainty. When recalled positive and negative signals are nearly balanced, the posterior lies close to 1/2 and subjective uncertainty is high. When recalled evidence is more one-sided, the posterior is more extreme and subjective uncertainty is low. Since different agents may recall differently balanced subsets of the same signal history with strictly positive probability, subjective uncertainty also differs across agents with strictly positive probability.

Perfect recall is the only case in which all agents retrieve the same signal history. In that case, realized binary beliefs coincide, subjective uncertainty is identical across agents, and beliefs are stable over time.

[5] Our mechanism is also related to the evidence in Augenblick and Rabin (2021) on belief movement, uncertainty reduction, and rational updating. Under stochastic recall, beliefs can change even in the absence of new information because different subsets of previously observed signals are retrieved at different times. As a result, the model can generate belief movement that is not systematically accompanied by uncertainty reduction, providing a natural mechanism for excess belief movement.

## 4.6 Contextual Cues

We now extend the baseline setting to analyze the role of associative memory in shaping disagreement and subjective uncertainty. The central intuition is simple. Cues that reinforce the signal type already dominant in memory make recalled evidence more one-sided and therefore compress disagreement and uncertainty. By contrast, cues that reinforce minority signals initially make recalled evidence more balanced, which can increase disagreement and uncertainty, but sufficiently strong cues eventually overcome the underlying imbalance and reduce both outcomes.

Each signal $S_i$ is associated with a context $C_i$, such as a story or an image. We consider a contextual cue that does not itself constitute a signal and does not provide new information, but matches the context associated with some stored signals. Importantly, this mechanism operates through changes in retrieval probabilities rather than through distortions in signal weighting. By virtue of contextual similarity, the cue increases the probability that matched signals are recalled, consistent with associative memory mechanisms documented in Bordalo, Conlon, Gennaioli, Kwon and Shleifer (2023).

We assume that all positive signals share one context and all negative signals share another, distinct context.[6] A contextual cue matches the context associated with one signal type—either positive or negative—and increases the probability of recalling each matched signal by $a > 0$. As a result, the recall probability for the cued signal type rises from $p$ to $\widetilde{p} = p + a$, while the recall probability for the non-cued type remains equal to $p$. Feasibility requires

$$a \in (0, 1 - p].$$

Depending on which signal type is cued, the cue may therefore enhance recall of either the dominant signal type (the majority in the memory database) or the non-dominant signal type (the minority).

Let $\mathsf{Var}(\widehat{Y}_i)|_{\text{cue}}$ denote the cross-sectional variance of realized beliefs in the presence of a cue and $\mathsf{Var}(\widehat{Y}_i)|_{\text{no cue}}$ the corresponding variance without a cue. Let $U_i = \mu_i(1-\mu_i)$ denote individual subjective uncertainty and $E[U_i]|_{\text{cue}}$ the expected level of uncertainty across agents in the presence of a cue.

[6] The analysis extends straightforwardly to settings in which signals of the same sign are associated with multiple contexts, so that a cue matches only a subset of positive or negative signals.

Two model-implied thresholds summarize the comparative statics under minority cueing. The first threshold,

$$\Delta = \frac{(2\lambda-1)^2 p(1-2p) - 2(2\lambda-1)p(1-p)}{\lambda(1-p) + (2\lambda-1)^2 p},$$

governs the effect of minority cueing on disagreement, where $\lambda$ denotes the proportion of the cued signal type in the memory database. The second threshold,

$$\Theta = \frac{|N^+ - N^-|p}{N^m}, \qquad N^m = \min\{N^+, N^-\},$$

governs the effect of minority cueing on expected subjective uncertainty under the mean-based approximation described below.

For subjective uncertainty, we use a mean-based approximation. Since subjective uncertainty is decreasing in the absolute recalled net evidence, we approximate expected subjective uncertainty by a decreasing function of the absolute expected recalled net evidence,

$$|E[D_i]|, \qquad D_i \equiv X_i^+ - X_i^-.$$

**Proposition 6.** ***(Associative memory, disagreement, and subjective uncertainty)*** *Let $a \in (0, 1-p]$ denote the strength of a contextual cue that increases the recall probability of one signal type from $p$ to $p+a$.*

1. ***Cueing dominant signals and disagreement.*** *If the cue enhances recall of the signal type that constitutes the majority in the memory database, belief disagreement decreases:*

$$\mathsf{Var}(\widehat{Y}_i)|_{cue} < \mathsf{Var}(\widehat{Y}_i)|_{no\ cue}.$$

2. ***Cueing non-dominant signals and disagreement.*** *If the cue enhances recall of the minority signal type, disagreement increases if $a < \Delta$, is unchanged if $a = \Delta$, and decreases if $a > \Delta$.*

3. ***Cueing dominant signals and subjective uncertainty.*** *Under the mean-based approximation above, if the cue enhances recall of the dominant signal type, expected subjective uncertainty decreases:*

$$E[U_i]|_{cue} < E[U_i]|_{no\ cue}.$$

4. ***Cueing non-dominant signals and subjective uncertainty.*** *Under the same mean-based approximation, if the cue enhances recall of the minority signal type, expected subjective uncertainty increases if $a < \Theta$, is maximized if $a = \Theta$, and decreases if $a > \Theta$.*

Appendix K provides proof details. Proposition 6 shows how contextual cues interact with memory structure to shape both belief dispersion and subjective uncertainty. Cueing dominant signals produces unambiguous convergence in beliefs and reductions in uncertainty. By reinforcing the signal type that already dominates agents' memory databases, the cue increases overlap in recalled information across decision-makers and makes recalled evidence more one-sided.

Cueing non-dominant signals generates richer effects. Weak cues increase the recall of minority signals without fully offsetting their numerical disadvantage. This makes recalled evidence more balanced on average and can therefore increase both disagreement and subjective uncertainty. Only sufficiently strong cues overcome the underlying signal imbalance and recall noise. Once cue strength exceeds the relevant threshold, recalled evidence becomes more similar across agents and more one-sided overall, reducing both disagreement and uncertainty.

Overall, the results in this section yield a unified set of comparative statics. Informational ambivalence raises disagreement, instability, and subjective uncertainty by making recalled evidence more balanced. Higher recall probability lowers disagreement and instability, while it can also reduce subjective uncertainty when one signal type is clearly dominant. Contextual cues can either compress or amplify disagreement and uncertainty depending on whether they reinforce the dominant or minority component of memory.

## 5 Belief Disagreement Experiment

This section provides causal evidence for the mechanism embedded in the model. The theory predicts that stochastic recall can generate belief disagreement even when individuals share common priors and observe identical information. Observational data alone cannot cleanly separate this mechanism from confounding factors such as heterogeneous information sets, differential attention, or divergent priors. The experiment addresses these concerns by holding the information environment fixed across participants while varying retrieval conditions only after information exposure. This design enables direct tests of the comparative statics for disagreement, subjective uncertainty, and contextual cues derived in Propositions 2, 4, 5, and 6.

### 5.1 Design of Experiment 1

**Experiment 1: Belief Disagreement Experiment** Participants form beliefs about the quality of a hypothetical company in a stylized asset-evaluation task. The company is described as

objectively either "good" or "bad," with equal ex-ante probability. Participants are informed of a common signal-generating process: for a good company, positive signals occur with probability 0.65 and negative signals with probability 0.35, while for a bad company the reverse holds. Information is conveyed through a sequence of binary signals ("news") embedded in short contextual narratives consisting of brief stories and accompanying images.

For identification, however, the realized signal history shown to participants is fixed by design within each treatment group. Thus, all participants within a group observe the same realized sequence of signals, even though the instructions describe the general signal-generating environment. This distinction is important: the experiment holds fixed the objective information history and tests whether differences in retrieval of that common history generate disagreement.

The experiment uses a between-subject design with nine treatment groups. The groups vary along three dimensions: informational ambivalence, retrieval effort, and contextual cues. Across all groups, participants observe 20 signals. Apart from the targeted manipulations described below, the information environment is held fixed within each group. The complete signal sequences are reported in Section 3 of the questionnaire in the Appendix.

**Treatment groups** The nine groups are organized into three sets.

**Groups 1–5 (information ambivalence)** These groups vary the composition $(N^+, N^-)$ of the realized signal history while holding the total number of signals fixed. This manipulation tests Proposition 2, which predicts that disagreement increases with informational ambivalence.

Group 1 receives $N^+ = 18$ and $N^- = 2$ signals ($A = 0.2$),

Group 2 receives $N^+ = 14$ and $N^- = 6$ signals ($A = 0.6$),

Group 3 receives $N^+ = 11$ and $N^- = 9$ signals ($A = 0.9$),

Group 4 receives $N^+ = 6$ and $N^- = 14$ signals ($A = 0.6$),

Group 5 receives $N^+ = 2$ and $N^- = 18$ signals ($A = 0.2$).

These groups are symmetric around the balanced case. Groups 1 and 5 have the same low degree of ambivalence but opposite signal valence, while Groups 2 and 4 have the same intermediate degree of ambivalence but opposite signal valence. This symmetry helps isolate ambivalence from the overall direction of the signal stream.

**Groups 6–7 (recall effort)** Groups 6 and 7 use the same realized signal history as Group 3, the most ambivalent environment, but manipulate retrieval conditions after information exposure. These treatments are designed to increase retrieval effort and, in the model, map to a higher effective recall probability at the moment beliefs are formed. In Group 6, we implement a *Stop-and-Think* procedure in which participants complete a structured recall module *before* reporting beliefs.[7] Because this intervention occurs only after all information has been observed, it is designed to affect retrieval rather than exposure to or encoding of signals. In Group 7, we layer *Incentivized Recall* onto this design by combining the same Stop-and-Think procedure with a surprise monetary reward for accurate recall. Since both interventions are introduced only after the information exposure stage, they cannot affect which signals participants observe and instead are intended to increase effort devoted to retrieving stored information before belief formation.

**Groups 8–9 (contextual cues)** Groups 8 and 9 use the same signal composition as Group 2 but introduce contextual cues to test Proposition 6. In Group 8, the image associated with positive signals is used as a cue to enhance recall of majority signals. In Group 9, the image associated with negative signals is used to cue minority signals. Participants are explicitly told that the images are illustrative only and contain no information about whether the company is good or bad; this is reinforced through a comprehension check. Because cues are introduced only at the belief-elicitation stage, after the full signal history has already been observed, they operate through retrieval rather than through attention at exposure.

**Procedures** Participants first read detailed instructions describing the prior, the signal structure, the independence of draws (sampling with replacement), and the incentive scheme. To impose a common prior, all participants are told that the company is ex ante equally likely to be good or bad, so that $P(G) = 0.5$. To impose a common signal structure, all participants are told that signals have diagnosticity $b = 0.65$: a good company generates positive news with probability 0.65, while a bad company generates positive news with probability 0.35.

Participants then complete seven multiple-choice comprehension checks, with answer-order

[7] Operationally, Stop-and-Think reverses the order of belief elicitation and recall: recall questions are administered immediately after the final news item and before any belief questions.

randomized across respondents.[8] Afterward, participants observe the sequence of 20 news items, presented sequentially as short contextual events with illustrative images.

After exposure, participants report both a binary belief and a probabilistic belief about the company's type.[9] Participants then complete recall tasks eliciting the number of positive and negative signals remembered as well as the valence of the 1st, 5th, 15th, and last signals. In Groups 6 and 7, recall tasks precede belief elicitation; Group 7 additionally includes the surprise monetary reward for accurate recall. Full procedural details and screenshots are provided in the Appendix.

**Why the design identifies retrieval** The identifying logic of the experiment is that the key interventions operate after information exposure. All participants within a treatment group observe the same realized signal history under the same presentation conditions. The retrieval-effort interventions and contextual cues are introduced only after the signal sequence has already been seen. As a result, these treatments do not affect which signals participants observe. Instead, they are designed to affect which stored signals are retrieved when participants form beliefs.

This timing is central for separating retrieval from attention and encoding. If the treatments shifted exposure to information, then treatment effects could reflect heterogeneous acquisition. Here, by construction, the treatments shift the retrieval environment after exposure. The same logic also motivates the Belief Instability Study below, where beliefs are re-elicited with no new information. Taken together, the evidence allows us to isolate retrieval as the relevant margin.

**Sample** The Belief Disagreement Experiment was conducted online via Prolific. Data collection began on 18 November 2025 and lasted eight days. Approximately 6,500 respondents were initially recruited from a broad U.S. general-population sample. About 75 percent passed all comprehension checks, yielding approximately 4,700 valid completed responses.[10] The median completion time was approximately 15 minutes. Appendix Table A.6 summarizes respondent

[8] The comprehension checks verify: (i) that more positive (negative) news makes the company more likely to be good (bad); (ii) that news draws are independent and with replacement; (iii) that the same event can occur multiple times and should be counted each time; and (iv) that illustrative images contain no information beyond the text. Participants can proceed only after answering all comprehension questions correctly.

[9] Probabilistic beliefs are elicited as percentage probabilities. Respondents are randomly asked to report either $P(\text{good})$ or $P(\text{bad})$. We place all responses on a common scale by defining $p_i = P(\text{good})$ when $P(\text{good})$ is elicited directly, and $p_i = 1 - P(\text{bad})$ otherwise.

[10] We also exclude respondents who report taking notes during the information screens, around 2.5 percent of the sample.

demographics across treatment groups.

**Incentives** Participants received a fixed participation payment of $2. In addition, they earned a $0.50 bonus if their belief about the company's type was correct. Participants in Group 7 earned an additional $0.50 bonus for accurate recall.

## 5.2 Retrieval versus Attention and Encoding

A natural concern is that the patterns we document reflect heterogeneity in attention or encoding at the time information is first presented rather than stochastic retrieval when beliefs are formed. Several features of the design help distinguish these mechanisms.

First, all participants within a group are exposed to the same sequence of information under identical conditions. The treatments therefore do not change the information participants observe. Second, respondents complete comprehension and attention-screening questions before the information stage. These checks ensure that participants understand the task, the signal structure, and the incentive environment before entering the main experiment. Although they do not directly measure encoding during exposure, they help rule out explanations based on misunderstanding or careless responding. Third, belief elicitation is accuracy-incentivized in all groups, and recall is additionally incentivized in Group 7. These incentives encourage careful reporting and reduce the likelihood that treatment effects reflect random responding or classical measurement error. Fourth, the retrieval-effort and cue manipulations occur only after the exposure stage. Stop-and-Think and the surprise recall incentive are introduced after all signals have been observed, so they cannot affect which signals participants initially saw. Likewise, contextual cues are shown only at the belief-elicitation stage, after the full information sequence is complete. Any resulting treatment effects therefore operate through retrieval of stored information rather than through differences in acquisition. Finally, the Belief Instability Study below provides complementary evidence from a design in which the information set is held fixed over time and no new information arrives between elicitations. Under those conditions, systematic belief changes must arise from changes in retrieved information rather than from new signals.

Overall, the evidence relies on three distinct sources of identification: post-exposure retrieval interventions, contextual cue manipulations at the belief stage, and repeated belief elicitations

under a fixed information set. The fact that all three margins point to the same mechanism strengthens the interpretation that stochastic retrieval, rather than heterogeneous attention or information acquisition, drives disagreement and belief dynamics.

## 5.3 Predictions and Experimental Findings: Disagreement

This subsection documents three experimental facts about belief disagreement under imperfect recall. Let $D_g$ denote disagreement in group $g$, measured as the cross-sectional variance of participants' reported binary beliefs about the company's type.

The model yields three sharp predictions. First, disagreement should increase with informational ambivalence. Second, holding the signal history fixed, interventions that increase retrieval effort should reduce disagreement. Third, contextual cues should have asymmetric effects: cueing dominant signals should reduce disagreement, while cueing minority signals can increase disagreement when the cue is sufficiently weak.

**Fact 6: Disagreement increases with informational ambivalence.** Groups 1–5 vary informational ambivalence while holding the total number of signals fixed. Proposition 2 predicts

$$D_3 > \{D_2, D_4\} > \{D_1, D_5\}.$$

The data strongly support this ordering. As shown in the top panel of Figure 6, disagreement is highest in Group 3, where positive and negative signals are most balanced, with variance 0.640. Disagreement is substantially lower in the least ambivalent environments, Groups 1 and 5, with variances 0.039 and 0.047, respectively, and takes intermediate values in Groups 2 and 4, 0.199 and 0.187. Thus, despite identical priors and identical information histories within group, disagreement is greatest when the signal history is most ambivalent.

**Fact 7: Increased retrieval effort reduces disagreement.** Groups 6 and 7 hold the information environment fixed at the high-ambivalence level of Group 3 while increasing retrieval effort after exposure. Proposition 2 predicts

$$D_3 > \{D_6, D_7\}.$$

Consistent with this prediction, both interventions substantially reduce disagreement. The variance of beliefs falls from 0.640 in Group 3 to 0.370 under Stop-and-Think (Group 6) and to 0.135 under Incentivized Recall (Group 7). Both reductions are statistically significant ($p$ value

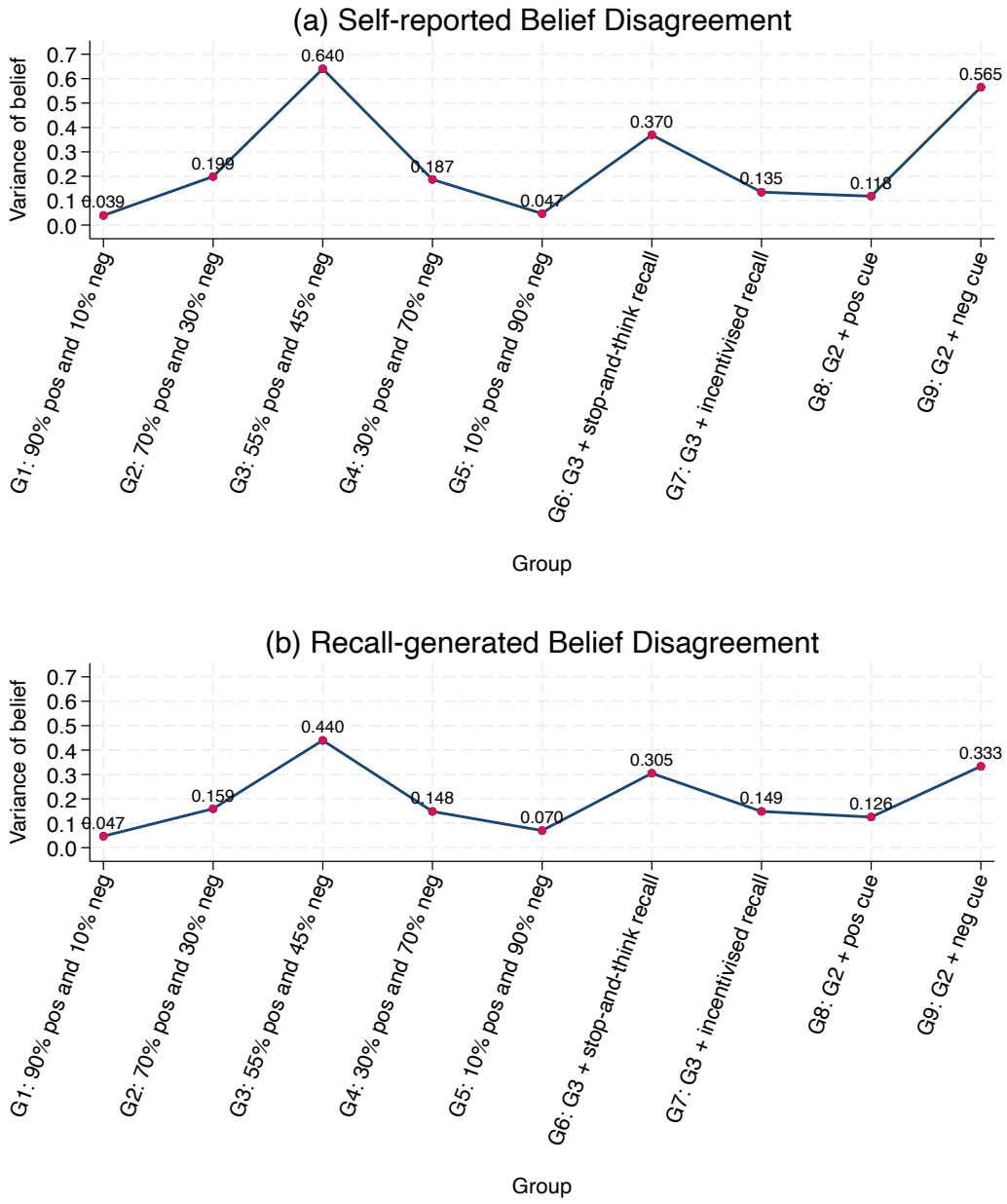



**Figure 6:** DISAGREEMENT ABOUT THE COMPANY STATE BY GROUP (REPORTED AND RECALL-GENERATED BELIEFS)

*Notes:* The figure plots disagreement in participants' binary beliefs across the nine experimental groups. Disagreement in the top figure (self-reported beliefs) is measured as the cross-sectional variance of an indicator for believing the company is "good" (1) versus "bad" (-1) within each treatment. Disagreement in the bottom figure (recall-generated beliefs) is coded as 1 if the number of recalled positive signals is greater than the number of recalled negative signals, and -1 otherwise. Groups 1–5 vary the degree of information ambivalence while holding the number of signals fixed; Groups 6 and 7 keep the signal composition of Group 3 but increase recall effort (via Stop-and-Think or incentivized recall). Groups 8 and 9 keep the signal composition of Group 2 and introduce associative memory cues: cueing dominant positive signals (Group 8) and cueing non-dominant negative signals (Group 9).

<0.01). Relative to the high-ambivalence baseline, incentivized recall lowers disagreement by nearly 80 percent.

**Fact 8: Contextual cues have asymmetric effects on disagreement.** Groups 8 and 9 share the same signal composition as Group 2 but introduce contextual cues that asymmetrically affect retrieval. Proposition 6 predicts that cueing dominant signals reduces disagreement,

$$D_2 > D_8,$$

whereas cueing minority signals can increase disagreement when the cue is weak,

$$D_2 < D_9 \qquad \text{if } a < \Delta.$$

The data match these implications closely. Cueing the dominant positive signal type in Group 8 slightly reduces disagreement relative to the no-cue benchmark in Group 2. By contrast, cueing minority negative signals in Group 9 substantially increases disagreement: belief variance rises to 0.565, almost tripling relative to Group 2.

Using the analytical expressions in Proposition 6, the implied cue strength in Group 9 is $a = \widetilde{p} - p = 0.26$, while the corresponding threshold is $\Delta = 0.87$. Because $a < \Delta$, the cue is weak in the model's sense, and the observed increase in disagreement is fully consistent with the theory.

## 5.4 Mechanism: Recall-Generated Beliefs and Retrieval Shifts

We now turn to the mechanism. The model implies that beliefs are formed by comparing recalled positive and negative signals. The experiment allows us to test this mechanism directly because we observe both participants' stated beliefs and their recalled signal counts.

**Recall-generated beliefs closely match reported beliefs** For each participant, we substitute the number of recalled positive and negative signals into equation (3.1) to construct an individual-level binary *recall-generated belief*. We then compare this mechanically generated belief to the participant's directly reported belief.

The alignment is extremely strong. Appendix Table A.7 shows that reported beliefs increase monotonically with the share of recalled positive signals and are strongly predicted ($p$ value <0.01) by an indicator for whether recalled positives exceed recalled negatives. Across specifications, recalled information is a powerful predictor of beliefs: the sign of recalled signal balance alone explains more than 80 percent of the variation in reported beliefs. Most notably,

**Table 3:** EFFECT OF STOP-AND-THINK AND MONETARY INCENTIVIZATION

| Dep. Variable: Absolute recall error | (1) | (2) |
|---|---|---|
| Group 3 | 3.737*** | 3.817*** |
| | (0.115) | (0.426) |
| Relative to Group 3 | | |
| Group 6: Group 3 + Stop-and-Think | -0.586*** | -0.553*** |
| | (0.186) | (0.189) |
| Group 7: Group 3 + incentivized recall | -0.846*** | -0.849*** |
| | (0.151) | (0.153) |
| Demographics | | ✓ |
| Observations | 1576 | 1576 |
| R-squared | 0.016 | 0.032 |

*Notes:* This table compares recall accuracy across Groups 3, 6, and 7. The dependent variable is the absolute recall error in the percentage-point share of positive news received. Group 3 is the omitted reference category. Group 6 adds a Stop-and-Think prompt (structured recalls elicited before belief reporting), and Group 7 adds monetary incentives for accurate recall; reported coefficients for Groups 6 and 7 are differences relative to Group 3. Column (2) includes the full set of demographic controls. Robust standard errors are in parentheses.

**Table 4:** EFFECT OF CUES ON MEMORY RECALL

| Dep. Variable: Share of recalled positive news | (1) | (2) |
|---|---|---|
| Group 2 | 59.395*** | 59.131*** |
| | (0.205) | (0.946) |
| Relative to Group 2 | | |
| Group 8: Group 2 + pos cue | 8.548*** | 8.503*** |
| | (0.350) | (0.352) |
| Group 9: Group 2 + neg cue | -3.103*** | -3.122*** |
| | (0.340) | (0.341) |
| Demographics | | ✓ |
| Observations | 1603 | 1603 |
| R-squared | 0.410 | 0.419 |

*Notes:* The table reports estimates of the effect of memory cues on the share of recalled positive news. The dependent variable is the share of recalled positive signals among all recalled signals. Group 2 is the reference group; coefficients for Groups 8 and 9 report differences relative to Group 2. Robust standard errors are in parentheses.

recall-generated beliefs match reported beliefs for 98 percent of participants.[11] This close correspondence is one of the clearest pieces of evidence in favor of the stochastic recall mechanism.

**Interventions shift retrieval in the predicted direction** The bottom panel of Figure 6 computes disagreement using recall-generated beliefs only. This isolates the retrieval channel because the object is constructed mechanically from recalled signals rather than from self-reported beliefs. The same treatment pattern reappears. Disagreement in recall-generated beliefs peaks in the most ambivalent environment (Group 3; variance 0.440), is low in the least ambivalent

[11] This excludes cases in which participants recall equal numbers of positive and negative signals. Including such cases reduces the consistency rate only slightly. Appendix Figure A.4 replicates the disagreement analysis using only participants for whom recall-generated and reported beliefs coincide and yields very similar patterns.

environments (Groups 1 and 5; 0.047 and 0.070), and is intermediate in Groups 2 and 4 (0.159 and 0.148). Increasing retrieval effort compresses disagreement relative to Group 3, from 0.440 to 0.305 under Stop-and-Think (Group 6) and to 0.149 under Incentivized Recall (Group 7). Associative cues also shift recall-generated disagreement relative to the no-cue baseline Group 2 (0.159), lowering it under the positive cue (Group 8; 0.126) and raising it under the negative cue (Group 9; 0.333).

These movements are attributable to changes in retrieval because they are computed solely from recalled signals. They therefore cannot be driven by heterogeneous priors or idiosyncratic reporting noise.

Two additional tables quantify the retrieval shifts directly. Table 3 shows that retrieval-effort interventions improve recall precision. The dependent variable is the absolute recall error, measured in percentage points, in the share of positive signals received. In the baseline Group 3, mean absolute error is 3.737 percentage points. Stop-and-Think (Group 6) reduces absolute error by 0.586 percentage points, a 16 percent improvement relative to Group 3, while Incentivized Recall (Group 7) reduces error by 0.846 percentage points, about 23 percent relative to Group 3.

Table 4 shows that contextual cues shift the composition of recalled signals. In the uncued baseline Group 2, the average recalled-positive share is about 59.4 percent. A positive cue (Group 8) increases this share by 8.55 percentage points, whereas a negative cue (Group 9) decreases it by 3.10 percentage points. These are economically meaningful shifts in retrieval composition, large enough to move a nontrivial fraction of participants across the recall-balance threshold that determines recall-generated beliefs.

## 5.5 Ruling Out Alternative Explanations

Several alternative mechanisms could potentially account for the observed disagreement patterns. The data provide little support for them.

First, one might worry that recall depends systematically on signal position or signal valence rather than on stochastic retrieval more generally. This is not what the data show. Recall accuracy does not depend significantly on signal position or signal valence, as evidenced by recall of the 1st, 5th, 15th, and last signals.

Second, disagreement differences across Groups 1–5 might reflect systematic differences in recall accuracy across levels of informational ambivalence. Appendix Table A.8 rejects this expla-

nation: despite large treatment differences in ambivalence, there are no systematic differences in absolute count-recall errors across Groups 1–5.

Third, recall accuracy might vary systematically with demographics such as age, income, education, or employment status. Appendix Table A.9 shows that recall accuracy is not systematically related to these characteristics.

Fourth, in the cue treatments, disagreement might arise because different participants perceive the cue-signal similarity differently. Appendix Table A.10 shows that demographics do not predict recall accuracy in Groups 8 and 9, suggesting that heterogeneity in perceived cue similarity is not the main source of the effect.

Fifth, one might worry that participants externally recorded the signal sequence, for example using pen and paper. If so, recall accuracy should be nearly perfect. In fact, fewer than 0.5 percent of participants in any group answer all recall questions correctly, indicating that such behavior is negligible.

Finally, one could imagine that participants perfectly recall their most recent beliefs rather than past signals and then update non-Bayesianly to varying degrees. Under such an account, contextual cues and retrieval-effort interventions should have little or no effect on beliefs or disagreement, because these treatments do not change the previously reported belief. This prediction is strongly rejected in the data. Disagreement shifts substantially across cue treatments, and both Stop-and-Think and Incentivized Recall markedly reduce disagreement. These patterns support imperfect recall of signals, rather than perfect recall of prior beliefs, as the main driver of disagreement.

## 5.6 Quantitative Estimation

We next discipline the memory-based model using a simulation-based minimum-distance procedure. The goal is to assess whether the model can account not only for the qualitative treatment ordering but also for the magnitude of shifts in beliefs, disagreement, and recall across groups.

The baseline model features a recall probability $p$ governing Bernoulli sampling of each stored signal. Given a treatment group $g$ with $N_g^+$ positive and $N_g^-$ negative signals, the model implies recalled counts $(X_{ig}^+, X_{ig}^-)$ and an individual binary belief $\widehat{Y}_{ig}$ determined by equation (3.1).

For any candidate parameter vector, we compute model moments by Monte Carlo simula-

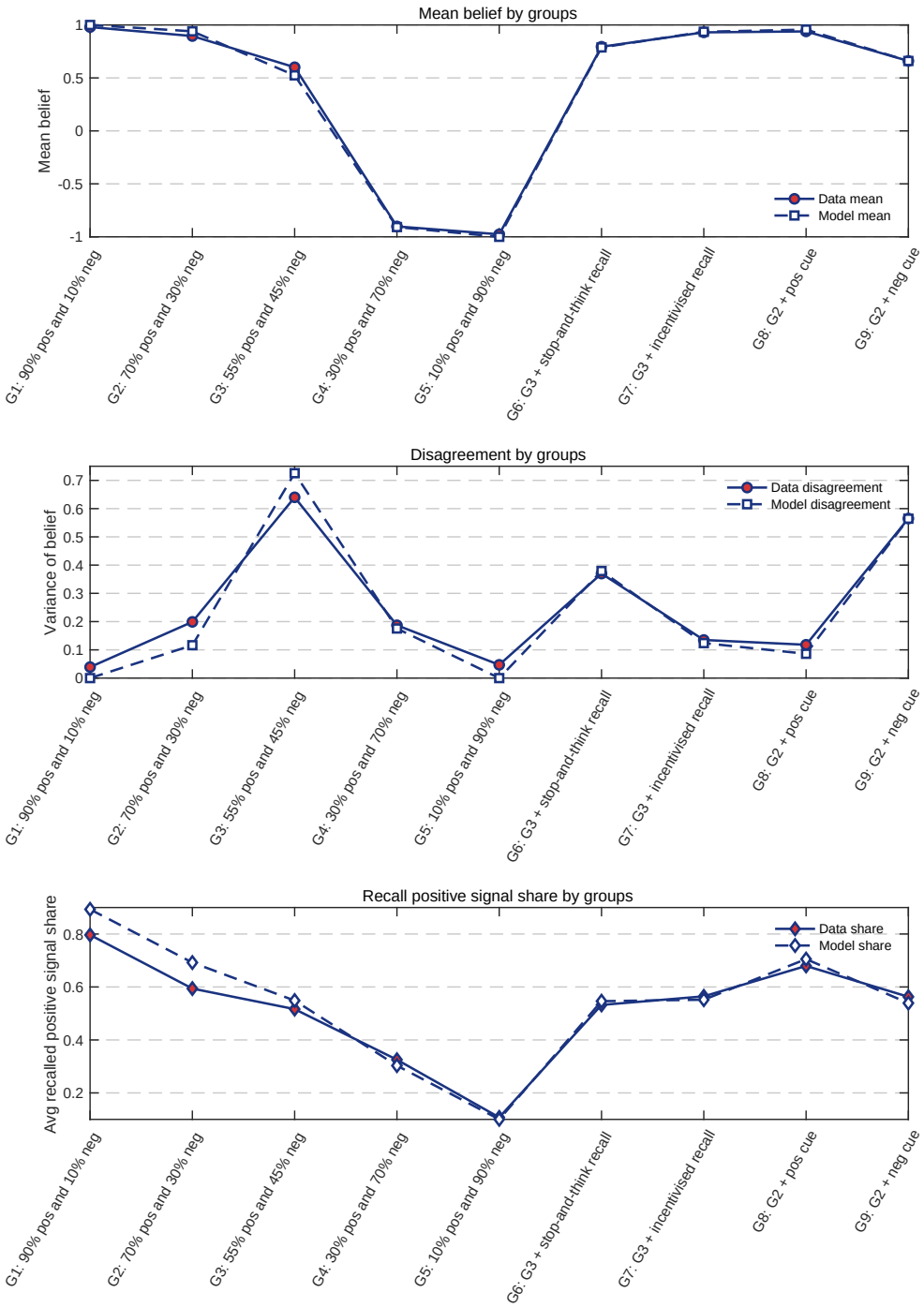



**Figure 7:** MODEL FIT: BELIEFS, DISAGREEMENT, AND RECALL ACROSS TREATMENTS

*Notes:* The figure compares experimental moments (solid) with model-implied moments (dashed) across nine groups, evaluated at the estimated parameter vector $(\hat{p}, \hat{p}_6, \hat{p}_7, \hat{a}, \hat{b})$. Top panel: within-group mean belief. Middle panel: within-group variance of binary beliefs (disagreement). Bottom panel: average share of recalled positive signals. Groups 1–5 identify a common baseline recall probability, estimated as $\hat{p} = 0.51$. Groups 6–7 share the Group 3 signal mix but increase recall effort and are fitted with $\hat{p}_6 = 0.81$ (Stop-and-Think) and $\hat{p}_7 = 0.90$ (Incentivized Recall). Groups 8–9 share the Group 2 mix and add contextual cues; holding $p = \hat{p}$ fixed, Group 8 increases the recall probability of positive signals by $\hat{a} = 0.02$, while Group 9 increases the recall probability of negative signals by $\hat{b} = 0.475$.

tion. Specifically, we draw $R = 500$ realizations of recalled positive and negative signals from independent binomial distributions,

$$X_{ig}^{+} \sim \text{Bin}(N_g^{+}, p_g^{+}), \qquad X_{ig}^{-} \sim \text{Bin}(N_g^{-}, p_g^{-}),$$

construct simulated beliefs

$$\widehat{Y}_{ig} = 1\{X_{ig}^{+} > X_{ig}^{-}\} - 1\{X_{ig}^{+} \leq X_{ig}^{-}\},$$

and compute the implied mean belief

$$M_g^{\text{mod}} = \mathbb{E}(\widehat{Y}_{ig}),$$

which we match to the corresponding experimental moment $M_g^{\text{exp}}$.

Groups 1–5 form the baseline environment, in which recall is governed by a single common probability $p$.[12] We estimate $p$ by minimizing

$$\sum_{g=1}^{5} \left(M_g^{\text{mod}}(p) - M_g^{\text{exp}}\right)^2.$$

Groups 6 and 7 share the same signal mix as Group 3 but introduce retrieval-effort interventions. We estimate group-specific recall probabilities, $p_6$ and $p_7$, by matching the model-implied mean belief in each group to its experimental counterpart. These estimates capture how the retrieval interventions shift effective recall probabilities relative to the Group 3 baseline.

Groups 8 and 9 share the Group 2 signal mix but introduce contextual cues that distort recall asymmetrically. In Group 8, the positive cue raises the recall probability of positive signals only,

$$p_8^{+} = \hat{p} + a, \qquad p_8^{-} = \hat{p},$$

while in Group 9 the negative cue raises the recall probability of negative signals only,

$$p_9^{+} = \hat{p}, \qquad p_9^{-} = \hat{p} + b,$$

with $a, b \geq 0$. Holding the baseline recall probability fixed at $\hat{p}$, we estimate $a$ and $b$ by matching model-implied and experimental mean beliefs in the two cue treatments.

Figure 7 compares experimental moments with model-implied moments evaluated at the estimated parameter vector $(\hat{p}, \hat{p}_6, \hat{p}_7, \hat{a}, \hat{b})$. The top panel shows that the model closely matches the level and ordering of mean beliefs across groups. The middle panel shows that the model reproduces the central non-monotonic disagreement pattern implied by informational ambiva-

[12] This restriction is supported by the mechanism evidence above, which shows no significant differences in recall accuracy across Groups 1–5.

lence: disagreement is lowest under one-sided evidence, rises at intermediate ambivalence, and peaks when the signal stream is most balanced. It also matches the large reductions in disagreement produced by retrieval effort and the divergence between the two cue treatments. The bottom panel shows that the model also closely tracks the recalled share of positive signals across treatments. This fit is informative because it validates the mechanism directly: the same parameter values that explain belief disagreement also explain retrieval patterns.

Overall, the estimated parameters show that the memory-sampling model accounts for the main qualitative patterns and a large share of the quantitative variation in mean beliefs, disagreement, and recall across all nine treatments.

## 5.7 Predictions and Experimental Findings: Subjective Uncertainty

The same retrieval variation that generates disagreement also has implications for subjective uncertainty. Under the model, balanced recalled evidence yields posterior beliefs closer to 50–50 and therefore higher uncertainty, while one-sided recalled evidence yields more extreme posteriors and lower uncertainty.

We measure subjective uncertainty using participants' probabilistic beliefs. Let $p_i \in [0,1]$ denote respondent $i$'s reported probability that the company is good, after placing all responses on a common scale. Define

$$U_i = p_i(1 - p_i),$$

which is maximized at $p_i = 0.5$ and decreases as beliefs become more extreme. Let $U_g = E[U_i \mid i \in g]$ denote average uncertainty in group $g$.

**Fact 9: At the individual level, realized net imbalance strongly predicts subjective uncertainty.** Figure 8 illustrates the central micro-level mechanism. Subjective uncertainty is highest when recalled positive and negative signals are relatively balanced, and declines as recalled evidence becomes more skewed toward one side. Intuitively, balanced recalled evidence supports less decisive posterior beliefs, whereas larger realized imbalances push posterior beliefs away from the center and reduce uncertainty. Appendix Table A.11 (Panel A) shows that this relationship is statistically strong and precisely estimated. The coefficient on realized net imbalance is $-0.003$ ($p < 0.01$), with similar estimates after controlling for demographics. While the per-unit effect is mechanically small, economically meaningful changes in recalled imbalance imply sizeable

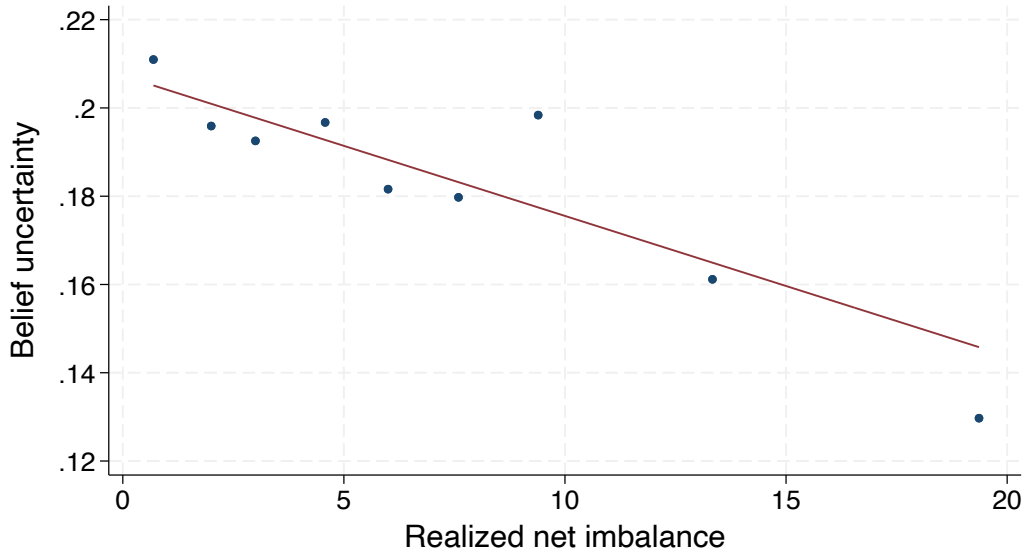



**Figure 8:** REALIZED NET IMBALANCE AND BELIEF UNCERTAINTY

*Notes:* The figure plots binned averages of individual belief uncertainty $U_i = p_i(1-p_i)$ against realized net imbalance, defined as the absolute value of $(X_i^+ - X_i^-)$, where $X_i^+$ and $X_i^-$ denote the numbers of positive and negative items recalled. The solid line is the fitted linear relationship. Appendix Table A.11 (Panel A) reports the corresponding individual-level regression estimates and inference.

changes in uncertainty: moving from a balanced recalled draw to a net imbalance of 10 lowers belief uncertainty by 0.03, or about 12% of the full theoretical range of $U_i \in [0, 0.25]$. Thus, more one-sided recalled evidence is associated with substantially lower belief uncertainty, while more balanced recalled evidence is associated with higher uncertainty. This pattern is consistent with Proposition 4.

**Fact 10: Subjective uncertainty increases with informational ambivalence.** Groups 1–5 vary informational ambivalence while holding the number of signals fixed. Proposition 5 predicts

$$U_3 > \{U_2, U_4\} > \{U_1, U_5\}.$$

Appendix Table A.11 (Panel B) confirms this pattern. Taking Group 3 (60% positive) as the reference category, belief uncertainty is significantly lower in Group 2 by 0.019, in Group 4 by 0.022, in Group 1 by 0.053, and in Group 5 by 0.075, with all estimates significant at the 1% level. These results are essentially robust after controlling for demographics.[13] Thus, subjective uncertainty

[13] Panel B also shows that the recall interventions in Groups 6 and 7 reduce subjective uncertainty relative to Group 3. Group 6 (Group 3 + Stop-and-Think), which increases recall effort, lowers uncertainty by 0.021; Group 7 (Group 3 + incentivized recall), which raises recall probability, lowers uncertainty by 0.033. Both estimates are statistically significant at the 1% level and remain robust with demographic controls. These findings suggest that interventions that strengthen recall also make posterior beliefs more decisive and reduce subjective uncertainty.

is greatest when the information environment is most balanced, declines at intermediate levels of imbalance, and is lowest when the information environment is most one-sided. This evidence is consistent with the proposition on expected subjective uncertainty.

**Fact 11: Contextual cues have asymmetric effects on subjective uncertainty.** Groups 8 and 9 share the Group 2 signal history but introduce associative cues that shift retrieval. Proposition 6 predicts

$$U_8 < U_2, \qquad U_9 > U_2 \text{ for a sufficiently weak minority cue.}$$

Appendix Table A.11 (Panel C) confirms this pattern. Relative to Group 2, Group 8 (positive cue) exhibits significantly lower belief uncertainty, with a coefficient of $-0.037$ ($p$ value $< 0.01$), while Group 9 (negative cue) exhibits significantly higher belief uncertainty, with a coefficient of 0.028 ($p$ value $< 0.01$). The estimates are identical with demographic controls. Quantitatively, these effects are sizable relative to the Group 2 baseline of 0.198: the positive cue lowers uncertainty by about 19%, while the negative cue raises it by about 14%. This evidence is consistent with the cue proposition.[14]

**Synthesis** Overall, the results from the Belief Disagreement Experiment line up closely with the model. Informational ambivalence increases disagreement and subjective uncertainty, while the realized composition of net recalled imbalance helps explain how that uncertainty is manifested at the individual level. Retrieval-effort interventions substantially reduce disagreement, consistent with the idea that stronger recall makes beliefs more stable. Contextual cues shift recall composition and have asymmetric effects depending on whether they reinforce dominant or minority signals. Most importantly, recall-generated beliefs match reported beliefs for the overwhelming majority of participants, providing direct evidence that stochastic retrieval from a common stored information history is the proximate mechanism linking memory to disagreement, instability, and subjective uncertainty.

## 6 Belief Instability Study

This section examines the dynamic implications of stochastic recall for belief formation. While the previous experiment provides causal evidence that stochastic retrieval generates cross-

[14] For the negative-cue case, we have $\hat{p} = 0.51$ and cue strength $a = 0.26$. The analytical expression then implies $\Theta = 0.68$. Since $a < \Theta$, the negative cue is weak, and the experimental findings are consistent with the cue proposition.

sectional disagreement, the present study asks whether the same mechanism can generate within-individual belief instability over time when the information set is fixed. The study consists of two linked experiments conducted over two consecutive days. Experiment 2 is a robustness replication of the disagreement design in a new sample. Experiment 3 re-elicits beliefs and recall approximately one day later, without providing any new information. This design allows us to test whether stochastic recall alone can generate belief revisions over time.

## 6.1 Experimental Design

The belief instability study follows a two-part design conducted over two consecutive days. All participants complete Part 1 on Day 1 and are re-invited to complete Part 2 approximately 24 hours later. No new information about the company is provided in Part 2; all beliefs in the second session must therefore be formed using only the information observed in Part 1.

**Experiment 2: Belief Disagreement Robustness Experiment** Experiment 2 replicates the core belief disagreement design from Section 5 in a new sample. Participants observe a sequence of 20 binary signals about a hypothetical company whose type is either good or bad with equal prior probability.[15] Participants are randomly assigned to one of four groups. Groups 1–3 replicate the informational-ambivalence manipulation from the first study, with signal compositions $(N^+, N^-) \in \{(18,2),(14,6),(11,9)\}$. Group 4 implements a Stop-and-Think intervention analogous to Group 6 in the first experiment.

**Experiment 3: Belief Instability Experiment** Experiment 3 studies belief dynamics under stochastic recall. Participants who complete Part 1 are re-invited approximately one day later to complete Part 2. In Part 2, they are reminded that they previously observed a sequence of news about the same company, but they are not shown the news again and receive no additional information.

Participants are then asked to (i) report their binary belief about whether the company is good or bad, (ii) report a probabilistic belief, and (iii) recall the number of positive and negative signals they received in Part 1.[16] Because the information set is fixed across sessions, any change

[15] The signal-generating environment, instructions, payments, presentation format, and incentives are identical to those in the belief disagreement study.

[16] The order of belief elicitation and recall mirrors the structure used in Part 1, with Stop-and-Think participants again completing recall before belief elicitation.

in beliefs between Part 1 and Part 2 must arise from differences in recalled information rather than from learning or new information arrival.

**Sample** The belief instability study was conducted online via Prolific on 22–23 January 2025 using a U.S. general-population sample.[17] In Part 1, we recruited approximately 2,700 new respondents, yielding about 2,000 valid completed responses after comprehension checks.[18] Participants who completed Part 1 were re-invited one day later for Part 2. The re-participation rate was 86 percent, resulting in approximately 1,700 respondents in Part 2. Median completion time was approximately 13 minutes for Part 1 and 3 minutes for Part 2. Appendix Table A.12 summarizes respondent demographics.

## 6.2 Predictions and Experimental Findings: Belief Instability

This subsection documents two additional experimental facts about belief dynamics over time. Together, Experiments 2 and 3 extend the earlier evidence by showing that stochastic retrieval not only generates cross-sectional disagreement but also generates within-individual belief instability when no new information arrives. Let $R_g$ denote the revision rate in group $g$, defined as the proportion of participants who switch their binary belief between Day 1 and Day 2.

**Fact 12: Belief instability increases with informational ambivalence.** Groups 1–3 vary informational ambivalence while holding the total number of signals fixed. Proposition 3 predicts

$$R_3 > R_2 > R_1.$$

The data strongly support this ordering. Figure 9 shows that belief revision is rare when information is highly one-sided (Group 1), with revision rates of 7.3 percent for self-reported beliefs and 0.2 percent for recall-generated beliefs. Revision becomes more frequent as the signal history becomes more balanced (Group 2: 11.3 percent and 4.3 percent) and peaks in the most ambivalent environment (Group 3: 30.3 percent and 26.0 percent).

These patterns closely mirror the disagreement results in the first experiment. When the stored information is ambivalent, small stochastic differences in recalled samples across time are more likely to change the recalled majority and therefore flip beliefs.

[17] Respondents who participated in the Belief Disagreement Experiment were excluded at recruitment.

[18] We also exclude respondents who report taking notes during the information screens, around 2 percent of the sample.

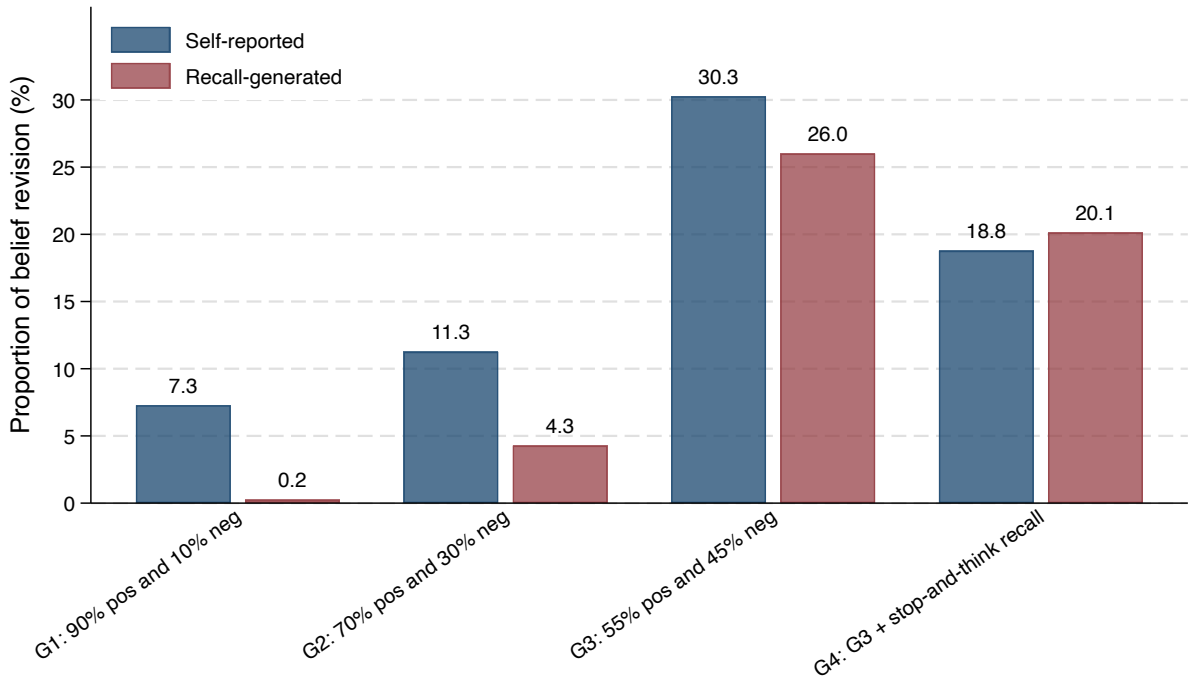



**Figure 9:** BELIEF INSTABILITY OVER TIME

*Notes:* The figure shows the proportion of participants whose belief about the company's type changes between Part 1 (Day 1) and Part 2 (Day 2) in Experiment 3. For self-reported beliefs, instability is defined as a change in the reported binary belief from good to bad or vice versa. For recall-generated beliefs, instability is defined as a change in the mechanically generated belief implied by recalled information. Groups 1–3 vary the signal mix while holding the total number of signals fixed; instability increases with informational ambivalence and is highest in Group 3. Group 4 shares the Group 3 signal composition but introduces a Stop-and-Think retrieval intervention, which reduces instability.

**Fact 13: Increased retrieval effort reduces belief instability.** Group 4 shares the same signal composition as Group 3 but introduces a Stop-and-Think intervention that increases retrieval effort. Proposition 3 predicts

$$R_3 > R_4.$$

Consistent with this prediction, belief instability falls sharply under the retrieval intervention. Relative to Group 3, revision rates decline to 18.8 percent for self-reported beliefs and 20.1 percent for recall-generated beliefs in Group 4. This reduction occurs despite identical underlying information and no new signals between elicitations.

## 6.3 Mechanism and Replication

**Mechanism** The instability patterns align closely with the stochastic recall mechanism. Appendix Table A.13 shows that revision rates increase significantly with informational ambiva-

lence and decline significantly with increased retrieval effort. Relative to the low-ambivalence benchmark, more balanced signal environments substantially raise revision rates, while a Stop-and-Think intervention dampens this effect despite identical underlying information.

Appendix Table A.14 provides direct micro-level evidence linking recall to belief dynamics. Within individuals, both the magnitude and direction of changes in recalled positive news between Part 1 and Part 2 strongly predict belief revisions for both self-reported and recall-generated beliefs ($p < 0.01$). In particular, switching from recalling relatively more negative to relatively more positive information is associated with large shifts in belief direction.

Taken together, the evidence shows that belief instability arises endogenously from stochastic variation in retrieval. Even in the absence of new information, small changes in recalled signal composition can induce substantial belief revisions, while increasing retrieval effort stabilizes beliefs by reducing their sensitivity to recall fluctuations.

**Replication of disagreement patterns** The same sample also replicates the core disagreement patterns from the first experiment. Appendix Figure A.6 shows that disagreement in self-reported beliefs again increases with informational ambivalence: it is lowest when evidence is one-sided (Group 1), rises in the intermediate environment (Group 2), and peaks in the most ambivalent environment (Group 3). Introducing the Stop-and-Think intervention in Group 4 reduces disagreement relative to Group 3. These patterns hold for both self-reported and recall-generated beliefs and closely mirror the results of the first experiment, revalidating Facts 6 and 7 in a new sample and timing structure.

# 7 Quantitative Belief Disagreement and Instability in Dynamic Environments

In this section, we study how stochastic retrieval generates disagreement across individuals and instability within individuals in dynamic quantitative environments. Decision-makers observe the same realized history of a persistent stochastic process and share identical priors and belief-formation rules, but differ in which past realizations they retrieve when forming beliefs. This section generalizes the mechanisms established above. Stochastic retrieval generates economically large disagreement and belief instability in environments with persistent and volatile histories: both cross-sectional dispersion and within-individual revisions scale with the

variance of the realized history and arise even in the absence of new information.

## 7.1 Model Setup

**Environment** Let $\{Z_t\}_{t\geq 1}$ follow the stationary AR(1) process

$$Z_t - \mu = \rho(Z_{t-1} - \mu) + \varepsilon_t, \tag{7.1}$$

where $|\rho| < 1$ and $\varepsilon_t \sim \mathcal{N}(0, \sigma_\varepsilon^2)$ are i.i.d. shocks. The unconditional variance of $Z_t$ is

$$\mathrm{Var}(Z_t) = \frac{\sigma_\varepsilon^2}{1-\rho^2}.$$

The long-run mean $\mu$ is unknown.

A continuum of decision-makers observes the same realized history $\{Z_1, \ldots, Z_T\}$ but has imperfect memory. Each decision-maker must form a belief about the mean of the realizations.

**Belief formation** At the recall stage, each decision-maker recalls each realization $Z_k$ independently with probability $p \in (0,1)$. Let $I_i^k \in \{0,1\}$ indicate whether decision-maker $i$ recalls observation $Z_k$. At the information-processing stage, decision-maker $i$ forms a belief about the mean by averaging recalled observations:

$$\mu_i = \frac{\sum_{k=1}^T I_i^k Z_k}{\sum_{k=1}^T I_i^k}. \tag{7.2}$$

## 7.2 Cross-Sectional Disagreement

Disagreement is defined as the cross-sectional variance of beliefs,

$$\mathscr{D} \equiv \mathrm{Var}\big(\mu_i\big).$$

**Proposition 7.** *Suppose $\{Z_t\}$ follows (7.1) and decision-makers recall each observation independently with probability $p \in (0,1)$. Then, for large $T$,*

$$\mathscr{D} \approx \frac{1-p}{Tp}\mathrm{Var}(Z_t) = \frac{1-p}{Tp}\cdot\frac{\sigma_\varepsilon^2}{1-\rho^2}. \tag{7.3}$$

*Equivalently, conditional on the realized history,*

$$\mathrm{Var}(\mu_i \mid Z_1, \ldots, Z_T) \approx \frac{1-p}{Tp}\widehat{\mathrm{Var}}(Z_1, \ldots, Z_T),$$

*where $\widehat{\mathrm{Var}}$ denotes the sample variance.*

The proof is provided in Appendix L. Proposition 7 shows that cross-sectional disagreement arises purely from stochastic recall. All decision-makers observe the same realized history and use the same belief-formation rule; disagreement reflects idiosyncratic subsampling of

a common dataset. Because beliefs are sample means computed from overlapping random subsets of the same history, disagreement scales with the volatility of that history. Increasing the history length $T$ or the recall probability $p$ raises the effective sample size used in belief formation and reduces dispersion. Persistence matters through its effect on historical variance: conditional on a realized history, disagreement is proportional to $\widehat{\mathrm{Var}}(Z_1,\ldots,Z_T)$.

## 7.3 Within-Individual Belief Instability

We now turn to within-individual belief instability. Fix a realized history $\{Z_1,\ldots,Z_T\}$. Consider a single decision-maker whose belief is elicited twice, with no new information arriving between elicitations. At each elicitation $\tau \in \{1,2\}$, the decision-maker draws a fresh recall realization $\{I^k_{i,\tau}\}_{k=1}^T$, where $\{I^k_{i,\tau}\}_{k=1}^T \sim \text{Bernoulli}(p)$ independently across $k$ and $\tau$, and reports

$$\hat{\mu}_{i,\tau} = \frac{\sum_{k=1}^T I^k_{i,\tau} Z_k}{\sum_{k=1}^T I^k_{i,\tau}}.$$

We measure belief instability as the expected squared revision,

$$\mathscr{I}(Z_1,\ldots,Z_T) \equiv \mathbb{E}\left[\left(\hat{\mu}_{i,1}-\hat{\mu}_{i,2}\right)^2 \,\middle|\, Z_1,\ldots,Z_T\right].$$

**Proposition 8.** *Suppose* $\{Z_t\}$ *follows* (7.1) *and recall is independent across observations and elicitations with probability* $p \in (0,1)$*. Then, for large* $T$*,*

$$\mathscr{I}(Z_1,\ldots,Z_T) \approx \frac{2(1-p)}{Tp}\widehat{\mathrm{Var}}(Z_1,\ldots,Z_T). \tag{7.4}$$

*Unconditionally,*

$$\mathbb{E}\left[\left(\hat{\mu}_{i,1}-\hat{\mu}_{i,2}\right)^2\right] \approx \frac{2(1-p)}{Tp}\mathrm{Var}(Z_t) = \frac{2(1-p)}{Tp}\cdot\frac{\sigma_\varepsilon^2}{1-\rho^2}. \tag{7.5}$$

The proof is provided in Appendix M. Belief instability is the within-individual analogue of cross-sectional disagreement. Each elicited belief is the average of a random subset drawn from the same memory database. When the realized history is volatile, different recall draws can yield meaningfully different averages, generating belief revisions even with no new information. The factor of two in equation (7.4) reflects that the two elicited beliefs are independent draws from the same recall-induced belief distribution. As in the cross-sectional case, instability vanishes as recall becomes nearly complete ($p \to 1$) or as the history grows long ($T \to \infty$).

**Remarks.** First, Appendix N extends the analysis to one-step-ahead forecasts in the AR(1) environment and shows that stochastic retrieval generates forecast disagreement through both heterogeneous recall of the most recent realization and dispersion in beliefs about the mean.

Second, consistent with the evidence in Bordalo, Gennaioli, Ma and Shleifer (2020b), stochastic recall can generate a negative coefficient in a regression of forecast errors on forecast revisions. This occurs because recalling a favorable (unfavorable) subset of information simultaneously leads to an upward (downward) forecast revision and a negative (positive) forecast error.[19]

## 7.4 Quantitative Belief Study: Experimental Design

We next implement two quantitative belief-elicitation experiments that parallel the dynamic environment studied in Section 7.1. Participants observe a common realization of a stochastic process. We elicit their beliefs about the mean of the process and ask them to recall the numerical values they remember on Day 1 and Day 2.

**Overview** Participants observe a sequence of 20 realizations generated from a stable AR(1) process with an unknown long-run mean. The information environment is common across participants within each treatment group, and no new information arrives between the Day 1 and Day 2 elicitations.

**Experiment 4: quantitative disagreement** Experiment 4 examines cross-sectional disagreement in quantitative beliefs. Participants observe 20 numerical realizations from a stationary AR(1) process, displayed sequentially on separate screens. Participants are randomly assigned to one of three groups that vary the persistence and volatility of the underlying process. Group 1 observes data generated from a low-persistence, low-volatility process ($\rho = 0.1, \sigma = 0.5$). Group 2 observes a high-persistence, low-volatility process ($\rho = 0.9, \sigma = 0.5$). Group 3 observes a high-persistence, high-volatility process ($\rho = 0.9, \sigma = 5$). In all groups, the long-run mean is fixed at $\mu = 5$ and unknown to participants. After viewing the sequence, participants complete unrelated tasks, then report their best estimate of the series average, with accuracy incentives, and finally complete a free-recall task in which they list any values they remember.

**Experiment 5: quantitative instability** Experiment 5 examines within-individual belief instability. Participants who complete Experiment 4 are re-invited approximately 24 hours later. No new information about the data-generating process is provided in the second session; all beliefs must therefore be formed solely on the basis of information observed in Experiment 4.

[19] Theoretical proofs and simulation results confirming this finding are omitted for space and are available upon request.

Participants again report their best estimate of the series average, with accuracy incentives, and complete the same free-recall task without being shown the data. Because the information set is fixed across sessions, any belief revision must arise from imperfect memory.

**Sample** The quantitative belief study was conducted online via CloudResearch using its Connect participant pool.[20] The experiment targeted a U.S. general-population sample. Approximately 2,300 participants were recruited for Experiment 4 on 1 February 2026, of whom about 83 percent returned to complete Experiment 5 one day later.[21] Median completion time was approximately 12 minutes in Experiment 4 and 4 minutes in Experiment 5. Appendix Table A.15 reports respondent demographics by group.

## 7.5 Experimental Results

The AR(1) quantitative belief experiments provide a controlled numerical analogue to the disagreement and instability patterns documented above. Within each treatment group, participants observe the same realized sequence and face identical incentives, and no new information arrives between the Day 1 and Day 2 elicitations.

**Fact 14: Quantitative belief disagreement increases with volatility.** Appendix Figure A.8 shows that the cross-sectional distribution of mean estimates widens sharply as the realized history becomes more volatile. Appendix Figure A.9, panel (a), summarizes the magnitudes while holding persistence fixed at $\rho = 0.9$: the variance of mean estimates increases from 3.23 in Group 2 (low volatility) to 13.81 in Group 3 (high volatility) on Day 1, and from 4.09 to 21.74 on Day 2. Thus, increasing volatility raises disagreement by about a factor of 4.3 on Day 1 and 5.3 on Day 2 despite a common realized history within each group.

**Fact 15: Quantitative belief disagreement increases with persistence.** Persistence also increases disagreement when volatility is held fixed. Comparing Groups 1 and 2, which share the same innovation standard deviation ($\sigma_\epsilon = 0.5$) but differ in persistence ($\rho = 0.1$ versus $\rho = 0.9$), Appendix Figure A.9, panel (a), shows that the variance of mean estimates rises from 0.47 to 3.23

[20] We also applied CloudResearch's built-in quality assurance system to pre-screen respondents prior to survey entry based on historical response behavior, device-level checks, and automated bot-detection signals. We additionally implemented multiple pre-specified in-survey attention and consistency checks, including an explicit attention check and automated screening for completion times shorter than 3 minutes or longer than 20 minutes.

[21] We also exclude respondents who report taking notes during the information screens, around 1 percent of the sample.

on Day 1 and from 0.78 to 4.09 on Day 2. The recall data move in parallel: Appendix Figure A.9, panel (b), shows that the cross-sectional variance of recall-generated averages is also higher in Group 2 than in Group 1 on both days. Thus, more persistent histories generate greater disagreement in both recall-based summaries and stated quantitative beliefs.

**Fact 16: Quantitative belief instability increases with volatility.** Experiment 5 re-elicits beliefs approximately 24 hours later without providing any new information. Appendix Figure A.11 plots the distribution of within-participant belief revisions (Day 2 minus Day 1). Holding persistence fixed at $\rho = 0.9$, belief revisions are substantially more dispersed in the high-volatility environment (Group 3) than in the low-volatility environment (Group 2). Appendix Figure A.12 shows the same pattern for recall revisions: changes in recalled averages are markedly more dispersed in Group 3 than in Group 2. Higher volatility therefore amplifies instability in beliefs by amplifying instability in what participants retrieve from memory.

**Fact 17: Quantitative belief instability increases with persistence.** Persistence also raises within-individual instability when volatility is held fixed. Comparing Groups 1 and 2, Appendix Figure A.11 shows that the distribution of Day 1 to Day 2 revisions is tighter in the low-persistence environment and wider in the high-persistence environment. Appendix Figure A.12 shows the same directional pattern for recall revisions. Thus, even without new information, more persistent histories generate larger within-person belief revisions, consistent with stochastic retrieval from a more persistent sequence producing more variable recall-based summaries over time.

**Mechanism: beliefs move closely with recalled averages** Table A.16 quantifies the mapping from recalled information to quantitative beliefs. In the cross section (Panels A–B), coefficients of mean estimates on recalled averages range from 0.78 to 0.95 on Day 1 and from 0.70 to 0.99 on Day 2, all significant at the 1 percent level. Within individuals (Panel C), coefficients on changes range from 0.75 to 0.94, so a one-unit upward revision in the recalled average between days predicts roughly a 0.75–0.94 unit upward revision in the reported mean estimate. Because Day 2 beliefs are elicited without new information, these magnitudes directly implicate stochastic retrieval as the proximate driver of both disagreement and instability in the quantitative environment.

# 8 Survey Evidence from the Michigan Survey of Consumers

This section presents complementary survey evidence from the Michigan Survey of Consumers (MSC). The experiments isolate stochastic recall through controlled post-exposure interventions and repeated elicitations under fixed information. The MSC evidence plays a different role: it asks whether comparable reduced-form patterns appear in naturally occurring expectations data. We show that disagreement, instability, and subjective uncertainty are systematically related to richer and more mixed recent information histories. For stock price expectations, we measure the composition of recent information using the balance of positive and negative realized returns. For inflation expectations, we use the volatility of recent realized inflation as the empirical analogue of a more ambivalent quantitative information environment. We also present evidence that salient recent stock returns are associated with disagreement in a way consistent with cue-based retrieval.

## 8.1 Stock Price Expectations

**Empirical setup** We study the period from June 2002 to March 2025 and focus on households' expectations about future stock price movements. The MSC elicits respondents' subjective probability that a $1,000 investment in a diversified stock fund will be worth more than $1,000 one year later. We convert this probability into a binary directional expectation: respondents assigning a probability of at least 50 percent are classified as expecting a stock price increase, and those assigning a lower probability are classified as expecting a decline.[22] Disagreement is measured as the monthly cross-sectional standard deviation of this binary expectation measure.

To proxy the relevant recent information history, we use realized S&P 500 returns over the past $h$ years and consider alternative horizon lengths. Because stock expectations are directional, the natural empirical analogue of informational ambivalence is the balance of positive and negative realized returns rather than the variance of returns. For horizon $h \in \{1Y, 5Y, 10Y\}$ and counting frequency $f \in \{\text{Monthly}, \text{Quarterly}\}$, we define stock-return ambivalence as

$$A^f(h) = 1 - \frac{\left|\#\text{Neg}^f(h) - \#\text{Pos}^f(h)\right|}{\#\text{Neg}^f(h) + \#\text{Pos}^f(h)},$$

where $\#\text{Neg}^f(h)$ and $\#\text{Pos}^f(h)$ denote the numbers of negative and positive realized returns, respectively, in the trailing window. This measure is highest when recent returns are evenly

[22] The results are robust to alternative cutoff values.

balanced between positive and negative realizations and lowest when recent returns are overwhelmingly of one sign.

**Ambivalence and disagreement** Panel A of Table 5 shows that disagreement in stock price expectations increases with trailing stock-return ambivalence at all horizons and frequencies. The relationship is strongest for longer windows. In the monthly specifications, the ambivalence coefficient rises from 0.081 at the one-year horizon to 0.145 at the five-year horizon and 0.236 at the ten-year horizon. The quarterly specifications show the same pattern, with coefficients of 0.045, 0.100, and 0.147. In economically relevant units, a 0.10 increase in trailing ambivalence is associated with a 0.8–2.4 percentage point increase in disagreement in the monthly specifications and a 0.5–1.5 percentage point increase in the quarterly specifications. These relationships remain after controlling for short-run and long-run cumulative returns, indicating that disagreement co-moves with the balance of recent positive and negative return realizations rather than simply with recent market performance.[23]

The stronger association at longer horizons is consistent with the paper's broader logic: richer recent information histories create more scope for heterogeneous retrieval of different subsets of past realizations.

**Ambivalence and belief instability** We next examine whether the same environments associated with greater disagreement also exhibit less stable beliefs within individuals. Using the MSC rotating panel, we link respondents across consecutive interviews, typically six months apart, and define instability as an indicator for switching between expecting a stock price increase and expecting a decline.

Panel A of Appendix Table A.17 shows that instability increases with trailing stock-return ambivalence across horizons and sampling frequencies. The monthly coefficients range from 0.036 to 0.062, and the quarterly coefficients range from 0.032 to 0.041. A 0.10 increase in trailing ambivalence is associated with a 0.3–0.6 percentage point higher probability of switching. These estimates are robust to controlling for short-run and long-run cumulative returns, indicating that ambivalent recent return histories are associated not only with greater cross-sectional disagreement but also with more frequent within-household belief reversals.

[23] Appendix Figure A.13 illustrates the corresponding co-movement over time.

**Ambivalence and subjective uncertainty** We next ask whether more ambivalent recent return histories are associated not only with greater disagreement in directional beliefs, but also with higher uncertainty in probabilistic expectations. Let $p_{it} \in [0,1]$ denote respondent $i$'s subjective probability at time $t$ that average stock prices will increase over the next year. We measure subjective uncertainty as

$$U_{it} = p_{it}(1 - p_{it}),$$

which is maximized at $p_{it} = 0.5$ and declines as beliefs become more extreme.

Appendix Table A.18 shows a robust positive relationship between trailing stock-return ambivalence and subjective uncertainty. Across all specifications, the coefficient on ambivalence is positive and statistically significant at the 1 percent level. In the monthly regressions, the coefficient rises from 0.004 at the one-year horizon to 0.023 at the ten-year horizon; the quarterly specifications display the same pattern, increasing from 0.003 to 0.014. Thus, a 0.10 increase in trailing ambivalence is associated with an increase in subjective uncertainty of roughly 0.0004 to 0.0023 in the monthly specifications and 0.0003 to 0.0014 in the quarterly specifications. Consumers are therefore most uncertain when the recent stock-return environment is more evenly balanced between positive and negative realizations.

**Salient recent returns as natural cues** Finally, we examine whether a salient recent return is associated with disagreement in a way consistent with cue-based retrieval. The economic intuition is straightforward: if the most recent return reinforces the dominant sign of recent return history, it may make recalled evidence more one-sided and compress disagreement; if it instead goes against the dominant sign, it may make recalled evidence more mixed and increase disagreement.

Table A.19 studies this idea using an indicator for whether the most recent S&P 500 return is positive. We classify this recent-return cue as majority-aligned if its sign matches the dominant sign of realized returns in the trailing window used to construct the memory database, and as minority-aligned otherwise. Columns (1)–(2) use monthly counting windows and columns (3)–(4) use quarterly counting windows.

Across specifications, the interaction between the recent-return cue and majority alignment is negative and statistically significant, implying that the association between the cue and disagreement differs sharply depending on whether the cue reinforces the dominant sign of

recent return history. In particular, the marginal effect of a positive recent-return cue when it is majority-aligned equals the sum of the cue coefficient and the interaction coefficient, and this sum is negative in all four columns. For example, in column (1) the implied majority-aligned effect is $0.015-0.046=-0.031$ ($p<0.01$), while in column (3) it is $0.023-0.068=-0.045$ ($p<0.01$). Thus, when the most recent return reinforces the prevailing sign of past returns, disagreement is lower; when it corresponds to the minority sign, disagreement is generally higher. Because the most recent return is highly salient and temporally proximate, it is a plausible natural reminder that may affect which past returns households retrieve when forming expectations. This pattern is therefore consistent with cue-based retrieval, e.g., Jiang, Liu, Peng and Yan (Forthcoming), although the evidence is observational rather than causal.

## 8.2 Inflation Expectations

**Empirical setup** We next study households' quantitative expectations about inflation over the next year, using MSC data from June 1980 to March 2025. Disagreement is measured as the monthly cross-sectional standard deviation of reported expected inflation rates.

Because inflation expectations are quantitative rather than binary, we use realized inflation volatility as the empirical analogue of an ambivalent recent information environment. The idea is that a more volatile inflation history provides a richer and less one-sided set of inflation realizations from which different households may recall different subsets. For horizon $h \in \{1\text{Y}, 5\text{Y}, 10\text{Y}\}$ and frequency $f \in \{\text{Monthly}, \text{Quarterly}\}$, we define inflation ambivalence as

$$A^f(h) = \sqrt{\frac{1}{T_h}\sum_{t'=1}^{T_h}\left(\pi^f_{t-t'} - \bar{\pi}^f_h\right)^2},$$

where $\pi^f_t$ denotes realized inflation and $\bar{\pi}^f_h$ is the average realized inflation rate over the corresponding trailing window.

**Ambivalence and disagreement** Panel B of Table 5 shows that inflation disagreement rises with trailing inflation volatility across horizons and sampling frequencies. The effect is again stronger at longer horizons. In the monthly specifications, the coefficients increase from 0.015 at the one-year horizon to 0.072–0.086 at the five- and ten-year horizons. The quarterly specifications show the same pattern, with coefficients ranging from 0.015 to 0.102–0.109. In economically relevant units, a 0.10 increase in trailing inflation volatility is associated with a 0.2–1.1 percentage

**Table 5:** DISAGREEMENT IN EXPECTATIONS: STOCK PRICE MOVEMENTS AND INFLATION

| | Monthly | | | Quarterly | | |
|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) |
| **Panel A. Disagreement in stock price movement expectations** | | | | | | |
| Ambivalence (1 year) | 0.081*** | | | 0.045*** | | |
| | (0.009) | | | (0.005) | | |
| Ambivalence (5 years) | | 0.145*** | | | 0.100*** | |
| | | (0.014) | | | (0.008) | |
| Ambivalence (10 years) | | | 0.236*** | | | 0.147*** |
| | | | (0.029) | | | (0.016) |
| Cumulative return (1 month) | -0.111*** | -0.101*** | -0.096** | -0.155*** | -0.129*** | -0.114*** |
| | (0.038) | (0.036) | (0.039) | (0.044) | (0.034) | (0.038) |
| Cumulative return (10 years) | -0.005*** | -0.007*** | -0.001 | -0.006*** | -0.004** | 0.004** |
| | (0.002) | (0.002) | (0.002) | (0.002) | (0.002) | (0.002) |
| *R-squared* | 0.265 | 0.299 | 0.250 | 0.223 | 0.426 | 0.304 |
| *N* | 274 | 274 | 274 | 274 | 274 | 274 |
| **Panel B. Disagreement in inflation (price level change) expectations** | | | | | | |
| Ambivalence (1 year) | 0.015*** | | | 0.015*** | | |
| | (0.005) | | | (0.005) | | |
| Ambivalence (5 years) | | 0.072*** | | | 0.102*** | |
| | | (0.010) | | | (0.012) | |
| Ambivalence (10 years) | | | 0.086*** | | | 0.109*** |
| | | | (0.010) | | | (0.011) |
| Current inflation | 0.159*** | 0.155*** | 0.147*** | 0.238*** | 0.224*** | 0.217*** |
| | (0.030) | (0.029) | (0.030) | (0.044) | (0.042) | (0.043) |
| *R-squared* | 0.078 | 0.145 | 0.135 | 0.115 | 0.209 | 0.181 |
| *N* | 538 | 538 | 538 | 538 | 538 | 538 |

*Notes:* This table reports OLS estimates linking recent information histories to disagreement in expectations. Panel A studies disagreement in stock price expectations, measured as the monthly cross-sectional standard deviation of respondents' binary one-year-ahead stock price movement expectations in the Michigan Survey of Consumers. Respondents report a probability between 0 and 100; individuals assigning a probability of at least 50 percent are classified as expecting a stock price increase (coded as +1), while those assigning less than 50 percent are classified as expecting a decrease (coded as −1). The sample period for Panel A is June 2002 through March 2025, reflecting the availability of the stock price expectations question. In Panel A, stock-return ambivalence over horizon $h \in \{1Y, 5Y, 10Y\}$ is defined as $A(h) = 1 - \frac{|\#\text{Neg} - \#\text{Pos}|}{\#\text{Neg} + \#\text{Pos}}$, where #Pos and #Neg count positive and negative realized stock returns over a trailing window of length $h$. Panel B studies disagreement in inflation expectations, measured as the monthly cross-sectional standard deviation of respondents' one-year-ahead expected inflation. The sample period for Panel B is June 1980 through March 2025. In Panel B, inflation ambivalence over horizon $h \in \{1Y, 5Y, 10Y\}$ is measured as the standard deviation of realized inflation over a trailing window of length $h$, $A(h) = \sqrt{\frac{1}{T_h}\sum_{t'=1}^{T_h}(\pi_{t-t'} - \bar{\pi}_h)^2}$, where $\pi_t$ denotes realized inflation, $\bar{\pi}_h$ is the mean inflation rate over the corresponding window, and $T_h$ is the number of observations in the window. Columns (1)–(3) report specifications using monthly counting frequency, while columns (4)–(6) use quarterly counting frequency. All specifications in Panel A control for cumulative S&P 500 returns over the previous 1 month and 10 years. All specifications in Panel B control for the contemporaneous level of inflation. Robust standard errors are reported in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$.

point increase in disagreement. These estimates condition on the contemporaneous level of inflation, indicating that disagreement co-moves with volatility in realized inflation histories rather than simply with current inflation.

**Ambivalence and belief instability** We next relate inflation ambivalence to within-individual instability, measured here as the absolute change in a respondent's one-year-ahead expected inflation rate between consecutive interviews. This is a quantitative revision measure, in contrast to the stock-price application above, where instability is defined as a directional switch.

Panel B of Appendix Table A.17 shows that more volatile inflation histories are associated with larger within-household revisions. The coefficients are positive across all horizons and frequencies, ranging from 0.017 to 0.066. A 0.10 increase in trailing inflation volatility predicts a 0.2–0.7 percentage point larger absolute revision in expected inflation. The relationship remains when controlling for the contemporaneous level of inflation, implying that more volatile inflation histories are accompanied not only by greater cross-sectional disagreement but also by less stable beliefs within households over time.

**Interpretation** Taken together, the inflation results parallel the stock-price results despite relying on a different empirical proxy for informational ambivalence. In both domains, richer and less one-sided recent information histories are associated with more disagreement and less stable expectations. For stock prices, the relevant empirical object is the balance of positive and negative recent returns; for inflation, it is the volatility of recent realized inflation. These observational patterns are consistent with the model's comparative statics, although they do not by themselves isolate retrieval from other channels.

**Synthesis** The MSC evidence complements the experimental results in three ways. First, more ambivalent recent information histories are associated with greater cross-sectional disagreement in both stock-price and inflation expectations. Second, these same environments are associated with less stable beliefs within households over time. Third, for stock-price expectations, naturally occurring salient recent returns exhibit the same qualitative asymmetry as the cue intervention in the experiment: disagreement is lower when the recent return reinforces the dominant sign of recent history and higher when it goes against it. While these patterns are reduced-form and observational, they line up closely with the experimentally identified comparative statics of the

stochastic recall framework.

## 9 Discussion

This paper shows experimentally that stochastic recall affects disagreement, belief instability, and subjective uncertainty even when information is held fixed. The purpose of this section is to discuss the broader implications of that mechanism for real-world expectation formation.

**Ambivalence, recall, and belief instability** A central implication of the framework is that disagreement, belief instability, and subjective uncertainty are governed not only by the amount of information available, but crucially by its composition. When the information history contains a balanced mix of positive and negative signals, beliefs become especially sensitive to stochastic recall. Because posterior beliefs depend on the difference between recalled positive and negative signals, ambivalent environments frequently generate recalled samples in which the evidence is nearly balanced. As a result, beliefs vary more across individuals and across time, and subjective uncertainty remains elevated.

This mechanism helps explain why disagreement, belief instability, and uncertainty tend to co-move across environments. Information histories that generate high cross-sectional disagreement also tend to produce frequent belief revisions within individuals and greater subjective uncertainty. Increasing recall probability—through effort, incentives, repetition, or expertise—raises overlap in recalled information both across agents and across time. As recall becomes more complete, recalled samples better reflect the underlying signal distribution, compressing disagreement and stabilizing beliefs. Its effect on subjective uncertainty, however, depends on the balance of the underlying information history: in environments with clearly one-sided evidence, more complete recall tends to lower uncertainty, whereas in more ambivalent environments it can increase uncertainty by making the balance of evidence more apparent.

More broadly, this logic helps reconcile the experimental results with survey evidence on macroeconomic and financial expectations. Periods characterized by mixed or volatile realizations exhibit elevated disagreement and uncertainty, whereas sustained booms or busts generate more aligned and more stable beliefs. In this sense, disagreement need not arise only because individuals observe different information; it can also arise because individuals retrieve different subsets of a shared information history. Such patterns are difficult to reconcile with standard

learning models in their canonical forms, but they arise naturally under stochastic recall.

**Policy communication and contextual cues** The analysis also has implications for information design and policy communication. Increasing recall probability—for example, by simplifying messages, repeating core facts, using clear visual summaries, or otherwise making key information easier to retrieve—can reduce disagreement and stabilize beliefs even without changing the underlying information content. By making recalled evidence more representative of the underlying information history, improved recall also changes subjective uncertainty, though the direction of that effect depends on whether the underlying history is clearly one-sided or instead finely balanced.

By contrast, contextual cues can have more complex effects. Cues that reinforce dominant information promote convergence by increasing overlap in recalled evidence across individuals and, when they strengthen the already dominant balance of recalled signals, tend to reduce subjective uncertainty as well. However, cues that activate minority information can fragment recall when they are weak, leading different individuals to retrieve different subsets of signals. In such cases, cues can raise both disagreement and subjective uncertainty. In the model, only sufficiently strong and coordinated cues restore convergence by aligning the information that is recalled.

These results suggest caution in interpreting disagreement or uncertainty solely as evidence of divergent information or preferences. Dispersion and uncertainty may also reflect how information is retrieved from memory rather than only what is known.

**Experts versus households** The framework also offers a possible interpretation of persistent differences between experts and households in both beliefs and perceived uncertainty. Experts may exhibit higher recall accuracy for core mechanisms because of training, repetition, and repeated exposure to similar information environments. This would increase overlap in recalled information and compress belief dispersion, while also stabilizing beliefs. In environments where the underlying evidence is clearly tilted in one direction, higher recall would also tend to reduce subjective uncertainty.

Households, by contrast, may exhibit lower and more variable recall accuracy for economically relevant signals. Even when exposed to similar information environments, they may retrieve different subsets of stored signals, leading to more dispersed beliefs and higher per-

ceived uncertainty. This interpretation complements experience-based explanations of belief heterogeneity and suggests that differences between experts and households may arise not only from differences in information access or experience, but also from differences in how stored information is retrieved.

Taken together, these observations suggest that stochastic recall affects disagreement, stability, and uncertainty jointly. For that reason, it belongs in benchmark frameworks of belief formation rather than only in richer behavioral extensions.

## 10 Conclusion

This paper identifies stochastic recall as a minimal and powerful source of belief disagreement, belief instability, and heterogeneity in subjective uncertainty. Once memory retrieval is stochastic, posterior consensus and belief stability are no longer robust implications of Bayesian learning, even when agents share common priors, observe the same information, store all signals, and update optimally conditional on recalled information. Perfect recall, often implicit in standard formulations, plays a central role in sustaining consensus and stable beliefs.

Motivated by new field evidence, we develop a parsimonious model in which agents recall each stored signal only probabilistically when forming beliefs. This small departure from standard learning is sufficient to generate cross-sectional disagreement under identical information histories, within-individual belief revisions in the absence of new information, and heterogeneity in subjective uncertainty across agents. The model delivers sharp comparative statics: disagreement and instability are amplified when the information environment is ambivalent and attenuated as recall probability increases. Subjective uncertainty is also highest in more ambivalent environments, but its response to improved recall depends on the composition of the underlying signal history. Contextual cues can either coordinate or fragment beliefs depending on whether they reinforce dominant or minority signals.

Large-scale preregistered experiments provide causal support for these mechanisms. Holding priors and information constant, we show that increasing informational ambivalence raises disagreement and belief instability, while increasing recall effort reduces them. We also show that beliefs implied by recalled information closely match stated beliefs, providing micro-level evidence that variation in memory retrieval plays a central role in belief heterogeneity and belief dynamics. Complementary survey evidence on macroeconomic and financial expectations

shows similar patterns in naturally occurring environments: disagreement, instability, and subjective uncertainty tend to rise following mixed or volatile information histories and decline following sustained, one-sided developments.

More broadly, our findings suggest that belief dispersion, belief instability, and uncertainty heterogeneity can arise endogenously from imperfect memory even under shared information and Bayesian updating. Stochastic recall operates at a primitive stage of belief formation—the retrieval of stored signals—and can coexist with other mechanisms such as heterogeneous information acquisition, rational inattention, or salience-based weighting. Incorporating stochastic recall into models of expectation formation therefore provides a tractable framework for understanding persistent heterogeneity in beliefs and uncertainty in information-rich environments.

An important direction for future research is to study how stochastic recall interacts with attention, salience, and information acquisition in richer settings. The central message of this paper, however, is simple: even when individuals share the same information, imperfect retrieval of that information can generate persistent disagreement, instability, and uncertainty heterogeneity.

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# Appendix A Summaries of Studies and Experiments

**Appendix Table A.1:** OVERVIEW OF MAIN DATA COLLECTIONS

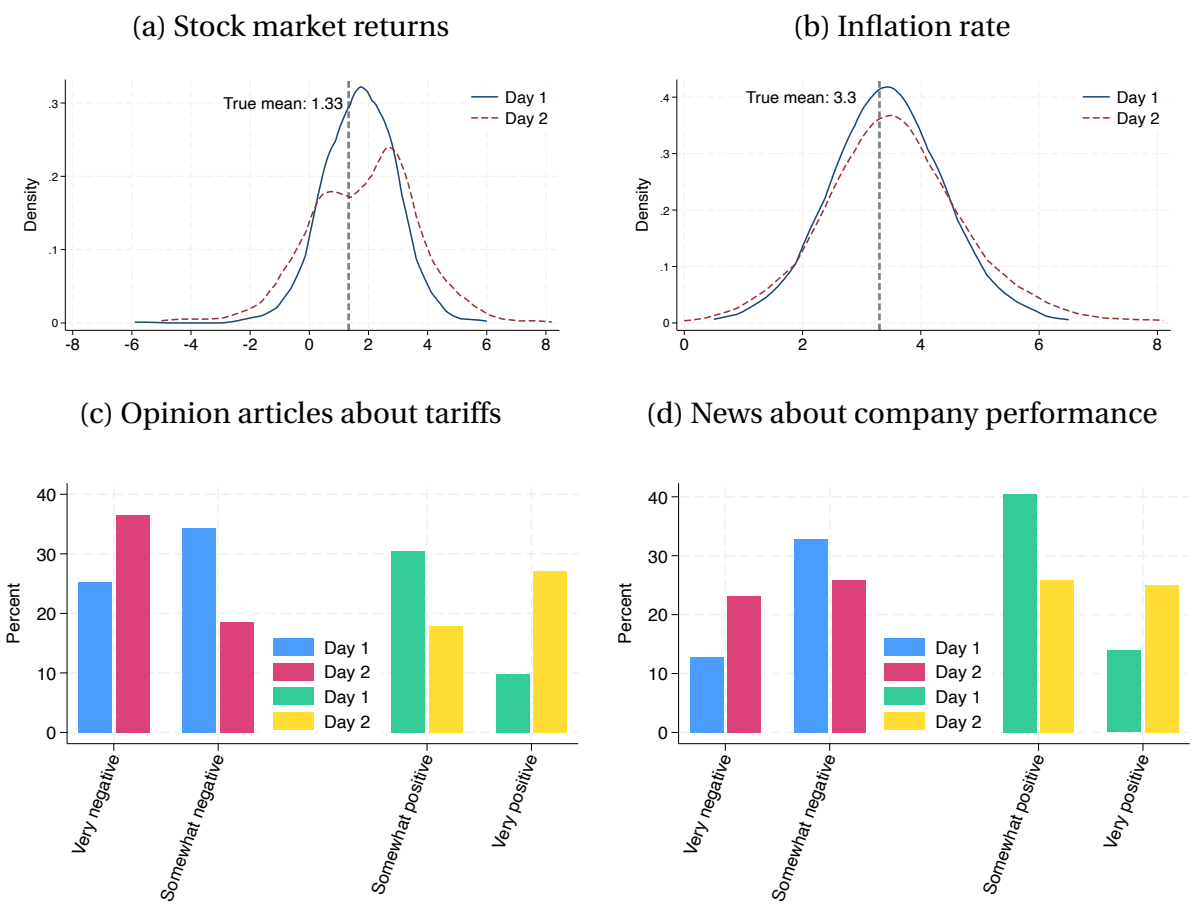
| Study | Domain | Information and variation | Sample | Elicitations | Incentives | AEA RCT # |
|---|---|---|---|---|---|---|
| ***Field studies*** | | | | | | |
| Study 1: Wave 1 | Financial markets | Monthly stock returns (past 1 year) | CloudResearch Connect (606) | Recall stat.; estimate of mean return | Estimate accuracy | 17773 |
| Wave 2 | Financial markets | No new information; Second elicitation | CloudResearch Connect (500) | Recall stat.; estimate of mean return | Estimate accuracy + Participation bonus | 17773 |
| Study 2: Wave 1 | Macroeconomics | Annual inflation rates (past 10 years) | CloudResearch Connect (600) | Recall stat.; estimate of mean inflation | Estimate accuracy | 17773 |
| Wave 2 | Macroeconomics | No new information; Second elicitation | CloudResearch Connect (460) | Recall stat.; estimate of mean inflation | Estimate accuracy + Participation bonus | 17773 |
| Study 3: Wave 1 | Public policy | Tariff opinion headlines | CloudResearch Connect (600) | Recall +/- numbers; opinion evaluation | Recall accuracy | 17773 |
| Wave 2 | Public policy | No new information; Second elicitation | CloudResearch Connect (522) | Recall +/- numbers; opinion evaluation | Recall accuracy + Participation bonus | 17773 |
| Study 4: Wave 1 | Firm-level news | EV company news headlines | CloudResearch Connect (611) | Recall +/- numbers; news evaluation | Recall accuracy | 17773 |
| Wave 2 | Firm-level news | No new information; Second elicitation | CloudResearch Connect (522) | Recall +/- numbers; news evaluation | Recall accuracy + Participation bonus | 17773 |
| ***Experimental studies*** | | | | | | |
| Experiment 1 (belief disagreement) | Asset evaluation | Binary signals; ambivalence of information; recall probability; contextual cues | Prolific (4,758) | Recall; probabilistic and binary beliefs | Judgment accuracy | 17150 |
| Experiment 2 (Robustness; disagreement) | Asset evaluation | Binary signals; ambivalence of information; recall probability | Prolific (2,039) | Recall; probabilistic and binary beliefs | Judgment accuracy | 17671 |
| Experiment 3 (belief instability) | Asset evaluation | No new information; Second elicitation | Prolific (1,744) | Recall; probabilistic and binary beliefs | Judgment accuracy + participation bonus | 17671 |
| Experiment 4 (AR(1) process; belief disagreement) | Statistic aggregation | Statistical observation from AR(1) processes | Cloudresearch Connect (2,301) | Recall stat.; estimate of quantitative mean | Judgment accuracy | 17805 |
| Experiment 5 (AR(1) process; belief instability) | Statistic aggregation | No new information; Second elicitation | Cloudresearch Connect (1,928) | Recall stat.; estimate of mean | Judgment accuracy + participation bonus | 17805 |

# Appendix B Additional Results for Field Studies 1 - 4

**Appendix Table A.2:** FIELD STUDIES 1 - 4 DEMOGRAPHIC CHARACTERISTICS

| | Study 1 (Stock) (1) | Study 2 (Inflation) (2) | Study 3 (Tariff) (3) | Study 4 (EV Company) (4) |
|---|---|---|---|---|
| Observations | 606 | 600 | 600 | 611 |
| *Panel A: Personal background* | | | | |
| Female (%) | 48.7 | 51.0 | 50.3 | 49.9 |
| Age (years) | 47.4 | 48.6 | 46.2 | 47.3 |
| | (18.8) | (18.1) | (18.0) | (18.8) |
| Bachelor's degree or higher (%) | 29.7 | 28.8 | 32.7 | 29.8 |
| Employed full-time (%) | 44.2 | 47.2 | 44.3 | 44.0 |
| Household income < $60,000 (%) | 57.1 | 57.0 | 57.0 | 57.0 |
| *Panel B: Financial characteristics* | | | | |
| Homeowner (%) | 60.3 | 59.2 | 59.0 | 59.2 |
| Stock investor (%) | 56.6 | 55.0 | 54.0 | 55.0 |

*Notes:* The table reports baseline demographic and financial characteristics of participants in each of the four field studies. Entries are percentages for indicator variables and means for continuous variables, with standard deviations reported in parentheses. All studies were conducted using the same recruitment platform, eligibility criteria, and survey procedures. Participants were restricted to taking part in only one study. The similarity of observable characteristics across studies indicates that the samples are broadly comparable in terms of demographic composition and socioeconomic background.




**Appendix Figure A.1:** DISTRIBUTIONS OF BELIEF AND OPINIONS ACROSS FOUR STUDIES

*Notes:* The figure plots the distribution of beliefs and opinion elicited immediately after information exposure (Day 1, solid lines or bars on the left hand side) and one day later (Day 2, dashed lines or bars on the right hand side), across the four field studies. The top-left panel shows the distribution of estimated mean monthly stock market rate of returns over the past 12 months; the top-right panel shows the distribution of estimated average rate of annual inflation over the past decade. The bottom-left panel shows evaluations of the sentiment of opinion articles on U.S. trade tariffs, and the bottom-right panel shows evaluations of news coverage about a major electric vehicle company. In all panels, Day 2 beliefs are elicited without any additional information.

**Appendix Table A.3:** CROSS-SECTIONAL RELATIONSHIP BETWEEN STATED BELIEF AND RECALLED INFORMATION

| | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| | Day 1 elicitation | | Day 2 elicitation | |
| **Panel A (Study 1): Stock market return** | | | | |
| Average of recalled returns | 0.895*** | 0.898*** | 0.942*** | 0.943*** |
| | (0.016) | (0.016) | (0.017) | (0.017) |
| Constant | 0.170*** | -0.401*** | 0.187*** | -0.073 |
| | (0.031) | (0.109) | (0.040) | (0.165) |
| Demographics | | ✓ | | ✓ |
| Observations | 605 | 605 | 501 | 501 |
| R-squared | 0.866 | 0.890 | 0.880 | 0.885 |
| **Panel B (Study 2): Inflation rate** | | | | |
| Average of recalled inflation | 0.899*** | 0.903*** | 0.876*** | 0.877*** |
| | (0.026) | (0.027) | (0.025) | (0.026) |
| Constant | 0.315*** | 0.230 | 0.431*** | 0.378** |
| | (0.092) | (0.155) | (0.092) | (0.161) |
| Demographics | | ✓ | | ✓ |
| Observations | 583 | 583 | 474 | 474 |
| R-squared | 0.707 | 0.712 | 0.754 | 0.760 |
| **Panel C (Study 3): Tariff opinion article headlines** | | | | |
| Recalled positive share | 2.599*** | 2.630*** | 1.933*** | 1.951*** |
| | (0.118) | (0.124) | (0.151) | (0.154) |
| Constant | -1.389*** | -1.334*** | -0.997*** | -0.869*** |
| | (0.052) | (0.166) | (0.077) | (0.214) |
| Demographics | | ✓ | | ✓ |
| Observations | 600 | 600 | 522 | 522 |
| R-squared | 0.274 | 0.291 | 0.164 | 0.179 |
| **Panel D (Study 4): Electric vehicle news headlines** | | | | |
| Recalled positive share | 3.949*** | 4.211*** | 2.536*** | 2.663*** |
| | (0.173) | (0.179) | (0.191) | (0.198) |
| Constant | -2.015*** | -1.729*** | -1.303*** | -1.254*** |
| | (0.088) | (0.187) | (0.105) | (0.230) |
| Demographics | | ✓ | | ✓ |
| Observations | 611 | 611 | 522 | 522 |
| R-squared | 0.326 | 0.358 | 0.174 | 0.210 |

*Notes:* The table reports OLS estimates relating recalled information to contemporaneous belief or opinion measures across four studies. In Panel A, the dependent variable is respondents' estimate of the average monthly stock market return over the past 12 months. In Panel B, the dependent variable is respondents' estimate of the average annual inflation rate over the past 10 years. In In Panel C, the dependent variable is a binary evaluation of the overall sentiment of opinion articles about a tariff policy, coded as +1 for positive and −1 for negative. Panel D, the dependent variable is a binary evaluation of the overall sentiment of news about an electric vehicle company, coded as +1 for positive and −1 for negative. Columns (1)–(2) use recall elicited on Day 1, while columns (3)–(4) use recall elicited on Day 2. Robust standard errors are reported in parentheses. Recall measures are expressed in percentage points. Statistical significance is denoted by *** $p < 0.01$, ** $p < 0.05$, and * $p < 0.10$.

**Appendix Table A.4:** WITHIN-INDIVIDUAL RELATIONSHIP BETWEEN CHANGES IN BELIEF AND CHANGES IN RECALLED INFORMATION

| | (1) | (2) |
|---|---|---|
| **Panel A (Study 1): Stock market return** | | |
| Δ average of recalled returns | 0.935*** | 0.933*** |
| | (0.017) | (0.018) |
| Constant | 0.085*** | 0.336 |
| | (0.031) | (0.212) |
| Demographics | | ✓ |
| Observations | 500 | 500 |
| R-squared | 0.870 | 0.878 |
| **Panel B (Study 2): Inflation rate** | | |
| Δ average of recalled inflation | 0.893*** | 0.894*** |
| | (0.026) | (0.027) |
| Constant | 0.028 | 0.062 |
| | (0.033) | (0.165) |
| Demographics | | ✓ |
| Observations | 460 | 460 |
| R-squared | 0.756 | 0.763 |
| **Panel C (Study 3): Tariff opinion article headlines** | | |
| Δ recalled positive share | 2.096*** | 2.054*** |
| | (0.256) | (0.262) |
| Constant | 0.041 | 0.102 |
| | (0.052) | (0.267) |
| Demographics | | ✓ |
| Observations | 522 | 522 |
| R-squared | 0.105 | 0.121 |
| **Panel D (Study 4): Electric vehicle news headlines** | | |
| Δ recalled positive share | 2.733*** | 2.714*** |
| | (0.307) | (0.319) |
| Constant | -0.037 | -0.260 |
| | (0.052) | (0.291) |
| Demographics | | ✓ |
| Observations | 522 | 522 |
| R-squared | 0.116 | 0.139 |

*Notes:* The table reports OLS estimates relating changes in recalled information to changes in beliefs or opinions between Part 1 and Part 2 across four studies. In Panel A, the dependent variable is the change in respondents' stated beliefs about the average monthly stock market return over the past 12 months. In Panel B, the dependent variable is the change in respondents' stated beliefs about the average annual inflation rate over the past 10 years. In Panel C, the dependent variable is the change in respondents' evaluation of the overall sentiment of opinion articles about a tariff policy, coded as +1 for positive and −1 for negative. In Panel D, the dependent variable is the change in respondents' evaluation of the overall sentiment of news about an electric vehicle company, coded as +1 for positive and −1 for negative. Columns (1)–(2) use changes in recall measured between Part 1 and Part 2. Robust standard errors are reported in parentheses. Changes in recall are expressed in percentage points. Statistical significance is denoted by *** $p < 0.01$, ** $p < 0.05$, and * $p < 0.10$.

## Appendix C Deriving the Majority Rule (3.1) from Bayesian updating

The paper models belief formation as a two-stage process: (i) the stochastic recall of stored signals (the recall stage) and (ii) aggregation via a majority rule (3.1) (the information-processing stage).

The majority rule can be microfounded by embedding the model in a standard Bayesian classification problem. Suppose:

1. The state is binary $Y \in \{G, B\}$ with symmetric prior
$$P(G) = P(B) = \tfrac{1}{2}.$$

2. Signals are i.i.d. and symmetric in diagnosticity:
$$P(s = p \mid G) = P(s = n \mid B) = b > \tfrac{1}{2}, \qquad P(s = p \mid B) = P(s = n \mid G) = 1 - b.$$

3. Memory is imperfect: only a random subset of signals is recalled. The decision maker observes $(X_i^+, X_i^-)$, the counts of recalled positive and negative signals.

Given the recalled evidence $R_i$, the likelihoods are:
$$P(R_i \mid G) = b^{X_i^+}(1-b)^{X_i^-}, \qquad P(R_i \mid B) = (1-b)^{X_i^+} b^{X_i^-}.$$

Posterior odds are therefore
$$\frac{P(G \mid R_i)}{P(B \mid R_i)} = \frac{P(G)}{P(B)} \cdot \frac{P(R_i \mid G)}{P(R_i \mid B)} = \left(\frac{b}{1-b}\right)^{X_i^+ - X_i^-}.$$

Since $b > 1/2$, we have $\frac{b}{1-b} > 1$, so
$$P(G \mid R_i) > \tfrac{1}{2} \iff X_i^+ - X_i^- > 0.$$

The Bayes–optimal decision is:
$$\text{choose } G \text{ iff } X_i^+ > X_i^-,$$
which is precisely the majority rule used in the paper. Thus, majority voting over recalled signals is optimal under symmetry.

## Appendix D Existing Survey Responses on House Price Expectation

Case and Shiller (2003) study consumer expectations during housing booms using survey data collected in 1988 and 2003 across four U.S. metropolitan areas: Los Angeles, San Francisco, Boston, and Milwaukee. The surveys elicit respondents' expectations for house price changes over one-year and ten-year horizons. Table A.5 reproduces the exact survey questions and summarizes the distribution of responses. Across both episodes, expectations are characterized by strong optimism and remarkably little dispersion. Roughly 90 percent or more of respondents expected house prices to rise, and disagreement over both short-run and long-run price changes was minimal. Importantly, in each survey period respondents had recently experienced sustained house price appreciation in their local markets.

**Appendix Table A.5:** SURVEY RESPONSES ON HOUSE PRICE EXPECTATIONS, 1988 AND 2003 (CASE AND SHILLER (2003))

| | *Los Angeles* | | *San Francisco* | | *Boston* | | *Milwaukee* | |
|---|---|---|---|---|---|---|---|---|
| *Question* | *1988* | *2003* | *1988* | *2003* | *1988* | *2003* | *1988* | *2003* |
| Do you think that housing prices in the [city] area will increase or decrease over the next several years? | | | | | | | | |
| Increase | 98.3 | 89.7 | 99.0 | 90.5 | 90.2 | 83.1 | 87.1 | 95.2 |
| Decrease | 1.7 | 10.3 | 1.0 | 9.5 | 9.8 | 16.9 | 12.9 | 4.8 |
| No. of responses | 240 | 145 | 199 | 158 | 194 | 201 | 233 | 187 |
| How much of a change do you expect there to be in the value of your home over the next 12 months? | | | | | | | | |
| Mean response (percent) | 15.3 | 10.5 | 13.5 | 9.8 | 7.4 | 7.2 | 6.1 | 8.9 |
| Standard error | 0.8 | 0.6 | 0.6 | 0.6 | 0.6 | 0.4 | 0.5 | 1.0 |
| No. of responses | 217 | 139 | 185 | 147 | 176 | 179 | 217 | 160 |
| On average over the next 10 years, how much do you expect the value of your property to change each year? | | | | | | | | |
| Mean response (percent) | 14.3 | 13.1 | 14.8 | 15.7 | 8.7 | 14.6 | 7.3 | 11.7 |
| Standard error | 1.2 | 1.2 | 1.4 | 1.8 | 0.6 | 1.8 | 0.5 | 1.3 |
| No. of responses | 208 | 137 | 181 | 152 | 177 | 186 | 211 | 169 |

*Notes:* This table reproduces survey results reported in Case and Shiller (2003) based on responses from homebuyers in four U.S. metropolitan areas (Los Angeles, San Francisco, Boston, and Milwaukee) in two survey waves (1988 and 2003). Respondents were asked whether they expected local housing prices to increase or decrease over the next several years, and the table reports the percentage who indicated an increase or decrease as well as the number of respondents. The table also summarizes quantitative expectations of house price changes: (i) expected percentage change in home values over the next 12 months and (ii) expected annual percentage change in home values over the next 10 years. For each question, the table reports mean expected changes (in percent), associated standard errors, and sample sizes. Data correspond to Table 9 of Case and Shiller (2003).

In the language of the model, these environments correspond to low informational ambivalence: the recent history of signals stored in memory was overwhelmingly positive. With imperfect memory, recalled information is therefore dominated by positive signals for most

respondents, leading to highly aligned recalled samples across individuals. As a result, belief formation under stochastic recall naturally generates near-consensus expectations and very low disagreement.

This housing-market evidence complements the stock-market results by illustrating how environments with strongly one-sided historical experiences produce compressed belief distributions and minimal disagreement, even when recall is imperfect.

## Appendix E Proof of Proposition 1

As discussed in the text, when $N^+$ and $N^-$ are large, $X_i^+$ and $X_i^-$ can be approximated by normal distributions:

$$X_i^+ \sim \mathcal{N}(N^+ p, N^+ p(1-p))$$
$$X_i^- \sim \mathcal{N}(N^- p, N^- p(1-p))$$

Define $N = N^+ + N^-$. Let $Z_i = X_i^+ - X_i^-$, then $Z_i \sim \mathcal{N}((N^+ - N^-)p, p(1-p)N)$.

To find $P(X_i^+ < X_i^-) = P(Z_i < 0)$:

$$P(Z_i < 0) = P\left(Z_i^* < \frac{0 - (N^+ - N^-)p}{\sqrt{p(1-p)N}}\right) = P\left(Z_i^* < -\frac{(N^+ - N^-)p}{\sqrt{p(1-p)N}}\right)$$

Using the standard normal distribution function $\Phi$, we get:

$$P(X_i^+ < X_i^-) = \Phi\left(-\frac{(N^+ - N^-)p}{\sqrt{p(1-p)N}}\right)$$

Because $\Phi(-x) = 1 - \Phi(x)$, this simplifies to:

$$P(X_i^+ < X_i^-) = 1 - \Phi\left(\frac{(N^+ - N^-)p}{\sqrt{p(1-p)N}}\right).$$

Similarly, we get that

$$q = P(X_i^+ > X_i^-) = \Phi\left(\frac{(N^+ - N^-)p}{\sqrt{p(1-p)N}}\right).$$

Note that $\widehat{Y}_i = 1$ when $X_i^+ > X_i^-$. $\widehat{Y}_i = -1$ when $X_i^+ \leq X_i^-$. Thus, the cross-sectional mean and variance of DMs' beliefs are

$$E(\widehat{Y}_i) = 2q - 1 \tag{E.1}$$

and

$$Var(\widehat{Y}_i) = 4q(1-q) \tag{E.2}$$

**Remark.** When $N$ goes to infinity, $q$ goes to 1 if $N^+ > N^-$ and $-1$ if $N^+ < N^-$. In this case, disagreement goes to zero.

## Appendix F Proof of Proposition 2

We firstly prove the first part of the proposition. DMs' disagreement about the asset value $Var(\widehat{Y}_i)$ is an increasing function of $q$ when $q \leq \frac{1}{2}$ and a decreasing function of $q$ when $q \geq \frac{1}{2}$.

Recall the degree of ambivalence is

$$A = 1 - \left| \frac{N^+ - N^-}{N} \right| \tag{F.1}$$

If $N^+ < N^-$, $A = 1 + \frac{N^+ - N^-}{N}$, so $A$ is increasing in $\frac{N^+ - N^-}{N}$. In this case, $q < \frac{1}{2}$ and $q$ is increasing in $\frac{N^+ - N^-}{N}$. Thus, we have $Var(\widehat{Y}_i)$ increasing in $A$.

If $N^+ > N^-$, $A = 1 - \frac{N^+ - N^-}{N}$, so $A$ is decreasing in $\frac{N^+ - N^-}{N}$. In this case, $q > \frac{1}{2}$ and $q$ is decreasing in $\frac{N^+ - N^-}{N}$. Thus, we have $Var(\widehat{Y}_i)$ increasing in $A$.

Taken together, we have proved that the DM's belief disagreement $Var(\widehat{Y}_i)$ is an increasing function of the degree of ambivalence $A$.

Now we prove the second part. For $N^+ > N^-$, we have $q \geq \frac{1}{2}$ and $q$ is increasing in $p$. Furthermore, $\text{Var}(\widehat{Y}_i)$ is decreasing in $q$ when $q \geq \frac{1}{2}$. Thus, we have $\text{Var}(\widehat{Y}_i)$ decreasing in $p$. For $N^+ < N^-$, we have $q \leq \frac{1}{2}$ and $q$ is decreasing in $p$. Furthermore, $\text{Var}(\widehat{Y}_i)$ is increasing in $q$ when $q \leq \frac{1}{2}$. Again, we have $\text{Var}(\widehat{Y}_i)$ decreasing in $p$. Taking the two cases together, we have $\text{Var}(\widehat{Y}_i)$ decreasing in $p$.

## Appendix G Proof of Proposition 3

To characterize the probability $\Pi(N^+, N^-, p)$, we use the same large-sample approximation as in Appendix E. Let

$$Z_\tau = X^+_{i,\tau} - X^-_{i,\tau}.$$

As shown in Appendix E, when $N^+$ and $N^-$ are large and $p$ is bounded away from zero and one,

$$Z_\tau \dot{\sim} \mathcal{N}\big((N^+ - N^-)p,\ p(1-p)N\big).$$

Since $\widehat{Y}_\tau = 1$ if and only if $Z_\tau > 0$, it follows that the probability of a positive belief at any date $\tau$ is

$$q = \Pr(\widehat{Y}_\tau = 1) = \Phi\big(c(N^+, N^-, p)\big), \qquad c(N^+, N^-, p) = \frac{(N^+ - N^-)p}{\sqrt{p(1-p)N}},$$

where $\Phi(\cdot)$ denotes the standard normal cumulative distribution function. Because recall realizations are independent across elicitation dates, $\widehat{Y}_t$ and $\widehat{Y}_{t+1}$ are i.i.d. Bernoulli random variables with success probability $q$. Therefore,

$$\Pi(N^+, N^-, p) = \Pr(\widehat{Y}_t \neq \widehat{Y}_{t+1}) = 2q(1-q) = 2\Phi(c)\big(1 - \Phi(c)\big).$$

Recall the definition of informational ambivalence as

$$A = 1 - \frac{|N^+ - N^-|}{N}.$$

The proposition can be proved by following the proof of Proposition 2.

## Appendix H Proof of Proposition 4

Recall that the posterior probability that the state is good is

$$\mu_i = \left[ 1 + \left( \frac{1-b}{b} \right)^{X_i^+ - X_i^-} \right]^{-1}, \qquad b > \frac{1}{2}.$$

Define recalled net evidence as

$$D_i \equiv X_i^+ - X_i^-.$$

Then

$$\mu_i = \left[1 + \left(\frac{1-b}{b}\right)^{D_i}\right]^{-1}.$$

Let

$$\alpha \equiv \log\left(\frac{b}{1-b}\right) > 0.$$

Using

$$\left(\frac{1-b}{b}\right)^{D_i} = e^{-\alpha D_i},$$

we can rewrite the posterior as

$$\mu_i = \frac{1}{1+e^{-\alpha D_i}}.$$

Subjective uncertainty is defined as

$$U_i = \mu_i(1-\mu_i).$$

Substituting the expression for $\mu_i$,

$$U_i = \frac{1}{1+e^{-\alpha D_i}}\left(1 - \frac{1}{1+e^{-\alpha D_i}}\right) = \frac{e^{-\alpha D_i}}{(1+e^{-\alpha D_i})^2}.$$

Multiplying numerator and denominator by $e^{\alpha D_i}$,

$$U_i = \frac{1}{e^{\alpha D_i} + 2 + e^{-\alpha D_i}}.$$

Using the identity

$$\cosh(x) = \frac{e^x + e^{-x}}{2},$$

this becomes

$$U_i = \frac{1}{2\big(1+\cosh(\alpha D_i)\big)}.$$

This expression implies two properties immediately.

First, $U_i$ depends only on $|D_i|$, because $\cosh(\alpha D_i)$ is an even function:

$$\cosh(\alpha D_i) = \cosh(\alpha |D_i|).$$

Second, $U_i$ is strictly decreasing in $|D_i|$. To see this, define

$$g(x) \equiv \frac{1}{2\big(1+\cosh(\alpha x)\big)}, \qquad x \geq 0.$$

Then

$$U_i = g(|D_i|).$$

Differentiating,

$$g'(x) = -\frac{\alpha \sinh(\alpha x)}{2\big(1+\cosh(\alpha x)\big)^2}.$$

Since $\alpha > 0$ and $\sinh(\alpha x) > 0$ for all $x > 0$, it follows that

$$g'(x) < 0 \qquad \text{for all } x > 0.$$

Hence $U_i$ is strictly decreasing in $|D_i|$.

Therefore, subjective uncertainty is maximized when $|D_i| = 0$, i.e. when $X_i^+ = X_i^-$, and decreases as the absolute recalled net evidence $|X_i^+ - X_i^-|$ increases. This proves Proposition 4.

## Appendix I Proof of Proposition 4

Let

$$D_i \equiv X_i^+ - X_i^-, \qquad \alpha \equiv \log\left(\frac{b}{1-b}\right) > 0.$$

Then the posterior probability that the state is good can be written as

$$\mu_i = \frac{1}{1+e^{-\alpha D_i}}.$$

Hence subjective uncertainty is

$$U_i = \mu_i(1-\mu_i) = \frac{e^{-\alpha D_i}}{(1+e^{-\alpha D_i})^2}.$$

Multiplying numerator and denominator by $e^{\alpha D_i}$,

$$U_i = \frac{1}{e^{\alpha D_i} + 2 + e^{-\alpha D_i}}.$$

Using the identity

$$\cosh(x) = \frac{e^x + e^{-x}}{2},$$

we obtain

$$U_i = \frac{1}{2\big(1+\cosh(\alpha D_i)\big)}.$$

Since $\cosh(\alpha D_i)$ depends only on $|D_i|$, it follows immediately that $U_i$ depends only on $|D_i|$. Moreover, $\cosh(x)$ is strictly increasing in $|x|$, so

$$U_i = \frac{1}{2\big(1+\cosh(\alpha D_i)\big)}$$

is strictly decreasing in $|D_i|$. Therefore subjective uncertainty is maximized at $|D_i| = 0$, i.e. when $X_i^+ = X_i^-$, and decreases as recalled evidence becomes more one-sided.

## Appendix J Proof of Proposition 5

Under the normal approximation used in Proposition 1,

$$D_i = X_i^+ - X_i^- \dot{\sim} \mathcal{N}(m, \sigma^2),$$

where

$$m = (N^+ - N^-)p, \qquad \sigma^2 = Np(1-p).$$

By Proposition 4, subjective uncertainty is

$$U_i = h(D_i), \qquad h(x) \equiv \frac{1}{2\big(1+\cosh(\alpha x)\big)},$$

where $h$ is an even function and strictly decreasing in $|x|$.

Hence expected subjective uncertainty is approximately

$$E[U_i] \approx F(m) \equiv E[h(m+\sigma Z)], \qquad Z \sim \mathcal{N}(0,1).$$

Because $h$ is even, $F(m) = F(-m)$. It therefore suffices to show that $F(m)$ is decreasing in $|m|$.

For $m > 0$, differentiating under the integral sign yields

$$F'(m) = \int_{-\infty}^{\infty} h'(x)\,\phi_\sigma(x-m)\,dx,$$

where $\phi_\sigma(\cdot)$ denotes the density of $\mathcal{N}(0,\sigma^2)$. Splitting the integral at zero and using that $h'$ is odd,

$$F'(m) = \int_0^{\infty} h'(x)\Big[\phi_\sigma(x-m) - \phi_\sigma(x+m)\Big]\,dx.$$

For every $x > 0$ and $m > 0$,

$$\phi_\sigma(x-m) > \phi_\sigma(x+m),$$

while $h'(x) < 0$ for all $x > 0$. Therefore every integrand is negative, implying

$$F'(m) < 0 \qquad \text{for all } m > 0.$$

Thus $F(m)$ is decreasing in $|m|$.

Finally, holding $N$ and $p$ fixed,

$$|m| = p\,|N^+ - N^-| = pN(1-A),$$

which is decreasing in $A$. Since $E[U_i] \approx F(m)$ and $F$ is decreasing in $|m|$, it follows that expected subjective uncertainty is increasing in informational ambivalence $A$.

## Appendix K Proof of Proposition 6

We prove the disagreement part first and then the subjective-uncertainty part.

**Step 1: Distribution of recalled net evidence under a cue.** Without loss of generality, suppose first that the cue is associated with positive signals and increases the recall probability of positive signals. The recall probability for positive signals is then

$$\widetilde{p} = p + a, \qquad a \in (0, 1-p].$$

Accordingly,

$$X_i^+ \sim \mathcal{N}\big(N^+\widetilde{p},\, N^+\widetilde{p}(1-\widetilde{p})\big), \qquad X_i^- \sim \mathcal{N}\big(N^-p,\, N^-p(1-p)\big).$$

Since $X_i^+$ and $X_i^-$ are independent, the recalled net evidence

$$Z_i \equiv X_i^+ - X_i^-$$

is normally distributed:

$$Z_i \sim \mathcal{N}(\mu_Z, \sigma_Z^2),$$

where

$$\mu_Z = N^+\widetilde{p} - N^-p, \qquad \sigma_Z^2 = N^+\widetilde{p}(1-\widetilde{p}) + N^-p(1-p).$$

The probability that decision-maker $i$ forms the belief $\widehat{Y}_i = 1$ is

$$\widetilde{q} = P(Z_i > 0) = \Phi\left(\frac{\mu_Z}{\sigma_Z}\right).$$

Hence the cross-sectional mean and variance of beliefs in the cued case are

$$E(\widehat{Y}_i \mid \text{cue}) = 2\widetilde{q} - 1, \qquad \mathsf{Var}(\widehat{Y}_i \mid \text{cue}) = 4\widetilde{q}(1-\widetilde{q}).$$

Explicitly,

$$E(\widehat{Y}_i \mid \text{cue}) = 2\Phi\left(\frac{N^+\widetilde{p} - N^- p}{\sqrt{N^+\widetilde{p}(1-\widetilde{p}) + N^- p(1-p)}}\right) - 1,$$

and

$$\mathsf{Var}(\widehat{Y}_i \mid \text{cue}) = 4\Phi\left(\frac{N^+\widetilde{p} - N^- p}{\sqrt{N^+\widetilde{p}(1-\widetilde{p}) + N^- p(1-p)}}\right)\left[1 - \Phi\left(\frac{N^+\widetilde{p} - N^- p}{\sqrt{N^+\widetilde{p}(1-\widetilde{p}) + N^- p(1-p)}}\right)\right].$$

Without a cue,

$$E(\widehat{Y}_i \mid \text{no cue}) = 2\Phi\left(\frac{(N^+ - N^-)p}{\sqrt{(N^+ + N^-)p(1-p)}}\right) - 1,$$

and

$$\mathsf{Var}(\widehat{Y}_i \mid \text{no cue}) = 4\Phi\left(\frac{(N^+ - N^-)p}{\sqrt{(N^+ + N^-)p(1-p)}}\right)\left[1 - \Phi\left(\frac{(N^+ - N^-)p}{\sqrt{(N^+ + N^-)p(1-p)}}\right)\right].$$

Let

$$N = N^+ + N^-, \qquad \lambda = \frac{N^+}{N}, \qquad 0 < \lambda < 1.$$

**Step 2: Cueing dominant signals and disagreement.** We compare the absolute standardized means with and without the cue:

$$\left|\frac{N^+(p+a) - N^- p}{\sqrt{N^+(p+a)(1-p-a) + N^- p(1-p)}}\right| > \left|\frac{(N^+ - N^-)p}{\sqrt{(N^+ + N^-)p(1-p)}}\right|$$

$$\iff \left|\frac{\lambda(p+a) - (1-\lambda)p}{\sqrt{\lambda(p+a)(1-p-a) + (1-\lambda)p(1-p)}}\right| > \left|\frac{(\lambda - (1-\lambda))p}{\sqrt{p(1-p)}}\right|$$

$$\iff \big(\lambda(p+a) - (1-\lambda)p\big)^2 p(1-p) > (\lambda - (1-\lambda))^2 p^2 \big(\lambda(p+a)(1-p-a) + (1-\lambda)p(1-p)\big)$$

$$\iff \big(\lambda^2(p+a)^2 + (1-\lambda)^2 p^2 - 2\lambda(1-\lambda)(p+a)p\big)\, p(1-p) >$$

$$(\lambda - (1-\lambda))^2 p^2 \big(\lambda(p+a)(1-p-a) + (1-\lambda)p(1-p)\big)$$

$$\iff \big(\lambda^2(2ap + a^2) - 2\lambda(1-\lambda)ap\big)(1-p) > (\lambda - (1-\lambda))^2 p\big(-\lambda ap - \lambda a^2 + \lambda a(1-p)\big)$$

$$\iff \big(\lambda(2p+a) - 2(1-\lambda)p\big)(1-p) > (\lambda - (1-\lambda))^2 p(1-2p-a)$$

$$\iff 2(\lambda - (1-\lambda))p(1-p) + a\big(\lambda(1-p) + (\lambda - (1-\lambda))^2 p\big) > (\lambda - (1-\lambda))^2 p(1-2p).$$

Case 1: $N^+ \geq N^-$, so $\lambda \geq \frac{1}{2}$. Then the above inequality holds, because

$$2(\lambda - (1-\lambda))p(1-p) > (\lambda - (1-\lambda))^2 p(1-2p).$$

Moreover,

$$\Phi\left(\frac{N^+(p+a) - N^- p}{\sqrt{N^+(p+a)(1-p-a) + N^- p(1-p)}}\right) > \Phi\left(\frac{(N^+ - N^-)p}{\sqrt{(N^+ + N^-)p(1-p)}}\right) > \frac{1}{2}.$$

Since $\mathsf{Var}(\widehat{Y}_i) = 4q(1-q)$ is decreasing in $q$ for $q > \frac{1}{2}$, it follows that cueing the dominant signal type decreases disagreement:

$$\mathsf{Var}(\widehat{Y}_i \mid \text{cue}) < \mathsf{Var}(\widehat{Y}_i \mid \text{no cue}).$$

This proves part (1) of the proposition.

**Step 3: Cueing non-dominant signals and disagreement.** Case 2: $N^+ < N^-$, so $\lambda < \frac{1}{2}$. Then the inequality above is equivalent to

$$a > \Delta,$$

where

$$\Delta = \frac{(2\lambda-1)^2 p(1-2p) - 2(2\lambda-1)p(1-p)}{\lambda(1-p) + (2\lambda-1)^2 p}.$$

In this case, cueing positive signals means cueing the minority signal type. Therefore:

1. If $\Delta > 1-p$, the inequality cannot hold for any feasible $a$, so disagreement increases:
$$\mathsf{Var}(\widehat{Y}_i \mid \text{cue}) > \mathsf{Var}(\widehat{Y}_i \mid \text{no cue}).$$
2. If $1-p > \Delta > 0$, disagreement increases if $a < \Delta$, is unchanged if $a = \Delta$, and decreases if $a > \Delta$.
3. If $\Delta \leq 0$, the inequality always holds, so disagreement decreases.

This proves part (2) of the proposition.

**Step 4: Subjective uncertainty under a mean-based approximation.** Recall from Proposition 4 that subjective uncertainty is a strictly decreasing function of the absolute recalled net evidence,

$$|D_i| = |X_i^+ - X_i^-|.$$

In this subsection, we use the mean-based approximation that expected subjective uncertainty is decreasing in the absolute expected recalled net evidence,

$$|E[D_i]|.$$

Accordingly, it is sufficient to characterize how the cue changes $E[D_i]$.

**Step 5: Cueing dominant signals and subjective uncertainty.** Suppose $N^+ > N^-$, so positive signals are dominant, and the cue increases the recall probability of positive signals from $p$ to $p+a$. Then

$$E[X_i^+] = N^+(p+a), \qquad E[X_i^-] = N^- p,$$

so

$$E[D_i] = E[X_i^+ - X_i^-] = N^+(p+a) - N^- p = (N^+ - N^-)p + N^+ a.$$

Since $N^+ > N^-$, we have $E[D_i] > 0$, and

$$\frac{d}{da} E[D_i] = N^+ > 0.$$

Hence $|E[D_i]|$ increases with $a$. Under the mean-based approximation, expected subjective uncertainty is decreasing in $|E[D_i]|$, so cueing dominant signals decreases expected subjective uncertainty:

$$E[U_i]|_{\text{cue}} < E[U_i]|_{\text{no cue}}.$$

This proves part (3) of the proposition.

**Step 6: Cueing non-dominant signals and subjective uncertainty.** Now suppose $N^+ > N^-$ but the cue increases the recall probability of negative signals, the minority signal type, from $p$ to $p+a$, while the recall probability of positive signals remains $p$. Then

$$E[X_i^+] = N^+ p, \qquad E[X_i^-] = N^-(p+a).$$

Thus

$$E[D_i] = N^+ p - N^-(p+a) = (N^+ - N^-)p - N^- a.$$

Define

$$\Theta \equiv \frac{(N^+ - N^-)p}{N^-}.$$

Then

$$E[D_i] > 0 \quad \text{if } a < \Theta, \qquad E[D_i] = 0 \quad \text{if } a = \Theta, \qquad E[D_i] < 0 \quad \text{if } a > \Theta.$$

Therefore

$$|E[D_i]| = \left|(N^+ - N^-)p - N^- a\right|$$

is decreasing in $a$ for $a < \Theta$, reaches its minimum at $a = \Theta$, and is increasing in $a$ for $a > \Theta$. Since expected subjective uncertainty is decreasing in $|E[D_i]|$ under the mean-based approximation, it follows that expected subjective uncertainty increases for $a < \Theta$, is maximized at $a = \Theta$, and decreases for $a > \Theta$.

If instead $N^- > N^+$, the same argument applies with the roles of positive and negative signals reversed. Writing

$$N^m = \min\{N^+, N^-\},$$

the threshold can be written compactly as

$$\Theta = \frac{|N^+ - N^-|p}{N^m}.$$

This proves part (4) of the proposition.

Combining the four parts establishes Proposition 6.

## Appendix K.1 Numerical Illustration of Proposition 6

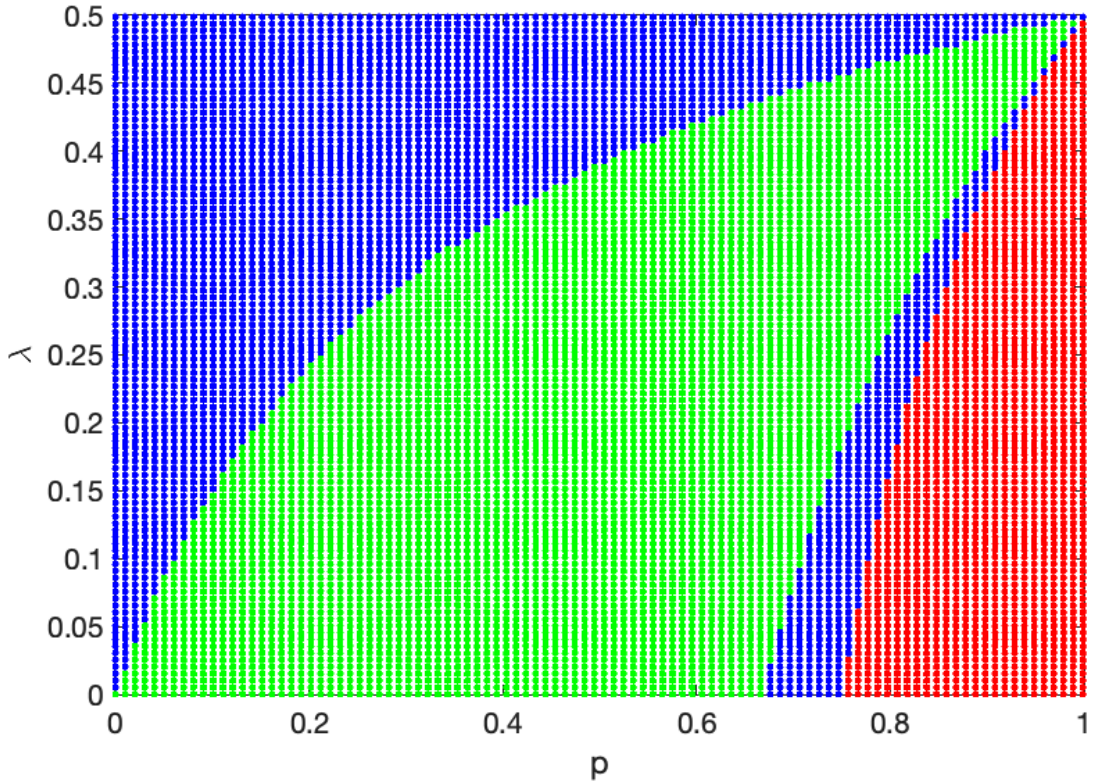
Figure A.2 shows the numerical illustration of Proposition 6 for the case when $\lambda < 0.5$. When $\lambda > 0.5$, any cue that increases the probability of recalling positive signals decreases disagreement.

## Appendix L Proof of Proposition 7

Fix a realized history $Z = (Z_1, \ldots, Z_T)$. All randomness below is taken with respect to DMs' recall indicators $\{I_i^k\}_{k=1}^T$, which are independent across $k$, satisfy

$$\mathbb{E}[I_i^k] = p, \qquad \mathrm{Var}(I_i^k) = p(1-p),$$

and are independent of $Z$.




**Appendix Figure A.2:** THE EFFECT OF CUE ON DISAGREEMENT WHEN $\lambda < 0.5$
Notes: In the green area, $\Delta > 1-p$, so disagreement increases. In the red area, $\Delta$ is non-positive, so disagreement decreases. In the blue area, $1-p > \Delta > 0$, so disagreement increases if $a < \Delta$ and decreases if $a > \Delta$.

For DM $i$, define

$$S_i = \sum_{k=1}^{T} I_i^k Z_k, \qquad N_i = \sum_{k=1}^{T} I_i^k, \qquad \mu_i = \frac{S_i}{N_i}.$$

Let

$$\bar{Z} = \frac{1}{T}\sum_{k=1}^{T} Z_k, \qquad \delta_k = Z_k - \bar{Z}.$$

Using $\sum_{k=1}^{T} p\,\delta_k = 0$,

$$\mu_i - \bar{Z} = \frac{\sum_{k=1}^{T} I_i^k \delta_k}{N_i} = \frac{\sum_{k=1}^{T} (I_i^k - p)\delta_k}{N_i}.$$

Write

$$N_i = Tp + \Delta_{N,i}, \qquad \Delta_{N,i} = \sum_{k=1}^{T} (I_i^k - p),$$

where $\Delta_{N,i} = O_p(\sqrt{T})$. Using the Taylor expansion

$$\frac{1}{Tp + \Delta_{N,i}} = \frac{1}{Tp} - \frac{\Delta_{N,i}}{(Tp)^2} + O_p(T^{-2}),$$

and defining

$$\Delta_{S,i} = \sum_{k=1}^{T} (I_i^k - p)\delta_k,$$

we obtain

$$\mu_i - \bar{Z} = \frac{1}{Tp}\Delta_{S,i} - \frac{1}{(Tp)^2}\Delta_{N,i}\Delta_{S,i} + O_p(T^{-3/2}).$$

Conditional on $Z$, $\Delta_{S,i}$ is a sum of independent mean-zero terms, so

$$\mathrm{Var}(\Delta_{S,i} \mid Z) = p(1-p)\sum_{k=1}^{T} \delta_k^2.$$

The remaining terms contribute $o(T^{-1})$ to the variance. Hence,

$$\mathrm{Var}(\mu_i \mid Z) \approx \frac{1}{(Tp)^2}\mathrm{Var}(\Delta_{S,i} \mid Z) = \frac{1-p}{Tp}\widehat{\mathrm{Var}}(Z_1, \ldots, Z_T).$$

Taking expectations over histories yields

$$\mathscr{D} \approx \frac{1-p}{Tp}\mathrm{Var}(Z_t) = \frac{1-p}{Tp} \cdot \frac{\sigma_\varepsilon^2}{1-\rho^2}.$$

## Appendix M Proof of Proposition 8

Fix a realized history $Z = (Z_1, \ldots, Z_T)$. Consider a single DM $i$ whose belief is elicited twice, at $\tau \in \{1, 2\}$, with no new information arriving between elicitations. At each elicitation, the DM draws an independent recall realization $\{I_{i,\tau}^k\}_{k=1}^T$, where $\{I_{i,\tau}^k\}_{k=1}^T \sim \text{Bernoulli}(p)$ independently across $k$ and $\tau$.

Define

$$S_{i,\tau} = \sum_{k=1}^{T} I_{i,\tau}^k Z_k, \qquad N_{i,\tau} = \sum_{k=1}^{T} I_{i,\tau}^k, \qquad \hat{\mu}_{i,\tau} = \frac{S_{i,\tau}}{N_{i,\tau}}.$$

We study

$$\mathscr{I}(Z_1, \ldots, Z_T) = \mathbb{E}\left[(\hat{\mu}_{i,1} - \hat{\mu}_{i,2})^2 \mid Z_1, \ldots, Z_T\right].$$

Conditional on $Z$, $\hat{\mu}_{i,1}$ and $\hat{\mu}_{i,2}$ are i.i.d., hence

$$\mathscr{I}(Z_1, \ldots, Z_T) = 2\,\mathrm{Var}(\hat{\mu}_{i,1} \mid Z_1, \ldots, Z_T).$$

From Proposition 7,

$$\mathrm{Var}(\hat{\mu}_{i,1} \mid Z_1, \ldots, Z_T) \approx \frac{1-p}{Tp}\widehat{\mathrm{Var}}(Z_1, \ldots, Z_T).$$

Therefore,

$$\mathscr{I}(Z_1, \ldots, Z_T) \approx \frac{2(1-p)}{Tp}\widehat{\mathrm{Var}}(Z_1, \ldots, Z_T),$$

which is equation (7.4).

Taking expectations over histories,

$$\mathbb{E}\left[(\hat{\mu}_{i,1} - \hat{\mu}_{i,2})^2\right] \approx \frac{2(1-p)}{Tp}\mathrm{Var}(Z_t) = \frac{2(1-p)}{Tp} \cdot \frac{\sigma_\varepsilon^2}{1-\rho^2},$$

which is equation (7.5).

## Appendix N Disagreement in One-Step-Ahead Forecasts

We extend the analysis to disagreement in one-step-ahead forecasts in the AR(1) environment.

**Proposition A.1** (Forecast Disagreement)**.** *For large $T$, conditional on the realized history $(Z_1,\dots,Z_T)$,*

$$\begin{aligned}\operatorname{Var}\big(\widehat{Z}_{T+1,i} \mid Z_1,\dots,Z_T\big) \;\approx\; &\rho^2 p(1-p)\,(Z_T-\bar{Z})^2 \\ &+\big(1-2\rho p+\rho^2 p\big)\frac{1-p}{Tp}\,\widehat{\operatorname{Var}}(Z_1,\dots,Z_T),\end{aligned} \tag{N.1}$$

*and unconditionally,*

$$\operatorname{Var}\big(\widehat{Z}_{T+1,i}\big) \;\approx\; \rho^2 p(1-p)\operatorname{Var}(Z_t)+\big(1-2\rho p+\rho^2 p\big)\frac{1-p}{Tp}\operatorname{Var}(Z_t). \tag{N.2}$$

## Proof of Proposition A.1

Fix a realized history $Z=(Z_1,\dots,Z_T)$ and define

$$\bar{Z}=\frac{1}{T}\sum_{k=1}^{T} Z_k.$$

All randomness below is taken with respect to DMs' recall indicators $\{I_i^k\}_{k=1}^T$.

The DM $i$'s one-step-ahead forecast is formed using the AR(1) structure when the most recent realization is recalled. If DM $i$ recalls $Z_T$, the plug-in forecast is $(1-\rho)\mu_i+\rho Z_T$; otherwise the DM uses $\mu_i$ as a proxy. Both cases can be written compactly as

$$\widehat{Z}_{T+1,i}=\mu_i+\rho I_i^T(Z_T-\mu_i)=(1-\rho I_i^T)\mu_i+\rho I_i^T Z_T. \tag{N.3}$$

Define the approximate cross-sectional mean forecast

$$m(Z)=(1-\rho p)\bar{Z}+\rho p Z_T. \tag{N.4}$$

This expression is obtained by replacing $\mu_i$ with $\bar{Z}$ and $I_i^T$ with its mean $p$ in (N.3). Any discrepancy between $\mathbb{E}[\widehat{Z}_{T+1,i}\mid Z]$ and $m(Z)$ is of order $O(T^{-1})$ and does not affect the leading variance terms.

Subtracting $m(Z)$ from (N.3) and subtracting $\bar{Z}$ yields

$$\widehat{Z}_{T+1,i}-m(Z)=(1-\rho I_i^T)(\mu_i-\bar{Z})+\rho(I_i^T-p)(Z_T-\bar{Z}). \tag{N.5}$$

From Proposition 7, conditional on $Z$,

$$\operatorname{Var}(\mu_i-\bar{Z}\mid Z)\;\approx\;\frac{1-p}{Tp}\,\widehat{\operatorname{Var}}(Z_1,\dots,Z_T),\qquad \mu_i-\bar{Z}=O_p(T^{-1/2}). \tag{N.6}$$

Moreover, changing $I_i^T$ perturbs both the numerator and denominator of $\mu_i$ by $O(1)$ while the denominator is $O(T)$, implying

$$\operatorname{Cov}\big(I_i^T-p,\;\mu_i-\bar{Z}\mid Z\big)=O(T^{-1}). \tag{N.7}$$

Using (N.5), the conditional variance decomposes as

$$\operatorname{Var}(\widehat{Z}_{T+1,i}\mid Z)=\operatorname{Var}\big((1-\rho I_i^T)(\mu_i-\bar{Z})\mid Z\big)+\operatorname{Var}\big(\rho(I_i^T-p)(Z_T-\bar{Z})\mid Z\big)+o(T^{-1}),$$

where the covariance term is negligible by (N.7).

Evaluating each component yields

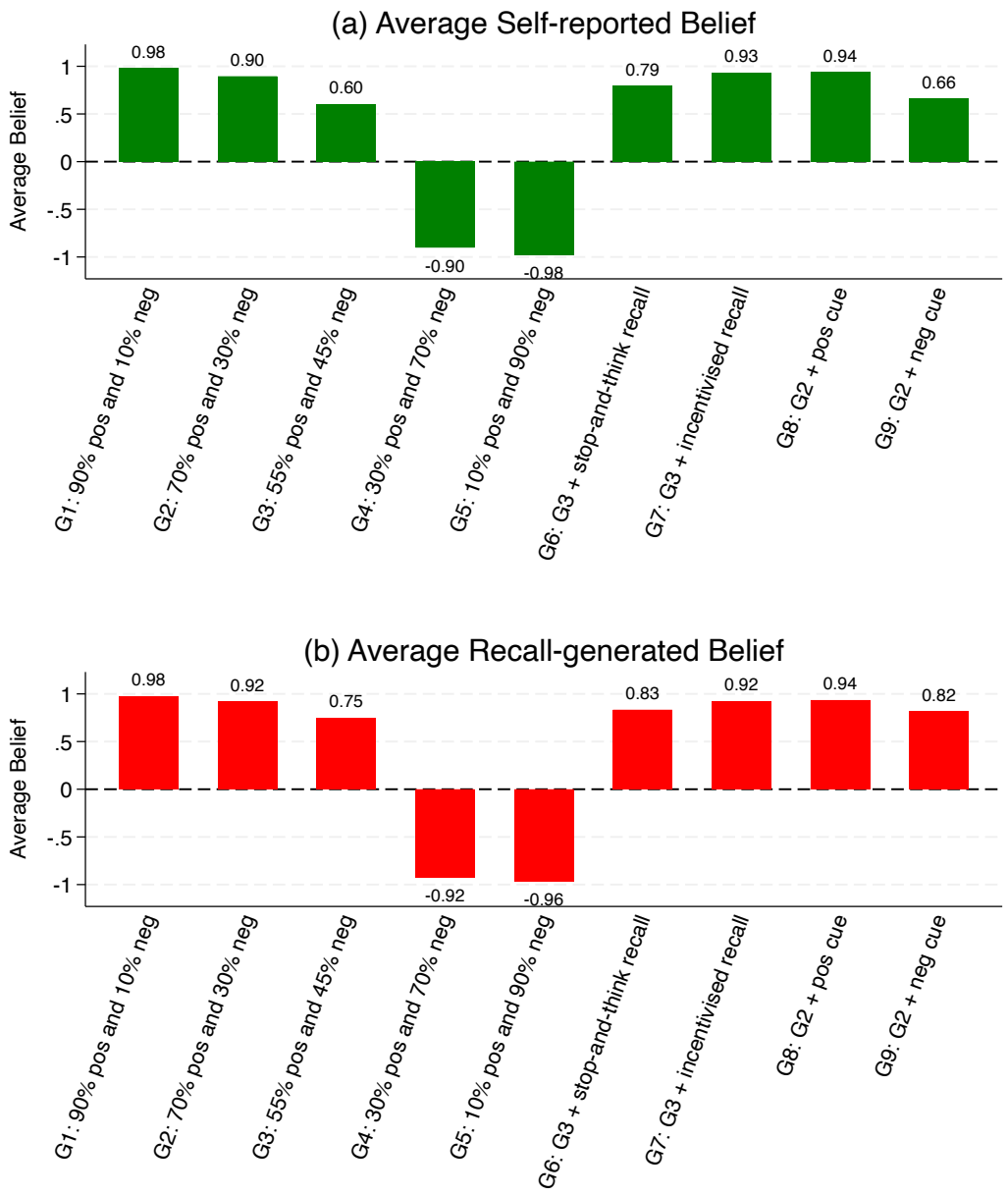
$$\mathrm{Var}\big(\rho(I_i^T - p)(Z_T - \bar{Z}) \mid Z\big) = \rho^2 p(1-p)(Z_T - \bar{Z})^2,$$

and

$$\mathrm{Var}\big((1-\rho I_i^T)(\mu_i - \bar{Z}) \mid Z\big) \;\approx\; (1 - 2\rho p + \rho^2 p)\frac{1-p}{Tp}\widehat{\mathrm{Var}}(Z_1, \ldots, Z_T).$$

Combining terms gives (N.1). Taking expectations over histories yields (N.2).

# Appendix O Additional Experimental 1 Results




**Appendix Figure A.3:** AVERAGE BELIEF ABOUT THE COMPANY STATE BY GROUP (REPORTED AND RECALL-GENERATED BELIEFS)

*Notes:* The figure plots the average binary belief across participants in each of the nine experimental groups. In the top panel (self-reported beliefs), beliefs take value 1 if the respondent reports that the company is "good" and −1 if the respondent reports that it is "bad"; group-level averages therefore summarize the net balance of positive versus negative beliefs within each treatment. In the bottom panel (recall-generated beliefs), beliefs are coded as 1 if the number of recalled positive signals is weakly greater than the number of recalled negative signals, and −1 otherwise.

**Appendix Table A.6:** BELIEF DISAGREEMENT EXPERIMENT DEMOGRAPHIC CHARACTERISTICS

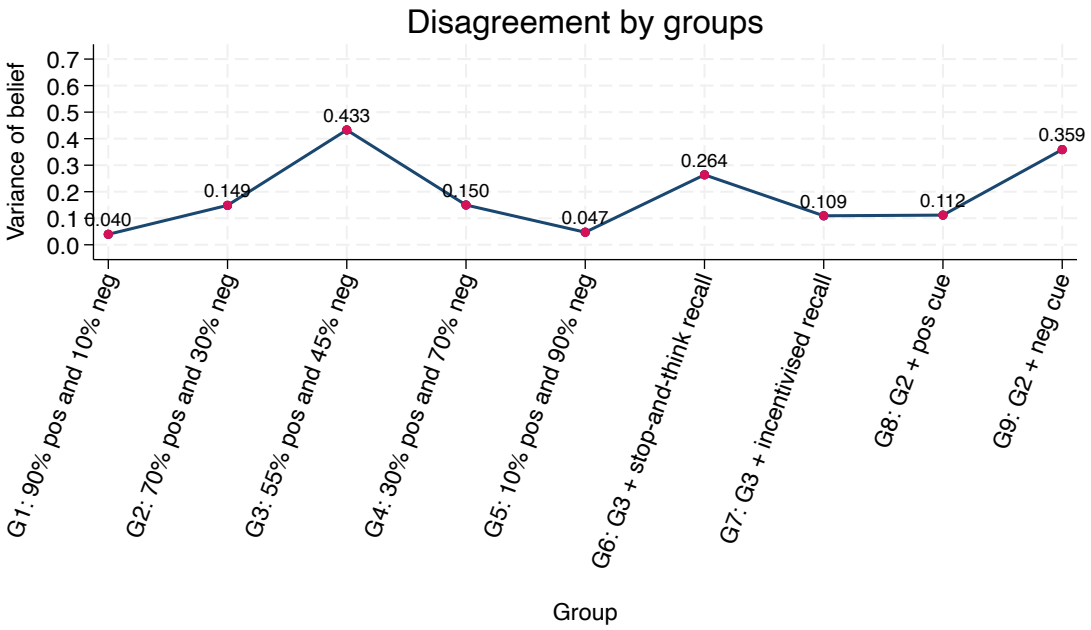
| | Full sample | T1 | T2 | T3 | T4 | T5 | T6 | T7 | T8 | T9 | $p$-value |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) |
| Observations | 4,758 | 503 | 554 | 526 | 571 | 505 | 506 | 544 | 525 | 524 | |
| **Panel A: Personal background** | | | | | | | | | | | |
| Female (%) | 59.06 | 56.86 | 57.22 | 62.74 | 56.22 | 59.41 | 61.07 | 60.29 | 60.38 | 57.63 | 0.37 |
| Age (years) | 44.83 | 44.16 | 44.88 | 44.19 | 44.05 | 43.26 | 45.90 | 45.67 | 44.78 | 46.58 | 0.40 |
| | (14.11) | (14.13) | (14.21) | (13.67) | (12.95) | (14.22) | (13.88) | (14.45) | (14.73) | (14.54) | |
| Above Bachelor's degree (%) | 62.61 | 66.60 | 63.00 | 65.59 | 61.65 | 61.39 | 58.30 | 60.85 | 63.43 | 62.79 | 0.21 |
| Employed full-time (%) | 55.82 | 57.65 | 54.51 | 53.42 | 55.69 | 58.22 | 56.72 | 52.39 | 57.33 | 56.87 | 0.54 |
| Household income < $60,000 (%) | 56.89 | 53.88 | 58.30 | 56.84 | 56.74 | 57.03 | 58.30 | 56.07 | 61.14 | 53.63 | 0.39 |
| **Panel B: Financial characteristics** | | | | | | | | | | | |
| Homeowner (%) | 60.30 | 62.82 | 61.37 | 59.70 | 60.60 | 60.79 | 59.68 | 60.11 | 58.48 | 59.16 | 0.94 |
| Stock investor (%) | 56.56 | 55.27 | 59.75 | 57.22 | 57.09 | 58.42 | 57.31 | 55.15 | 53.71 | 54.96 | 0.61 |

*Notes:* This table reports baseline demographic characteristics by experimental treatment group. Entries are percentages for indicator variables and means for continuous variables, with standard deviations reported in parentheses. Treatment groups T1–T9 correspond to different information treatments described in the text. The final column reports $p$-values from an ANOVA test of equality of means across treatment groups.

**Appendix Table A.7:** STOCHASTIC RECALLS OF NEWS AND BELIEF FORMATION

| | (1) | (2) | (3) | (4) | (5) | (6) |
|---|---|---|---|---|---|---|
| %Positive news recalled | 0.037*** | 0.037*** | | | | |
| | (0.000) | (0.000) | | | | |
| $1\{\text{Recall}_i^+ > \text{Recall}_i^-\}$ | | | 1.662*** | 1.661*** | | |
| | | | (0.019) | (0.019) | | |
| Recall balance (sign) | | | | | 0.941*** | 0.941*** |
| | | | | | (0.005) | (0.005) |
| Demographics | | ✓ | | ✓ | | ✓ |
| Observations | 4758 | 4758 | 4758 | 4758 | 4758 | 4758 |
| R-squared | 0.642 | 0.645 | 0.739 | 0.740 | 0.842 | 0.843 |

*Notes:* The dependent variable is the participant's self-reported binary belief about the company state, coded as 1 for "Good" and −1 for "Bad." %Positive news recalled is the share of recalled signals that are positive. $\mathbf{1}\{\text{Recall}_i^+ > \text{Recall}_i^-\}$ is an indicator equal to one if the number of recalled positive signals is greater than the number of recalled negative signals, and zero otherwise. Recall balance (sign) is defined as $\text{sgn}(\text{Recall}_i^+ - \text{Recall}_i^-)$ and takes values 1, 0, and −1 when recalled positives exceed, equal, or fall short of recalled negatives, respectively. Robust standard errors are in parentheses. Statistical significance is denoted by *** $p < 0.01$, ** $p < 0.05$, and * $p < 0.10$.




**Appendix Figure A.4:** DISAGREEMENT ABOUT COMPANY TYPE BY GROUP (CONSISTENT SAMPLE)

*Notes:* The figure plots disagreement in participants' reported binary beliefs across the nine experimental groups, calculated in the consistent-recall subsample. This subsample includes only respondents whose belief implied by their recalled signals is consistent with their reported belief, and we restrict to it when computing disagreement. Disagreement is measured as the cross-sectional variance of the indicator for believing the company is "good" (1) versus "bad" (-1) within each treatment. Groups 1–5 vary the degree of information ambivalence while holding the number of signals fixed; disagreement is lowest when signals are one-sided (Groups 1 and 5) and highest when signals are most balanced (Group 3). Groups 6 and 7 keep the signal mix of Group 3 but increase recall effort (Stop-and-Think and incentivized recall), which reduces disagreement relative to Group 3. Groups 8 and 9 keep the signal mix of Group 2 and introduce associative memory cues: cueing dominant positive signals (Group 8) lowers disagreement, whereas cueing non-dominant negative signals (Group 9) raises disagreement, consistent with the model's predictions on cue direction and strength.

**Appendix Table A.8:** COUNT RECALL ERRORS AND INFORMATION AMBIVALENCE ACROSS TREATMENTS

| Dep. variable: Absolute count recall errors | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| | #Positive news | | #Negative news | |
| Group 1 ($A = 0.2$) | 2.195*** | 2.550*** | 2.604*** | 2.847*** |
| | (0.601) | (0.817) | (0.512) | (0.759) |
| Relative to Group 1 | | | | |
| Group 2 ($A = 0.6$) | -0.032 | -0.036 | 0.385 | 0.414 |
| | (0.908) | (0.913) | (0.846) | (0.841) |
| Group 3 ($A = 0.9$) | -0.259 | -0.283 | 0.453 | 0.433 |
| | (0.907) | (0.903) | (0.851) | (0.843) |
| Group 4 ($A = 0.6$) | -0.666 | -0.673 | 0.308 | 0.308 |
| | (0.773) | (0.775) | (0.850) | (0.851) |
| Group 5 ($A = 0.9$) | -1.100 | -1.096 | 1.392 | 1.395 |
| | (0.727) | (0.732) | (1.266) | (1.257) |
| Demographics | | ✓ | | ✓ |
| Observations | 2659 | 2659 | 2659 | 2659 |
| R-squared | 0.020 | 0.028 | 0.012 | 0.021 |

*Notes:* This table tests whether recall accuracy varies with the degree of information ambivalence across treatment groups. The dependent variables are the absolute recall errors for the number of positive (in Columns (1) and (2)) and negative news (in Columns (3) and (4)), respectively. Treatments groups 1-5 correspond to the information ambivalence 0.2, 0.6, 0.9, 0.6 and 0.2, respectively; Group 1 is the omitted reference group, so coefficients are relative to Group 1. Columns (2) and (4) additionally control for employment status, housing tenure, mortgage type, household income, gender, age, college degree, and region. Clustered robust standard errors at the news-recall level are reported in parentheses. Statistical significance is denoted by *** $p < 0.01$, ** $p < 0.05$, and * $p < 0.10$.

**Appendix Table A.9:** RECALL ACCURACY AND DEMOGRAPHIC CHARACTERISTICS

| Dep. Variable: Absolute recall errors | (1) #Positive news | (2) #Negative news |
|---|---|---|
| Employment status | | |
| Full-time | 0.053 | 0.289 |
| | (0.153) | (0.247) |
| Part-time (for someone or self-employed) | 0.239 | 0.562 |
| | (0.229) | (0.390) |
| Not in Labor force | -0.088 | 0.245 |
| | (0.227) | (0.445) |
| Student | 0.254 | 0.229 |
| | (0.454) | (0.485) |
| Other | 0.357 | 0.049 |
| | (0.389) | (0.298) |
| Homeownership | | |
| Rent | -0.014 | 0.136 |
| | (0.101) | (0.204) |
| Other | 0.128 | -0.250 |
| | (0.321) | (0.302) |
| Mortgage | | |
| Fixed-rate | 0.107 | 0.080 |
| | (0.164) | (0.216) |
| Variable-rate | -0.313* | -0.584 |
| | (0.161) | (0.428) |
| HH income | 0.000 | -0.004 |
| | (0.022) | (0.024) |
| Female | 0.086 | 0.137 |
| | (0.142) | (0.162) |
| Age (grouped) | -0.025 | -0.050 |
| | (0.032) | (0.054) |
| College degree | -0.009 | -0.197 |
| | (0.112) | (0.204) |
| Region | | |
| Midwest | -0.117 | -0.335 |
| | (0.143) | (0.263) |
| South | 0.099 | -0.051 |
| | (0.138) | (0.222) |
| West | -0.048 | -0.392 |
| | (0.158) | (0.256) |
| Constant | 1.678*** | 3.138*** |
| | (0.307) | (0.424) |
| Observations | 2659 | 2659 |
| R-squared | 0.003 | 0.005 |

*Notes:* This table examines whether recall accuracy within treatment groups 1-5 varies with respondent demographics. The dependent variables are the absolute recall errors for the number of positive (Column (1)) and negative news (Column (2)), respectively. Each coefficient reports the association between a demographic characteristic and recall error, estimated by OLS. Reported categories are relative to omitted reference groups for each set of indicators (employment status, homeownership, mortgage type, and region). Robust standard errors are in parentheses. Statistical significance is denoted by *** $p < 0.01$, ** $p < 0.05$, and * $p < 0.10$.

**Appendix Table A.10:** RECALL ACCURACY WITH CUES BY DEMOGRAPHICS CHARACTERISTICS

| | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| | Group 8 | | Group 9 | |
| Dep. Variable: Absolute recall errors | #Positive news | #Negative news | #Positive news | #Negative news |
| Employment status | | | | |
| Full-time | -1.160 | -0.627 | 0.264 | 0.132 |
| | (1.083) | (0.572) | (0.420) | (0.578) |
| Part-time | -0.376 | -0.543 | 0.184 | -0.414 |
| | (1.027) | (0.648) | (0.609) | (0.943) |
| Not in the labor force | -1.064 | -0.040 | 0.479 | 0.059 |
| | (1.209) | (0.872) | (0.807) | (0.926) |
| Student | -1.394 | -1.255 | -0.460 | -0.356 |
| | (1.229) | (0.823) | (1.041) | (1.241) |
| Other | -0.999 | -0.244 | -0.086 | -0.157 |
| | (1.011) | (0.438) | (0.848) | (0.828) |
| Homeownership | | | | |
| Rent | 0.265 | 0.064 | -0.018 | -0.107 |
| | (0.438) | (0.324) | (0.271) | (0.170) |
| Other | 0.860 | 0.741 | -0.166 | -0.824 |
| | (1.082) | (1.192) | (0.466) | (0.707) |
| Mortgage | | | | |
| Fixed-rate | -0.264 | -0.174 | 0.280 | 0.118 |
| | (0.518) | (0.397) | (0.345) | (0.305) |
| Variable-rate | 0.522 | -0.290 | -1.316* | -1.957* |
| | (0.790) | (0.525) | (0.682) | (1.062) |
| HH income | -0.028 | -0.111 | 0.043 | 0.001 |
| | (0.087) | (0.094) | (0.048) | (0.056) |
| Female | 0.095 | -0.012 | -0.066 | 0.160 |
| | (0.364) | (0.378) | (0.324) | (0.497) |
| Age (grouped) | 0.009 | 0.002 | -0.079 | -0.122 |
| | (0.077) | (0.068) | (0.122) | (0.192) |
| College degree | 0.052 | -0.033 | -0.194 | -0.616 |
| | (0.344) | (0.255) | (0.315) | (0.553) |
| Region | | | | |
| Midwest | -0.681 | -0.641 | -0.450 | -0.222 |
| | (0.654) | (0.518) | (0.363) | (0.416) |
| South | -0.443 | -0.637 | 0.299 | 0.468 |
| | (0.493) | (0.515) | (0.368) | (0.477) |
| West | -0.237 | -0.224 | -0.038 | 0.272 |
| | (0.602) | (0.477) | (0.391) | (0.500) |
| Constant | 3.543** | 3.173** | 3.886*** | 3.532** |
| | (1.342) | (1.494) | (0.962) | (1.505) |
| Observations | 525 | 525 | 524 | 524 |
| R-squared | 0.018 | 0.021 | 0.016 | 0.021 |

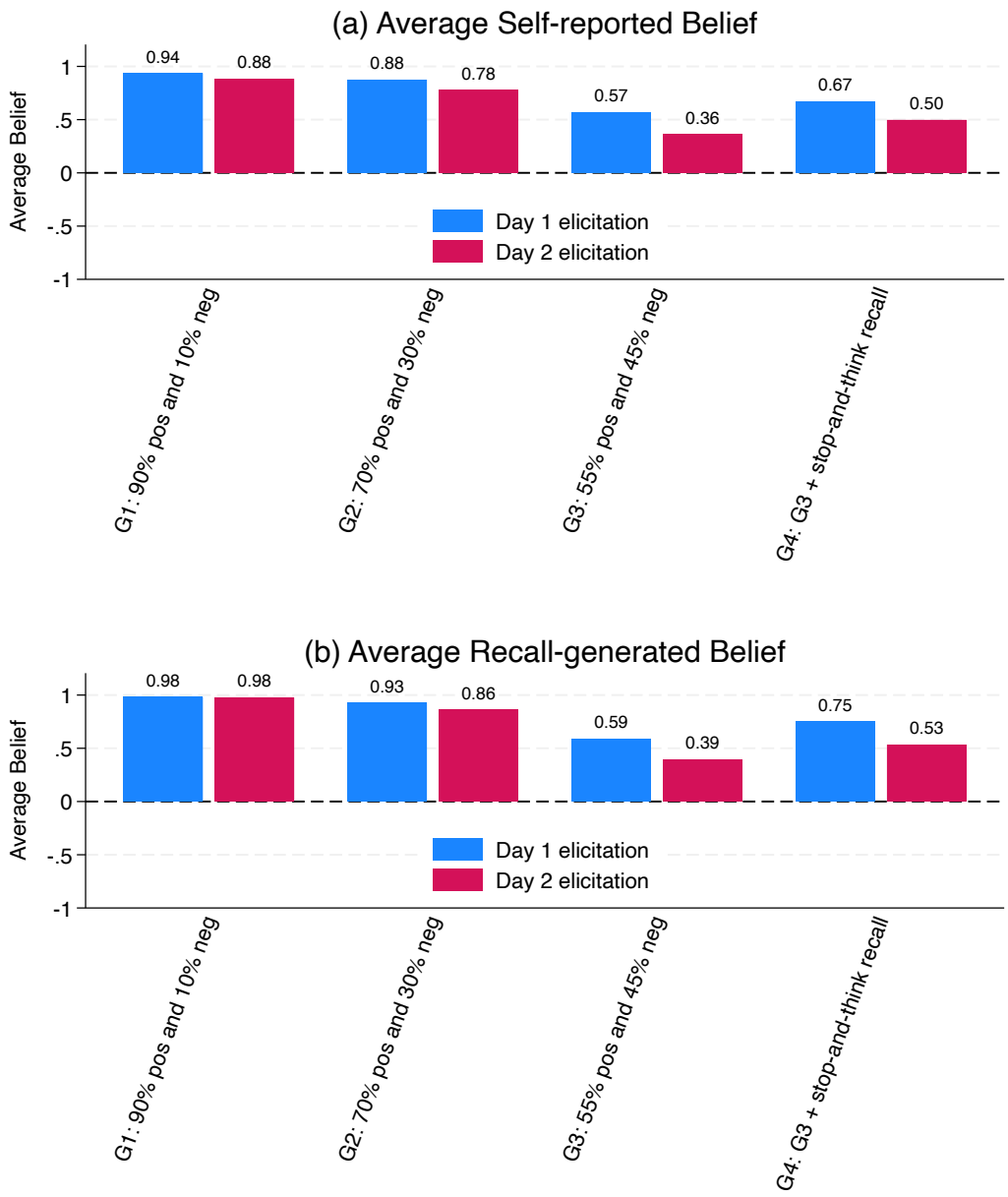
*Notes:* This table tests whether recall accuracy with cues varies across demographic characteristics in Groups 8 and 9. The dependent variables are absolute recall errors for positive and negative news. Columns (1)–(2) report estimates for Group 8 and columns (3)–(4) for Group 9. Each column presents OLS regressions of recall error on employment status, homeownership, mortgage type, household income, gender, age group, education, and region indicators; reported categories are relative to omitted reference groups within each set of indicators. Statistical significance is denoted by *** $p < 0.01$, ** $p < 0.05$, and * $p < 0.10$.

**Appendix Table A.11:** REALIZED NET IMBALANCE, CUE AND BELIEF UNCERTAINTY

| | (1) | (2) |
|---|---|---|
| **Panel A: Recalled information predicts belief uncertainty** | | |
| Realized net imbalance | -0.003*** | -0.003*** |
| | (0.000) | (0.000) |
| Constant | 0.207*** | 0.215*** |
| | (0.001) | (0.005) |
| Demographics | | ✓ |
| Observations | 4758 | 4758 |
| R-squared | 0.133 | 0.137 |
| **Panel B: Information ambivalence and belief uncertainty** | | |
| Group 3: 60% pos | 0.217*** | 0.228*** |
| | (0.002) | (0.006) |
| Relative to Group 3 | | |
| Group 1: 90% pos | -0.053*** | -0.052*** |
| | (0.003) | (0.003) |
| Group 2: 70% pos | -0.019*** | -0.018*** |
| | (0.003) | (0.003) |
| Group 4: 30% pos | -0.022*** | -0.022*** |
| | (0.003) | (0.004) |
| Group 5: 10% pos | -0.075*** | -0.075*** |
| | (0.003) | (0.003) |
| Group 6: Group 3 + Stop-and-Think | -0.021*** | -0.021*** |
| | (0.003) | (0.003) |
| Group 7: Group 3 + incentivized recall | -0.033*** | -0.033*** |
| | (0.003) | (0.003) |
| Demographics | | ✓ |
| Observations | 2659 | 2659 |
| R-squared | 0.188 | 0.194 |
| **Panel C: Effect of cues on belief uncertainty** | | |
| Group 2 | 0.198*** | 0.204*** |
| | (0.002) | (0.008) |
| Relative to Group 2 | | |
| Group 8: Group 2 + pos cue | -0.037*** | -0.037*** |
| | (0.004) | (0.004) |
| Group 9: Group 2 + neg cue | 0.028*** | 0.028*** |
| | (0.003) | (0.003) |
| Demographics | | ✓ |
| Observations | 1603 | 1603 |
| R-squared | 0.200 | 0.209 |

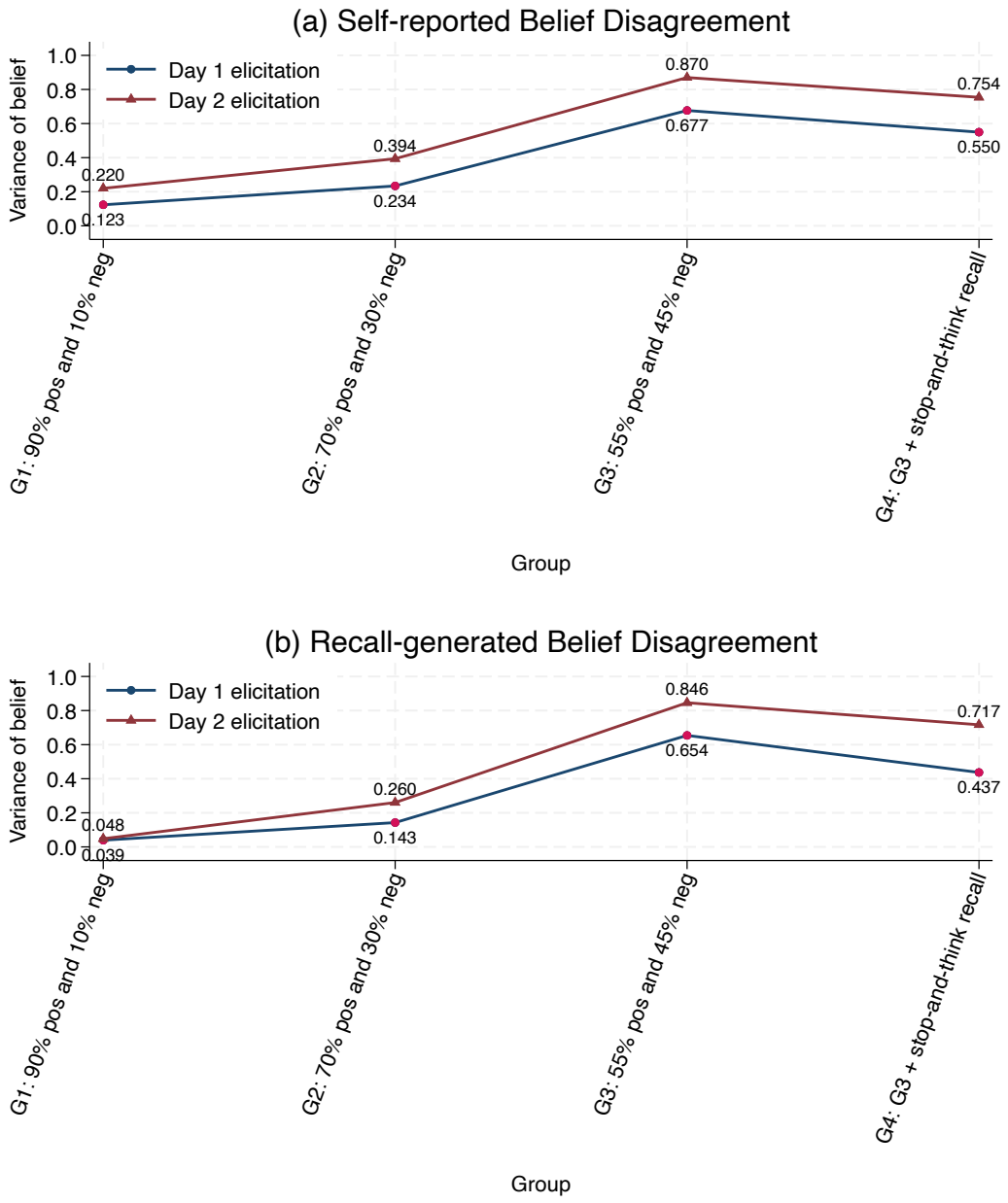
*Notes:* This table reports results from the Belief Disagreement Experiment on the effect of realized net imbalance recalled by respondents and cues on belief uncertainty. Probabilistic beliefs are elicited as percentage-point probabilities that the company is good. Let $p_i \in [0,1]$ denote respondent $i$'s reported probability that the company is good; when beliefs are elicited as $P$(bad), we convert to the common scale by setting $p_i = 1 - P$(bad). The dependent variable is belief uncertainty, defined as $p_i(1-p_i)$. Panel A relates belief uncertainty to *realized net imbalance*, defined as the absolute value of ($X_i^+$ - $X_i^-$), where $X_i^+$ and $X_i^-$ denote the numbers of positive and negative items recalled. Panel B relates belief uncertainty to information ambivalence (Groups 1-5) in information provision and recall probability (Groups 3, 6 and 7) using treatment-group indicators (omitted category is Group 3). Panel C estimates the effect of cues on belief uncertainty (omitted category is Group 2). Robust standard errors are reported in parentheses. Statistical significance is denoted by *** $p < 0.01$, ** $p < 0.05$, and * $p < 0.10$.

# Appendix P Additional Robustness Experiment 2 Results




**Appendix Figure A.5:** ROBUSTNESS EXPERIMENT: AVERAGE BELIEF ABOUT THE COMPANY STATE BY GROUP (REPORTED AND RECALL-GENERATED BELIEFS)

*Notes:* The figure plots the average binary belief across participants in each of the four experimental groups. In the top panel (self-reported beliefs), beliefs take value 1 if the respondent reports that the company is "good" and −1 if the respondent reports that it is "bad"; group-level averages therefore summarize the net balance of positive versus negative beliefs within each treatment. In the bottom panel (recall-generated beliefs), beliefs are coded as 1 if the number of recalled positive signals is weakly greater than the number of recalled negative signals, and −1 otherwise. Groups 1–3 vary the degree of information ambivalence while holding the number of signals fixed; Groups 4 keeps the signal composition of Group 3 but increase recall effort (via Stop-and-Think).




**Appendix Figure A.6:** ROBUSTNESS EXPERIMENT: DISAGREEMENT ABOUT COMPANY TYPE BY GROUP (SELF-REPORTED AND RECALL-GENERATED BELIEFS)

*Notes:* The figure plots disagreement in participants' reported binary beliefs across the four experimental groups. Disagreement in the top figure (self-reported beliefs) is measured as the cross-sectional variance of the indicator for believing the company is "good" (1) versus "bad" (-1) within each treatment. Disagreement in the bottom figure (recall-generated beliefs) is coded as 1 if the number of recalled positive signals is weakly greater than the number of recalled negative signals, and -1 otherwise. Groups 1–3 vary the degree of information ambivalence while holding the number of signals fixed; Groups 4 keeps the signal composition of Group 3 but increase recall effort (via Stop-and-Think).

**Appendix Table A.12:** ROBUSTNESS EXPERIMENT 2 DEMOGRAPHIC CHARACTERISTICS

| | Full sample | T1 | T2 | T3 | T4 | $p$-value |
|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) |
| Observations | 2,039 | 503 | 514 | 516 | 506 | |
| **Panel A: Personal background** | | | | | | |
| Female (%) | 59.49 | 56.86 | 56.61 | 63.37 | 61.07 | 0.14 |
| Age (years) | 44.87 | 44.16 | 45.11 | 44.33 | 45.90 | 0.77 |
| | (13.99) | (14.13) | (14.22) | (13.72) | (13.88) | |
| College (%) | 87.15 | 87.87 | 87.55 | 88.18 | 84.98 | 0.40 |
| Employed full-time (%) | 55.37 | 57.65 | 54.09 | 53.10 | 56.72 | 0.42 |
| Household income < $60,000 (%) | 56.94 | 53.88 | 58.75 | 56.78 | 58.30 | 0.46 |
| **Panel B: Financial characteristics** | | | | | | |
| Homeowner (%) | 60.96 | 62.82 | 61.48 | 59.88 | 59.68 | 0.71 |
| Stock investor (%) | 57.38 | 55.27 | 59.92 | 56.98 | 57.31 | 0.51 |

*Notes:* This table reports baseline demographic characteristics by experimental treatment group. Entries are percentages for indicator variables and means for continuous variables, with standard deviations reported in parentheses. Treatment groups T1–T4 correspond to different information treatments described in the text. The final column reports $p$-values from an ANOVA test of equality of means across treatment groups.

# Appendix Q Additional Results for Experiment 3 (Belief Instability Experiment)

**Appendix Table A.13:** INFORMATION AMBIVALENCE AND BELIEF INSTABILITY

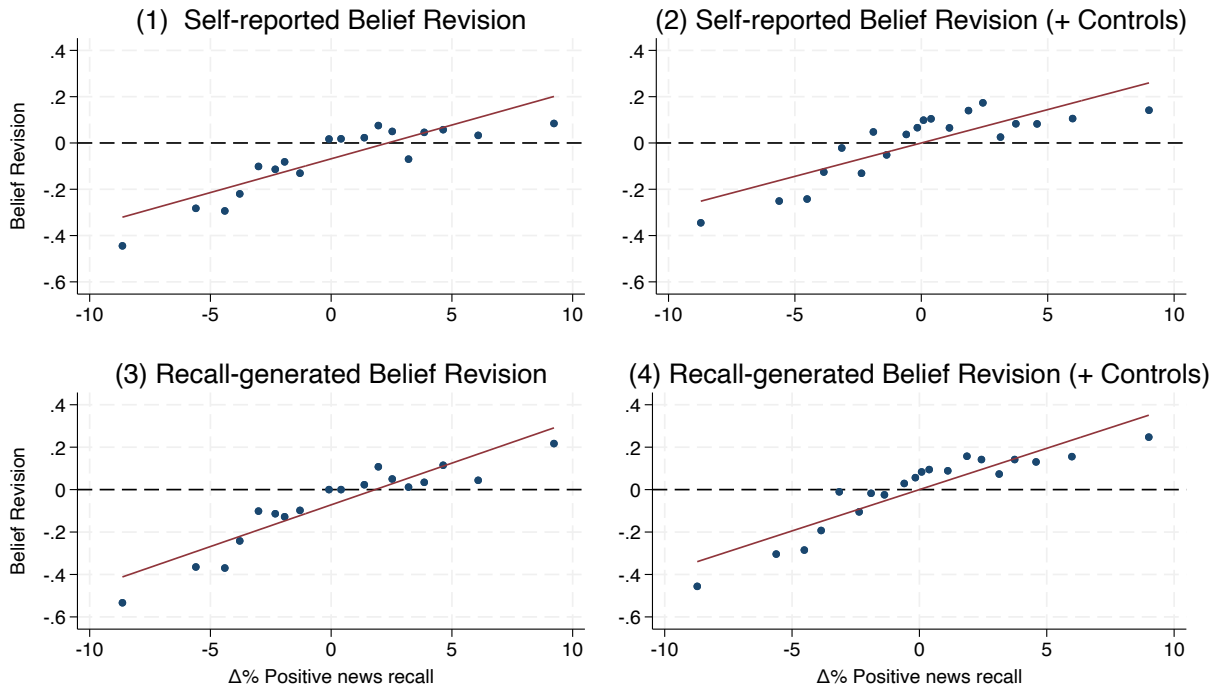
| | binary belief instability | | implied belief instability | |
|---|---|---|---|---|
| | (1) | (2) | (3) | (4) |
| T1: 90% pos and 10% | 0.073*** | 0.071 | 0.002 | -0.038 |
| | (0.013) | (0.047) | (0.002) | (0.037) |
| Relative to T1 | | | | |
| T2: 70% pos and 30% | 0.040** | 0.040** | 0.040*** | 0.041*** |
| | (0.020) | (0.020) | (0.010) | (0.010) |
| T3: 55% pos and 45% | 0.230*** | 0.229*** | 0.258*** | 0.258*** |
| | (0.025) | (0.025) | (0.021) | (0.021) |
| T4: T3 + stop-and-think recall | 0.115*** | 0.114*** | 0.199*** | 0.202*** |
| | (0.023) | (0.023) | (0.019) | (0.020) |
| Demographics | | ✓ | | ✓ |
| Observations | 1744 | 1744 | 1744 | 1744 |
| R-squared | 0.054 | 0.058 | 0.101 | 0.107 |

*Notes:* This table reports estimates from regressions of belief instability indicators on treatment-group dummies in Experiment 3. The dependent variable is an indicator equal to one if a participant's belief reverses between Part 1 and Part 2, and zero otherwise. Columns (1)–(2) use self-reported binary beliefs, while Columns (3)–(4) use recall-generated beliefs constructed from participants' remembered signals. The omitted reference group is T1 (90% positive, 10% negative signals). T2 and T3 correspond to increasingly ambivalent information environments, and T4 implements a Stop-and-Think recall intervention in the T3 signal environment. Columns (2) and (4) include demographic controls. Robust standard errors are reported in parentheses. Statistical significance is denoted by *** $p < 0.01$, ** $p < 0.05$, and * $p < 0.10$.

**Appendix Table A.14:** BELIEF INSTABILITY AND CHANGES IN RECALLED INFORMATION

| | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| **Panel A. Self-reported binary belief instability** | | | | |
| Δ%Positive news recall | 0.029*** | 0.029*** | | |
| | (0.003) | (0.003) | | |
| Δ%Positive news recall(Direction) | | | 0.114*** | 0.113*** |
| | | | (0.011) | (0.011) |
| Demographics | | ✓ | | ✓ |
| Observations | 1744 | 1744 | 1744 | 1744 |
| R-squared | 0.090 | 0.096 | 0.067 | 0.074 |
| **Panel B. Recall-generated belief instability** | | | | |
| Δ%Positive news recall | 0.039*** | 0.039*** | | |
| | (0.002) | (0.002) | | |
| Δ%Positive news recall (Direction) | | | 0.149*** | 0.148*** |
| | | | (0.009) | (0.009) |
| Demographics | | ✓ | | ✓ |
| Observations | 1744 | 1744 | 1744 | 1744 |
| R-squared | 0.220 | 0.225 | 0.155 | 0.161 |

*Notes:* This table relates within-individual changes in recalled information to within-individual belief instability between Part 1 (Day 1) and Part 2 (Day 2). In Panel A (self-reported belief), the dependent variable is $\Delta\text{Belief}_i \in \{-1, 0, 1\}$, constructed from the respondent's self-reported binary belief on Day 1 and Day 2. It equals 0 if the respondent reports the same belief across days, 1 if they revise from "bad" to "good," and −1 if they revise from "good" to "bad." In Panel B (recall-generated belief), the dependent variable is $\Delta\text{RecallBelief}_i \in \{-1, 0, 1\}$, constructed analogously from a *recall-generated* binary belief in each part. In each part, the recall-generated belief is coded as "good" if the respondent recalls more positive than negative news items, and "bad" otherwise (including ties). $\Delta\text{RecallBelief}_i$ equals 0 if this recall-generated classification is unchanged across days, 1 if it switches from "bad" to "good," and −1 if it switches from "good" to "bad." The regressor $\Delta\%\text{Positive news recall}_i$ is the change in the share of recalled items that are positive, defined as $\text{share_pos}_{i,2} - \text{share_pos}_{i,1}$. Columns (3)–(4) use $\Delta\%\text{Positive news recall (Direction)}_i \in \{-1, 0, 1\}$, which equals 1 if the positive recall share increases, −1 if it decreases, and 0 if it is unchanged. Columns with a checkmark include demographic controls ($control3). All models are estimated by OLS with heteroskedasticity-robust standard errors in parentheses. $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.10$.




**Appendix Figure A.7:** ROBUSTNESS EXPERIMENT 2: BELIEF INSTABILITY AND CHANGES IN RECALLED INFORMATION

*Notes:* The figure plots the average binary belief across participants in each of the four experimental groups. In the top panel (self-reported beliefs), beliefs take value 1 if the respondent reports that the company is "good" and −1 if the respondent reports that it is "bad"; group-level averages therefore summarize the net balance of positive versus negative beliefs within each treatment. In the bottom panel (recall-generated beliefs), beliefs are coded as 1 if the number of recalled positive signals is weakly greater than the number of recalled negative signals, and −1 otherwise. Groups 1–3 vary the degree of information ambivalence while holding the number of signals fixed; Groups 4 keeps the signal composition of Group 3 but increase recall effort (via Stop-and-Think).

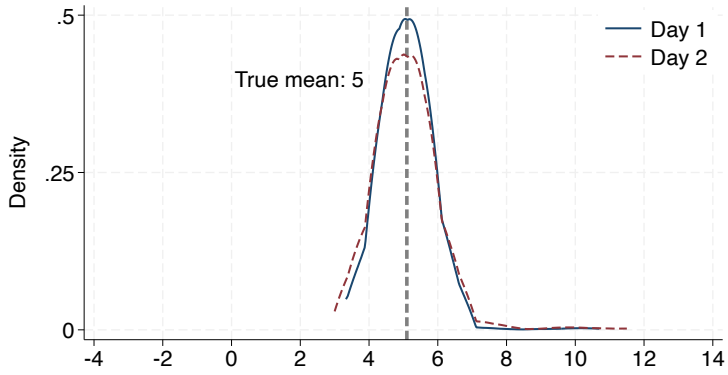
# Appendix R Additional Results for Experiment 4 (Quantitative Belief Disagreement)

**Appendix Table A.15:** EXPERIMENTS 4-5: DEMOGRAPHIC CHARACTERISTICS

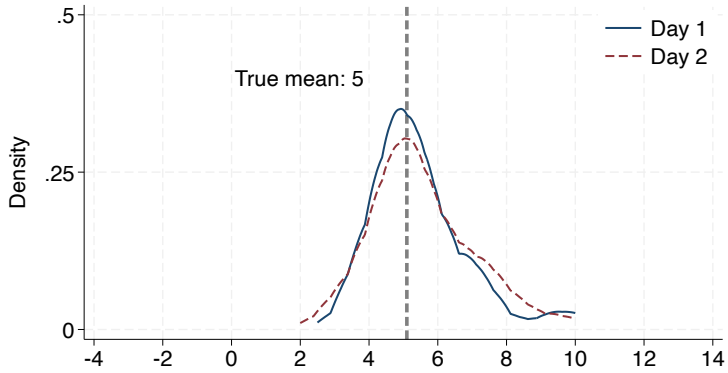
| | Full sample | Group 1 ($\rho = 0.1, \sigma_\epsilon = 0.5$) | Group 2 ($\rho = 0.9, \sigma_\epsilon = 0.5$) | Group 3 ($\rho = 0.9, \sigma_\epsilon = 5$) | $p$-value (ANOVA) |
|---|---|---|---|---|---|
| Observations | 2,301 | 816 | 771 | 714 | |
| *Panel A: Personal background* | | | | | |
| Female (%) | 51.11 | 50.98 | 51.23 | 51.12 | 0.995 |
| Age (years) | 48.94 | 49.41 | 49.13 | 48.20 | 0.280 |
| | (15.34) | (15.47) | (15.19) | (15.36) | |
| Bachelor's degree or higher (%) | 28.55 | 28.80 | 29.83 | 26.89 | 0.577 |
| Employed full-time (%) | 47.02 | 47.18 | 46.56 | 47.34 | 0.953 |
| Household income < $60,000 (%) | 56.84 | 57.11 | 56.42 | 57.00 | 0.962 |
| *Panel B: Financial characteristics* | | | | | |
| Stock investor (%) | 44.02 | 44.12 | 44.36 | 43.56 | 0.951 |

*Notes:* This table reports summary statistics by experimental group in the quantitative belief experiments. Groups differ in the persistence $\rho$ and innovation standard deviation $\sigma_\epsilon$ of the AR(1) data-generating process, while the long-run mean is held fixed at $\mu = 5$. Female, Bachelor's degree or higher, employed full-time, household income below $60,000, and stock investor are indicator variables and are reported as percentages. Age is reported as the sample mean, with standard deviation in parentheses. The final column reports $p$-values from one-way ANOVA tests of equality across the three groups. For indicator variables, the ANOVA tests correspond to tests of equality of group means. All variables are measured in Part 1 of the experiment.

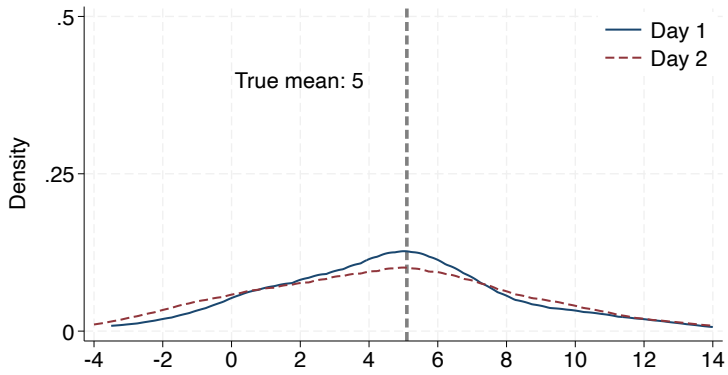
*(a) Group 1: Low persistence, low volatility*




*(b) Group 2: High persistence, low volatility*



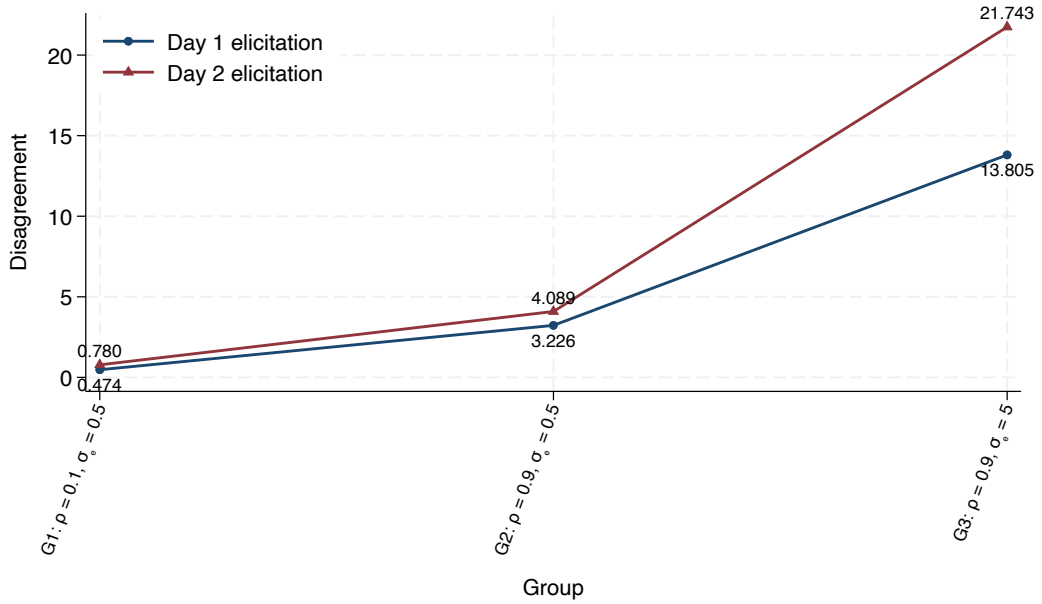

*(c) Group 3: High persistence, high volatility*



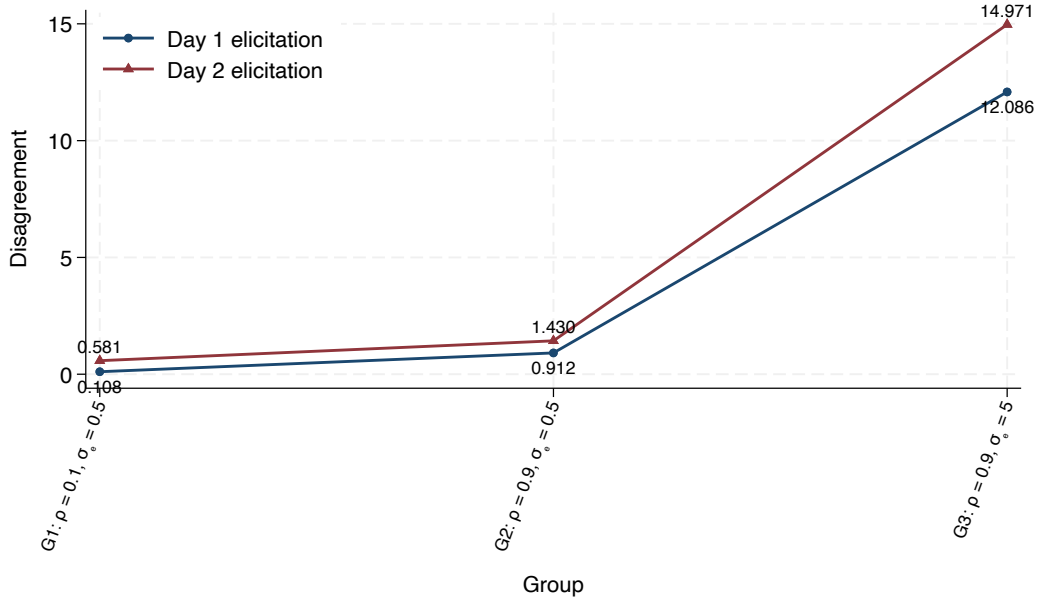

**Appendix Figure A.8:** QUANTITATIVE BELIEF EXPERIMENT: DISTRIBUTION OF ESTIMATED AVERAGE ACROSS GROUPS AND ACROSS DAYS

*Notes:* The figure plots the distribution of reported estimates of the series average on Day 1 and Day 2 for three data-generating processes with a common mean $\mu = 5$ and differing persistence and volatility. Group 1 observes data from a low-persistence, low-volatility process ($\rho = 0.1, \sigma_\epsilon = 0.5$). Group 2 observes data from a high-persistence, low-volatility process ($\rho = 0.9, \sigma_\epsilon = 0.5$). Group 3 observes data from a high-persistence, high-volatility process ($\rho = 0.9, \sigma_\epsilon = 5$). The vertical dashed line indicates the true mean.

*(a) Disagreement in self-reported mean estimates*



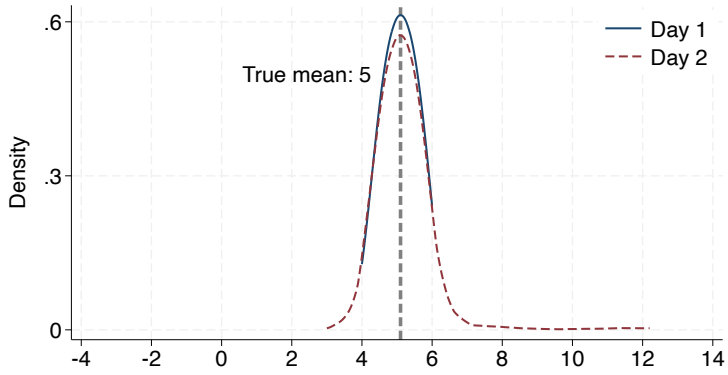

*(b) Disagreement in average of recalled values*



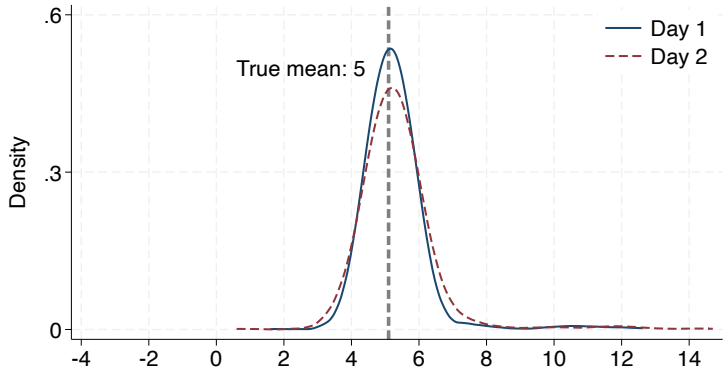

**Appendix Figure A.9:** QUANTITATIVE BELIEF EXPERIMENT: DISAGREEMENT IN MEAN ESTIMATES BY GROUP

*Notes:* The figure plots disagreement in participants' estimates of the series mean across the three AR(1) treatment groups. In panel (a), disagreement is measured as the cross-sectional variance of participants' self-reported estimates of the series average. In Panel B, disagreement is measured as the cross-sectional variance of recall-generated estimates, computed as the average of the values each participant recalls. Groups vary persistence $\rho$ and innovation standard deviation $\sigma_\eta$ while holding the long-run mean fixed at $\mu = 5$. Day 2 beliefs are elicited without any new information.

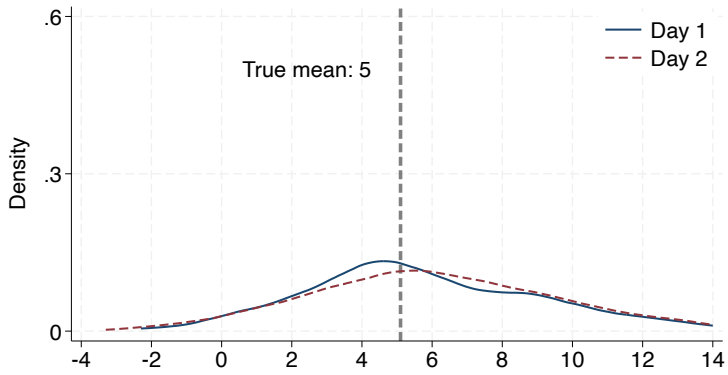
*(a) Group 1: Low persistence, low volatility*




*(b) Group 2: High persistence, low volatility*




*(c) Group 3: High persistence, high volatility*




**Appendix Figure A.10:** QUANTITATIVE BELIEF EXPERIMENT: DISTRIBUTION OF AVERAGE RECALLED VALUES ACROSS GROUPS AND ACROSS DAYS

*Notes:* The figure plots the cross-sectional distribution of average recalled values on Day 1 and Day 2 for three data-generating processes with a common mean $\mu = 5$ and differing persistence and volatility. Group 1 observes data from a low-persistence, low-volatility process ($\rho = 0.1, \sigma_\epsilon = 0.5$). Group 2 observes data from a high-persistence, low-volatility process ($\rho = 0.9, \sigma_\epsilon = 0.5$). Group 3 observes data from a high-persistence, high-volatility process ($\rho = 0.9, \sigma_\epsilon = 5$). The vertical dashed line indicates the true mean.

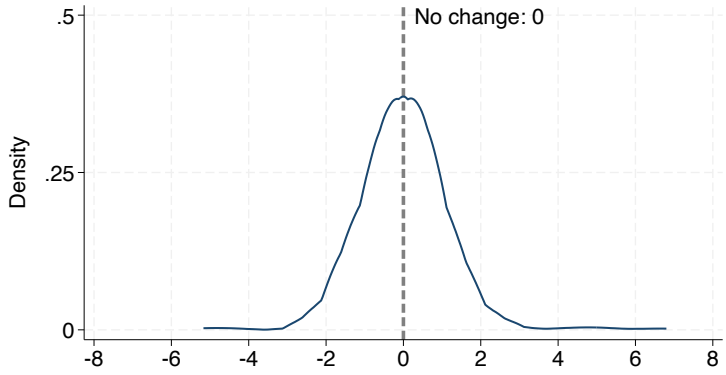
# Appendix S Additional Results for Experiment 5 (Quantitative Belief Instability)

**Appendix Table A.16:** STATED BELIEFS AND RECALLED INFORMATION IN THE QUANTITATIVE BELIEF EXPERIMENT

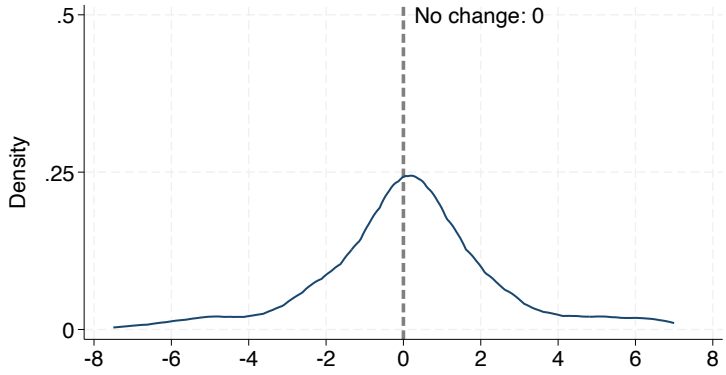
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
|---|---|---|---|---|---|---|---|---|
| **Panel A: Day 1 cross-sectional relationship between recall and beliefs (estimate of the series average)** | | | | | | | | |
| Average recall | 0.784*** | 0.782*** | 0.951*** | 0.935*** | 0.845*** | 0.799*** | 0.824*** | 0.833*** |
| | (0.029) | (0.029) | (0.073) | (0.073) | (0.056) | (0.057) | (0.029) | (0.028) |
| Constant | 0.968*** | 0.477* | 0.239 | 0.381 | 1.277*** | 0.280 | -0.110 | -0.207 |
| | (0.152) | (0.280) | (0.367) | (0.394) | (0.296) | (0.436) | (0.173) | (0.605) |
| Demographics | | ✓ | | ✓ | | ✓ | | ✓ |
| Observations | 2238 | 2238 | 777 | 777 | 771 | 771 | 690 | 690 |
| **Panel B: Day 2 cross-sectional relationship between recall and beliefs (estimate of the series average)** | | | | | | | | |
| Average recall | 0.708*** | 0.703*** | 0.985*** | 0.977*** | 0.857*** | 0.816*** | 0.760*** | 0.759*** |
| | (0.048) | (0.049) | (0.110) | (0.107) | (0.109) | (0.109) | (0.052) | (0.054) |
| Constant | 1.332*** | 0.835* | 0.070 | 0.158 | 1.357** | 0.219 | 0.094 | -0.090 |
| | (0.261) | (0.450) | (0.547) | (0.623) | (0.570) | (0.693) | (0.333) | (1.000) |
| Demographics | | ✓ | | ✓ | | ✓ | | ✓ |
| Observations | 1867 | 1867 | 606 | 606 | 617 | 617 | 644 | 644 |
| **Panel C: Within-individual relationship between changes in recall and changes in beliefs** | | | | | | | | |
| $\Delta$ average recall | 0.915*** | 0.918*** | 0.924*** | 0.922*** | 0.762*** | 0.748*** | 0.937*** | 0.938*** |
| | (0.055) | (0.055) | (0.089) | (0.090) | (0.108) | (0.108) | (0.060) | (0.062) |
| Constant | -0.048 | -0.002 | 0.020 | 0.027 | 0.103 | -0.076 | -0.259 | -0.243 |
| | (0.069) | (0.443) | (0.040) | (0.240) | (0.090) | (0.608) | (0.178) | (1.147) |
| Demographics | | ✓ | | ✓ | | ✓ | | ✓ |
| Observations | 1867 | 1867 | 606 | 606 | 617 | 617 | 644 | 644 |

*Notes:* This table reports regressions relating participants' beliefs about the mean of a stochastic process to recalled information in the quantitative belief experiment. Panel A reports cross-sectional regressions for Day 1, relating each participant's self-reported estimate of the series average (dependent variable) to the average value of observations they recall from the sequence (independent variable). Panel B reports analogous cross-sectional regressions for Day 2, in which beliefs are re-elicited without any new information. Panel C reports within-individual regressions relating changes in beliefs between Day 1 and Day 2 to changes in the average of recalled values over the same period. Specifications with demographic controls include age, gender, education, household income, employment status, state of residence, and indicators for stock market participation. All regressions are estimated separately by treatment group, which varies the persistence $\rho$ and innovation standard deviation $\sigma_\eta$ of the data-generating process while holding the long-run mean fixed at $\mu = 5$. Robust standard errors are reported in parentheses. Changes in recall are expressed in percentage points. Statistical significance is denoted by *** $p < 0.01$, ** $p < 0.05$, and * $p < 0.10$.

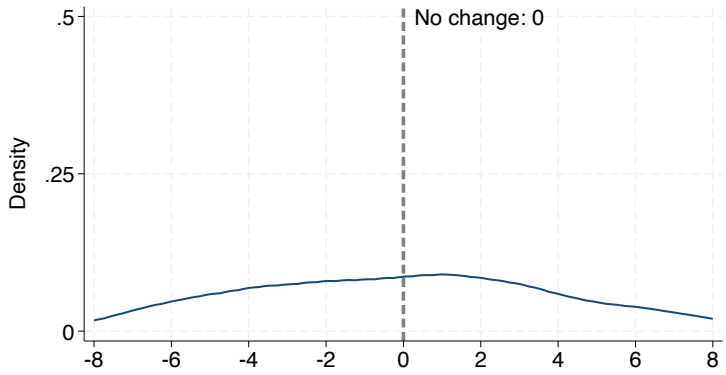
*(a) Group 1: Low persistence, low volatility*




*(b) Group 2: High persistence, low volatility*



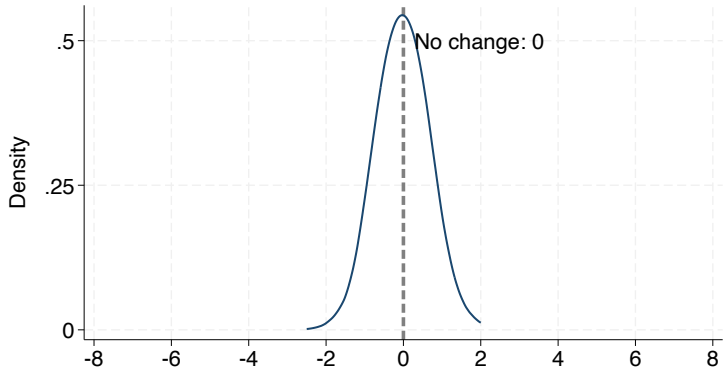

*(c) Group 3: High persistence, high volatility*



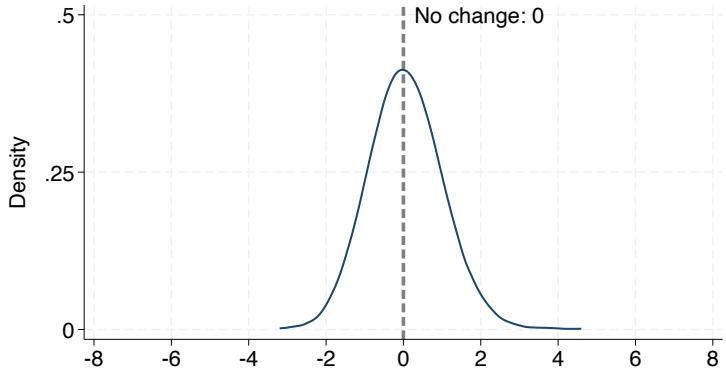

**Appendix Figure A.11:** QUANTITATIVE BELIEF EXPERIMENT: DISTRIBUTION OF BELIEF CHANGES ACROSS GROUPS

*Notes:* The figure plots the cross-sectional distribution of belief changes in the estimated series mean between Day 1 and Day 2 (Day 2 minus Day 1) for three data-generating processes with a common mean $\mu = 5$ and differing persistence and volatility. Group 1 observes data from a low-persistence, low-volatility process ($\rho = 0.1, \sigma_\epsilon = 0.5$). Group 2 observes data from a high-persistence, low-volatility process ($\rho = 0.9, \sigma_\epsilon = 0.5$). Group 3 observes data from a high-persistence, high-volatility process ($\rho = 0.9, \sigma_\epsilon = 5$). The vertical dashed line indicates zero change.

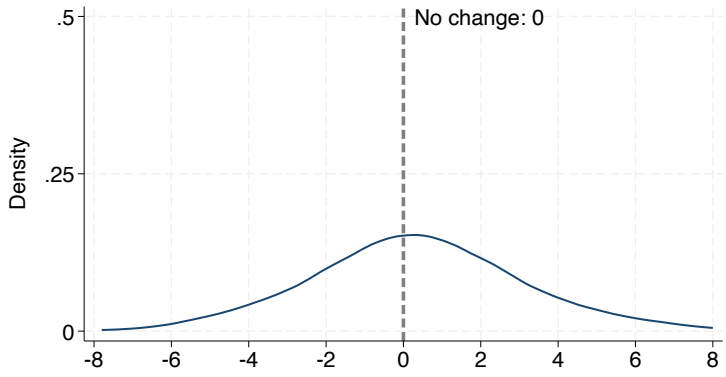
*(a) Group 1: Low persistence, low volatility*




*(b) Group 2: High persistence, low volatility*



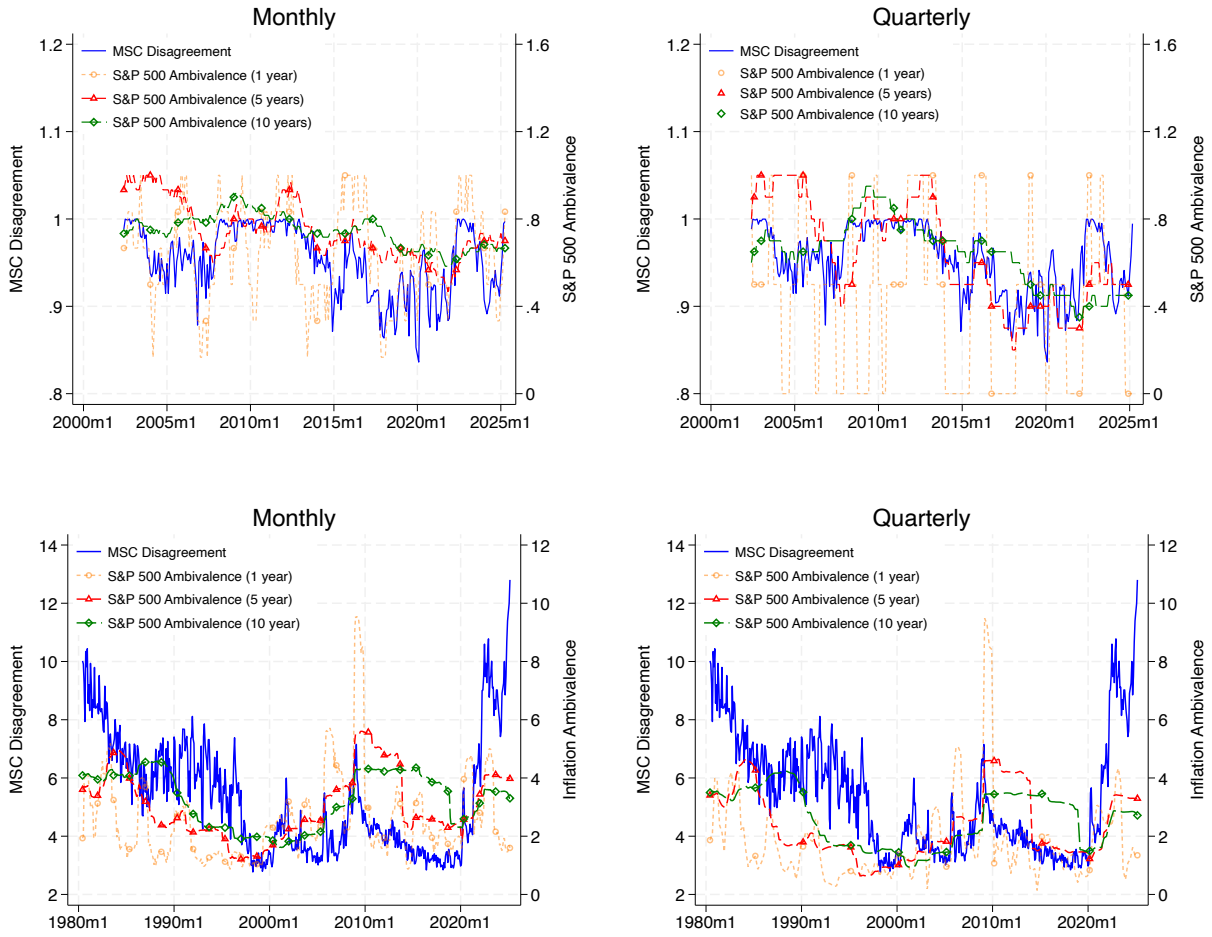

*(c) Group 3: High persistence, high volatility*




**Appendix Figure A.12:** QUANTITATIVE BELIEF EXPERIMENT: DISTRIBUTION OF RECALL CHANGES ACROSS GROUPS

*Notes:* The figure plots the cross-sectional distribution of changes in mean recalled values between Day 1 and Day 2 (Day 2 minus Day 1) for three data-generating processes with a common mean $\mu = 5$ and differing persistence and volatility. Group 1 observes data from a low-persistence, low-volatility process ($\rho = 0.1, \sigma_\epsilon = 0.5$). Group 2 observes data from a high-persistence, low-volatility process ($\rho = 0.9, \sigma_\epsilon = 0.5$). Group 3 observes data from a high-persistence, high-volatility process ($\rho = 0.9, \sigma_\epsilon = 5$). The vertical dashed line indicates zero change.

# Appendix T Stock Market and Inflation Ambivalence and Michigan Surveys of Consumers Households' Disagreement in Expectations




**Appendix Figure A.13:** INFORMATION AMBIVALENCE AND HOUSEHOLDS' DISAGREEMENT (STOCK PRICE AND INFLATION)

*Notes:* The figure plots the time series of disagreement in household expectations alongside corresponding measures of market ambivalence. The top panels display disagreement in 1-year-ahead stock price change beliefs from the Michigan Surveys of Consumers (monthly frequency, June 2002–March 2025) together with S&P 500 market ambivalence. The bottom panels display disagreement in inflation (price level) expectations from the Michigan Surveys of Consumers (monthly frequency, June 1980–March 2025) together with measures of inflation ambivalence. In each row, the left panel constructs ambivalence using monthly data, while the right panel uses quarterly data. Ambivalence $A^f(h)$ is computed over trailing windows of length $h \in \{1,5,10\}$ years. For stock prices, ambivalence is based on the balance of positive and negative S&P 500 returns; for inflation, ambivalence is measured as the standard deviation of realized inflation over the corresponding window. The left $y$-axis shows the cross-sectional disagreement in expectations within each month, while the right $y$-axis shows the corresponding measure of market ambivalence. The $x$-axis represents time (year–month). Higher ambivalence values indicate more mixed or variable historical realizations in the trailing window.

**Appendix Table A.17:** BELIEF INSTABILITY: STOCK PRICE MOVEMENT AND INFLATION

| | Monthly | | | Quarterly | | |
|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) |
| **Panel A. Belief instability in stock price movement expectations** | | | | | | |
| Ambivalence (1 year) | 0.045*** | | | 0.032*** | | |
| | (0.009) | | | (0.006) | | |
| Ambivalence (5 years) | | 0.036** | | | 0.041*** | |
| | | (0.015) | | | (0.008) | |
| Ambivalence (10 years) | | | 0.062** | | | 0.039*** |
| | | | (0.027) | | | (0.015) |
| Cumulative return (1 month) | -0.200*** | -0.202*** | -0.201*** | -0.225*** | -0.208*** | -0.206*** |
| | (0.038) | (0.038) | (0.038) | (0.038) | (0.037) | (0.038) |
| Cumulative return (10 years) | -0.001 | -0.001 | 0.000 | -0.001 | -0.000 | 0.002 |
| | (0.002) | (0.002) | (0.002) | (0.002) | (0.002) | (0.002) |
| *R-squared* | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 |
| N | 53743 | 53743 | 53743 | 53743 | 53743 | 53743 |
| **Panel B. Revision in inflation (price level change) expectations** | | | | | | |
| Ambivalence (1 year) | 0.020*** | | | 0.017*** | | |
| | (0.001) | | | (0.001) | | |
| Ambivalence (5 year) | | 0.054*** | | | 0.066*** | |
| | | (0.002) | | | (0.003) | |
| Ambivalence (10 year) | | | 0.051*** | | | 0.050*** |
| | | | (0.002) | | | (0.003) |
| Current inflation | 0.116*** | 0.112*** | 0.107*** | 0.162*** | 0.154*** | 0.155*** |
| | (0.005) | (0.005) | (0.005) | (0.007) | (0.007) | (0.007) |
| *R-squared* | 0.007 | 0.011 | 0.008 | 0.009 | 0.013 | 0.010 |
| N | 105253 | 105253 | 105253 | 105253 | 105253 | 105253 |

*Notes:* This table reports OLS estimates linking information ambivalence to belief instability in household expectations using the Michigan Surveys of Consumers. Panel A examines belief change in stock price movement expectations. Respondents report the probability (0–100) that stock prices will rise over the next 12 months. Individual beliefs are coded as $b_{it} = +1$ if the reported probability is at least 50 percent and $b_{it} = -1$ otherwise. The dependent variable is an indicator for belief revision between two consecutive survey interviews, equal to one if an individual switches from +1 to −1 or vice versa, and zero otherwise. The stock expectation question is available from June 2002 through March 2025. Panel B examines belief revision in inflation expectations using the rotating-panel structure of the survey. The dependent variable is the absolute change in an individual's one-year-ahead inflation expectation between two consecutive interviews, $|\Delta \mathbb{E}_i[\pi]| = |\mathbb{E}_{i,t_2}[\pi_{t+12}] - \mathbb{E}_{i,t_1}[\pi_{t+12}]|$. Individuals are linked across interviews using the respondent's previous-interview identifier (`idprev`) together with the reported date of the prior interview (`datepr`), yielding reinterviews typically spaced about six months apart. The inflation expectation sample covers June 1980 through March 2025. In Panel A, ambivalence over horizon $h \in \{1\text{Y}, 5\text{Y}, 10\text{Y}\}$ is defined as $\text{Ambivalence}(h) = 1 - \frac{|\#\text{Neg} - \#\text{Pos}|}{\#\text{Neg} + \#\text{Pos}}$, where #Pos and #Neg count positive and negative realizations of the underlying market return over a trailing window of length $h$. In Panel B, market ambivalence over horizon $h \in \{1\text{Y}, 5\text{Y}, 10\text{Y}\}$ is measured as the standard deviation of realized returns over a trailing window of length $h$, $\text{Ambivalence}(h) = \sqrt{\frac{1}{T_h}\sum_{t'=1}^{T_h}(\pi_{t-t'} - \bar{\pi}_h)^2}$, where $\pi_t$ denotes realized inflation, $\bar{\pi}_h$ is the mean inflation rate over the corresponding window, and $T_h$ is the number of observations in the window. Columns (1)–(3) construct ambivalence using monthly observations, while columns (4)–(6) use quarterly observations. Panel A controls for cumulative S&P 500 returns over the past 1 month and 10 years, while Panel B controls for the contemporaneous level of inflation. Robust standard errors are reported in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$.

**Appendix Table A.18:** BELIEF UNCERTAINTY: STOCK PRICE MOVEMENT

| | Monthly | | | Quarterly | | |
|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) |
| Ambivalence (1 year) | 0.004*** | | | 0.003*** | | |
| | (0.001) | | | (0.001) | | |
| Ambivalence (5 years) | | 0.014*** | | | 0.009*** | |
| | | (0.002) | | | (0.001) | |
| Ambivalence (10 years) | | | 0.023*** | | | 0.014*** |
| | | | (0.003) | | | (0.002) |
| Cumulative return (1 month) | 0.002 | 0.003 | 0.004 | -0.001 | 0.001 | 0.002 |
| | (0.004) | (0.004) | (0.004) | (0.004) | (0.004) | (0.004) |
| Cumulative return (10 years) | -0.000 | -0.000 | 0.000 | -0.000 | -0.000 | 0.001*** |
| | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) |
| Demographics | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| R-squared | 0.027 | 0.027 | 0.027 | 0.027 | 0.028 | 0.027 |
| N | 135201 | 135201 | 135201 | 135201 | 135201 | 135201 |

*Notes: Notes:* This table reports OLS estimates linking informational ambivalence to individual belief uncertainty in household stock-price expectations using the Michigan Surveys of Consumers. Respondents report the subjective probability, in percentage points, that the average stock price will increase over the next 12 months. Let $p_{it} \in [0,1]$ denote respondent $i$'s reported probability at time $t$. The dependent variable is individual belief uncertainty, $U_{it} = p_{it}(1-p_{it})$, which is maximized at $p_{it} = 0.5$ and declines as beliefs become more extreme. The stock-price expectation question is available from June 2002 through March 2025. Ambivalence over horizon $h \in \{1\text{Y}, 5\text{Y}, 10\text{Y}\}$ is defined as $\text{Ambivalence}^f(h) = 1 - \frac{|\#\text{Neg}^f(h) - \#\text{Pos}^f(h)|}{\#\text{Neg}^f(h) + \#\text{Pos}^f(h)}$, where $\#\text{Pos}^f(h)$ and $\#\text{Neg}^f(h)$ denote the numbers of positive and negative realized S&P 500 returns, respectively, over the trailing window of length $h$, constructed at frequency $f$. Columns (1)–(3) construct ambivalence using monthly return observations, while Columns (4)–(6) use quarterly return observations. All specifications control for cumulative S&P 500 returns over the past 1 month and past 10 years, as well as respondent demographics. Robust standard errors are reported in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$.

**Appendix Table A.19:** EFFECT OF CUES: STOCK PRICE MOVEMENT EXPECTATION

| | Monthly | | Quarterly | |
|---|---|---|---|---|
| | (1) | (2) | (3) | (4) |
| | Past 5Y | Past 10Y | Past 5Y | Past 10Y |
| Cue × Majority aligned | -0.046*** | -0.050*** | -0.068*** | -0.028*** |
| | (0.010) | (0.010) | (0.010) | (0.008) |
| Cue | 0.015** | 0.013** | 0.023*** | -0.001 |
| | (0.007) | (0.006) | (0.006) | (0.006) |
| Majority aligned | 0.018*** | 0.023*** | 0.026*** | 0.012* |
| | (0.006) | (0.009) | (0.006) | (0.006) |
| Ambivalence | 0.049*** | 0.076*** | 0.015** | 0.041*** |
| | (0.012) | (0.009) | (0.007) | (0.005) |
| Short-term return | ✓ | ✓ | ✓ | ✓ |
| Long-term return | ✓ | ✓ | ✓ | ✓ |
| *R-squared* | 0.331 | 0.315 | 0.375 | 0.279 |
| N | 274 | 274 | 274 | 274 |

*Notes:* This table reports OLS estimates relating stock-price-expectation disagreement in the Michigan Surveys of Consumers to recent return "cues" and the sign composition of past returns. The sample covers June 2002 through March 2025 at the monthly level ($N = 274$ months). The dependent variable is the cross-sectional standard deviation of a binary stock-price-movement belief in month $t$. Each respondent reports the probability (0–100) that stock prices will be higher over the next 12 months; individual beliefs are coded as $b_{it} = +1$ if the reported probability is at least 50 and $b_{it} = -1$ otherwise, and disagreement is computed as the standard deviation, $\mathrm{sd}_t(b_{it})$ within month $t$. *Cue* is an indicator for whether the most recent lagged one-month S&P 500 return is positive. *Majority aligned* is an indicator for whether this cue aligns with the majority sign of realized returns in a trailing window of length $h$, constructed from the same return series used to form the ambivalence measure; *Cue* × *Majority aligned* is their interaction. *Ambivalence* is a trailing sign-imbalance index, $\text{Ambivalence}(h) = 1 - \frac{|\#\text{Neg}(h) - \#\text{Pos}(h)|}{\#\text{Neg}(h) + \#\text{Pos}(h)}$, where $\#\text{Pos}(h)$ and $\#\text{Neg}(h)$ count positive and negative realized returns over the trailing window of length $h$. Columns (1)–(2) construct $\#\text{Pos}(h)$ and $\#\text{Neg}(h)$ using monthly return signs with horizons $h \in \{1\text{Y}, 5\text{Y}\}$; columns (3)–(4) use quarterly return signs with horizons $h \in \{4\text{Q}, 20\text{Q}\}$. All specifications control for cumulative S&P 500 returns over the previous 1 month and 10 years. The marginal effect of *Cue* equals $\beta_{\text{Cue}}$ when the cue is a minority sign in the trailing window and $\beta_{\text{Cue}} + \beta_{\text{Cue}\times\text{Maj}}$ when it matches the trailing majority sign; the negative interaction therefore implies attenuation when the cue aligns with the majority. Robust standard errors are reported in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$.

**Field Survey Study (Stock Market Return) Questionnaire**

# Part 1

## Section 1: Instruction

**Overview**
Thank you for taking part in this online study.

**Part 1 (today) and Part 2 (tomorrow)**

This study consists of **two parts**. **Part 1 takes place now**, and **Part 2 will take place tomorrow** at around the same time. Part 1 and Part 2 are paid separately, and **you will receive a participation payment for each part**.

By completing both parts of the study, you will also have a chance to earn an **additional bonus of $30**.

---

**Instruction**

In the next section, you will see a series of **stock market returns** from 2025, presented *one* at a time. **Please review each screen carefully**. You do not need to take notes. Simply view the information as it is presented.

Some of your responses **will be selected for a bonus payment**. Please **read the information carefully**, as accurate answers may increase your bonus.

---

## Section 2: Stock market returns display

**January** 2025 stock market return: **2.7%**

---

**February** 2025 stock market return: **−1.42%**

---

**March** 2025 stock market return: **−5.75%**

---

**April** 2025 stock market return: **−0.76%**

**May** 2025 stock market return: **6.15%**

**June** 2025 stock market return: **4.96%**

**July** 2025 stock market return: **2.17%**

**August** 2025 stock market return: **1.91%**

**September** 2025 stock market return: **3.53%**

**October** 2025 stock market return: **2.27%**

**November** 2025 stock market return: **0.13%**

**December** 2025 stock market return: **−0.05%**

Q1. Did you write down or take pictures/screenshots/recordings of any of the information provided to you on the previous screens? Your answer will not affect your bonus payment for this study. Please answer truthfully.

- ○ Yes
- ○ No

**Section 3: Estimate and recalls**

Q2**.** This is a question to check whether you are paying attention and reading the questions carefully. Please select both "**strongly disagree**" and "**strongly agree**" to continue. Otherwise, you will leave the survey.

- ○ Strongly agree
- ○ Agree
- ○ Neither strongly agree or disagree
- ○ Disagree
- ○ Strongly disagree

**Your estimate**

Q3. Based on the information you just received, what is your best estimate of the **average monthly** stock market return *in 2025*?

*Bonus*: After the study, answers will be compared to the true average of the data series you just observed. The **10% of participants with the most accurate answers** will each receive a **$1 bonus**.

Average monthly stock market return: _____ %

**Recalls**

Q4. Please enter any stock market return you remember seeing earlier. Please recall as many as you can.

January 2025: _____ %
February 2025: _____ %
March 2025: _____ %
April 2025: _____ %

May 2025: _____ %
June 2025: _____ %
July 2025: _____ %
August 2025: _____ %
September 2025: _____ %
October 2025: _____ %
November 2025: _____ %
December 2025: _____ %

## Section 4: Background information

Q5. What is the state of your primary residence? [*Dropdown list*]

Q6. How would you describe your present employment situation?

- ○ Working full-time (for someone or self-employed)
- ○ Working part-time (for someone or self-employed)
- ○ Not working, but would like to work
- ○ Not actively looking for work
- ○ Student, at school or in training
- ○ Other

Q7. Which category represents your total household pre-tax income during the past 12 months?

- ○ Less than $10,000
- ○ $10,000 to $19,999
- ○ $20,000 to $29,999
- ○ $30,000 to $39,999
- ○ $40,000 to $49,999

- ○ $50,000 to $59,999
- ○ $60,000 to $74,999
- ○ $75,000 to $99,999
- ○ $100,000 to $149,999
- ○ $150,000 to $199,999
- ○ $200,000 or more

Q8. Does your household hold any stock market investments?

- ○ Yes
- ○ No

Q9. What is your gender?

- ○ Male
- ○ Female
- ○ Other
- ○ Prefer not to answer

Q10. What is your age? [*Dropdown list*]

Q11. What is the highest level of school you have completed, or the highest degree you have received?

- ○ Less than high school
- ○ High school diploma
- ○ Some college but no degree
- ○ Bachelor’s Degree or higher

## Part 2 (one day after Part 1)

**Welcome!**

Thank you for participating in this study. This study consists of two parts. Part 1 took place yesterday and **Part 2 takes place now**. To complete the study, you will need to read all instructions carefully.

**Part 2 - Instruction**

Yesterday in Part 1, you received **a series of stock market returns** in 2025. This means **all of the information you received in Part 1 yesterday is relevant** for making your decisions on the following screens. You have a chance to **win an additional bonus of up to $30** by completing this part of survey.

You have a chance to **win an additional bonus of up to $30** by completing this part of survey.

---

**Your estimate**

Q1. Based on the information you received yesterday in Part 1, what is your best estimate of the **average monthly** stock market return *in 2025*?

*Bonus*: After the study, answers will be compared to the true average of the data series you just observed. The **10% of participants with the most accurate answers** will each receive a **$1 bonus**.

Average monthly stock market return: _____ %

**Recalls**

Q2. Please enter any stock market return you remember seeing yesterday in Part 1. Please recall as many as you can.

January 2025: _____ %
February 2025: _____ %
March 2025: _____ %
April 2025: _____ %
May 2025: _____ %
June 2025: _____ %
July 2025: _____ %

August 2025: _____ %
September 2025: _____ %
October 2025: _____ %
November 2025: _____ %
December 2025: _____ %

**Field Survey Study (Inflation) Questionnaire**

# Part 1

## Section 1: Instruction

**Overview**
Thank you for taking part in this online study.

**Part 1 (today) and Part 2 (tomorrow)**

This study consists of **two parts**. **Part 1 takes place now**, and **Part 2 will take place tomorrow** at around the same time. Part 1 and Part 2 are paid separately, and **you will receive a participation payment for each part**.

By completing both parts of the study, you will also have a chance to earn an **additional bonus of $30**.

---

**Instruction**

In the next section, you will see a series of **inflation rates** over the past 10 years presented *one* at a time. **Please review each screen carefully**. You do not need to take notes. Simply view the information as it is presented.

Some of your responses **will be selected for a bonus payment**. Please **read the information carefully**, as accurate answers may increase your bonus.

---

## Section 2: Inflation rates display

Inflation rate in **2016**: **2.05%**

---

Inflation rate in **2017**: **2.13%**

---

Inflation rate in **2018**: **2%**

---

Inflation rate in **2019**: **2.32%**

Inflation rate in **2020**: **1.32%**

Inflation rate in **2021**: **7.16%**

Inflation rate in **2022**: **6.41%**

Inflation rate in **2023**: **3.32%**

Inflation rate in **2024**: **2.87%**

Inflation rate in **2025**: **2.65%**

Q1. Did you write down or take pictures/screenshots/recordings of any of the information provided to you on the previous screens? Your answer will not affect your bonus payment for this study. Please answer truthfully.

- ○ Yes
- ○ No

## Section 3: Estimate and recalls

Q2**.** This is a question to check whether you are paying attention and reading the questions carefully. Please select both "**strongly disagree**" and "**strongly agree**" to continue. Otherwise, you will leave the survey.

- ○ Strongly agree
- ○ Agree
- ○ Neither strongly agree or disagree
- ○ Disagree
- ○ Strongly disagree

**Your estimate**

Q3. Based on the information you just received, what is your best estimate of the **average** annual inflation rate *over the past 10 years*?

*Bonus*: After the study, answers will be compared to the true average of the data series you just observed. The **10% of participants with the most accurate answers** will each receive a **$1 bonus**.

Average inflation rate: _____ %

**Recalls**

Q4. Please enter any inflation rate you remember seeing earlier. Please recall as many as you can.

Inflation rate in 2016: _____ %
Inflation rate in 2017: _____ %
Inflation rate in 2018: _____ %
Inflation rate in 2019: _____ %
Inflation rate in 2020: _____ %
Inflation rate in 2021: _____ %
Inflation rate in 2022: _____ %
Inflation rate in 2023: _____ %
Inflation rate in 2024: _____ %
Inflation rate in 2025: _____ %

## Section 4: Background information

Q5. What is the state of your primary residence? [*Dropdown list*]

Q6. How would you describe your present employment situation?

- ○ Working full-time (for someone or self-employed)
- ○ Working part-time (for someone or self-employed)
- ○ Not working, but would like to work
- ○ Not actively looking for work
- ○ Student, at school or in training
- ○ Other

Q7. Which category represents your total household pre-tax income during the past 12 months?

- ○ Less than $10,000
- ○ $10,000 to $19,999
- ○ $20,000 to $29,999
- ○ $30,000 to $39,999
- ○ $40,000 to $49,999
- ○ $50,000 to $59,999
- ○ $60,000 to $74,999
- ○ $75,000 to $99,999
- ○ $100,000 to $149,999
- ○ $150,000 to $199,999
- ○ $200,000 or more

Q8. Does your household hold any stock market investments?

- ○ Yes
- ○ No

Q9. What is your gender?

- ○ Male
- ○ Female
- ○ Other
- ○ Prefer not to answer

Q10. What is your age? [*Dropdown list*]

Q11. What is the highest level of school you have completed, or the highest degree you have received?

- ○ Less than high school
- ○ High school diploma
- ○ Some college but no degree
- ○ Bachelor’s Degree or higher

## Part 2 (one day after Part 1)

Q2.1 **Welcome!**

Thank you for participating in this study. This study consists of two parts. Part 1 took place yesterday and **Part 2 takes place now**. To complete the study, you will need to read all instructions carefully.

**Part 2 - Instruction**

Yesterday in Part 1, you received **a series of inflation rates** over the past 10 years. This means **all of the information you received in Part 1 yesterday is relevant** for making your decisions on the following screens. You have a chance to **win an additional bonus of up to $30** by completing this part of survey.

You have a chance to **win an additional bonus of up to $30** by completing this part of survey.

---

**Your estimate**

Q1. Based on the information you received yesterday in Part 1, what is your best estimate of the **average** annual inflation rate *over the past 10 years*?

*Bonus*: After the study, answers will be compared to the true average of the data series you just observed. The **10% of participants with the most accurate answers** will each receive a **$1 bonus**.

Average inflation rate: _____ %

**Recalls**

Q2. Please enter any inflation rate you remember yesterday in Part 1. Please recall as many as you can.

Inflation rate in 2016: _____ %
Inflation rate in 2017: _____ %
Inflation rate in 2018: _____ %
Inflation rate in 2019: _____ %
Inflation rate in 2020: _____ %
Inflation rate in 2021: _____ %
Inflation rate in 2022: _____ %

Inflation rate in 2023: _____ %
Inflation rate in 2024: _____ %
Inflation rate in 2025: _____ %

**Field Survey Study (EV Company) Questionnaire**

# Part 1

## Section 1: Instruction

**Overview**
Thank you for taking part in this online study.

**Part 1 (today) and Part 2 (tomorrow)**

This study consists of **two parts**. **Part 1 takes place now**, and **Part 2 will take place tomorrow** at around the same time. Part 1 and Part 2 are paid separately, and **you will receive a participation payment for each part**.

By completing both parts of the study, you will also have a chance to earn an **additional bonus of $30**.

---

**Instruction**

In the next section, you will see a series of recent **news article headlines about a major electric vehicle company (Tesla)**, presented one at a time. **Please review each screen carefully**. You do not need to take notes. Simply view the information as it is presented.

Some of your responses **will be selected for a bonus payment**. Please **read the information carefully**, as accurate answers may increase your bonus.

---

## Section 2: Headlines display

***Tesla Remains a Leader in Electric Vehicle Innovation***
This is a **positive** news about Tesla

---

***Tesla's Car Sales Rose 7% as U.S. E.V. Tax Credit Was Ending***
This is a **positive** news about Tesla

---

***Tesla Profit Falls, Hurt by Plunging EV Sales***
This is a **negative** news about Tesla

---

***Tesla Benefits From Long-run Growth in EV Adoption***
This is a **positive** news about Tesla

---

***Tesla's Brand Loyalty Continues to Attract Customers***
This is a **positive** news about Tesla

---

***Tesla Reports Falling Profit as Car Sales Slow***
This is a **negative** news about Tesla

---

***Tesla's Energy Business Supports Diversification Beyond Cars***
This is a **positive** news about Tesla

---

***Tesla Reports 20% Drop in Automotive Revenue***
This is a **negative** news about Tesla

---

***Tesla Shares Slide as Musk Feuds With Trump***
This is a **negative** news about Tesla

---

***Tesla's Manufacturing Focus Could Improve Efficiency***
This is a **positive** news about Tesla

---

***China's BYD Surpasses Tesla as World Leader in Electric Car Sales***

This is a **negative** news about Tesla

---

Q1. Did you write down or take pictures/screenshots/recordings of any of the information provided to you on the previous screens? Your answer will not affect your bonus payment for this study. Please answer truthfully.

- ○ Yes
- ○ No

**Section 3: Opinion and recalls**

Q2**.** This is a question to check whether you are paying attention and reading the questions carefully. Please select both "**strongly disagree**" and "**strongly agree**" to continue. Otherwise, you will leave the survey.

- ○ Strongly agree
- ○ Agree
- ○ Neither strongly agree or disagree
- ○ Disagree
- ○ Strongly disagree

**Your opinion**

Q3. [*Randomly flip the sequence of options*] Based on the news headlines you just read, how would you describe the **overall** sentiment of the news coverage toward Tesla?

- ○ Very negative
- ○ Somewhat negative
- ○ Somewhat positive
- ○ Very positive

Q4. [*Randomly display the order of positive and negative*] Based on the news headlines you just read, how many *times* was **positive** news shown to you, and how many *times* was **negative** news shown to you?

*Bonus Payment: If your answers are correct, you will receive a **£1 bonus**.*

Positive news: _____

Negative news: _____

## Section 4: Background information

Q5. What is the state of your primary residence? [*Dropdown list*]

Q6. How would you describe your present employment situation?

- ○ Working full-time (for someone or self-employed)
- ○ Working part-time (for someone or self-employed)
- ○ Not working, but would like to work
- ○ Not actively looking for work
- ○ Student, at school or in training
- ○ Other

Q7. Which category represents your total household pre-tax income during the past 12 months?

- ○ Less than $10,000
- ○ $10,000 to $19,999
- ○ $20,000 to $29,999
- ○ $30,000 to $39,999
- ○ $40,000 to $49,999

- ○ $50,000 to $59,999
- ○ $60,000 to $74,999
- ○ $75,000 to $99,999
- ○ $100,000 to $149,999
- ○ $150,000 to $199,999
- ○ $200,000 or more

Q8. Does your household hold any stock market investments?

- ○ Yes
- ○ No

Q9. What is your gender?

- ○ Male
- ○ Female
- ○ Other
- ○ Prefer not to answer

Q10. What is your age? [*Dropdown list*]

Q11. What is the highest level of school you have completed, or the highest degree you have received?

- ○ Less than high school
- ○ High school diploma
- ○ Some college but no degree
- ○ Bachelor’s Degree or higher

## Part 2 (one day after Part 1)

Q2.1 **Welcome!**
Thank you for participating in this study. This study consists of two parts. Part 1 took place yesterday and **Part 2 takes place now**. To complete the study, you will need to read all instructions carefully.

**Part 2 - Instruction**

Yesterday in Part 1, you received **a series of news headlines about a major electric vehicle company (Tesla)**. This means **all of the information you received in Part 1 yesterday is relevant** for making your decisions on the following screens.

You have a chance to **win an additional bonus of up to $30** by completing this part of survey.

---

**Your opinion**

Q1. [*Randomly flip the sequence of options*] Based on the news headlines you read yesterday in Part 1, how would you describe the **overall** sentiment of the news coverage toward Tesla?

- ○ Very negative
- ○ Somewhat negative
- ○ Somewhat positive
- ○ Very positive

**Recalls**

Q2. [*Randomly display the order of positive and negative*] Based on the news headlines you read yesterday in Part 1, how many *times* was **positive** news shown to you, and how many *times* was **negative** news shown to you?

*Bonus Payment: If your answers are correct, you will receive a **£1 bonus**.*

Positive news: _____

Negative news: _____

**Field Survey Study (Trump's Tariff) Questionnaire**

# Part 1

## Section 1: Instruction

**Overview**
Thank you for taking part in this online study.

**Part 1 (today) and Part 2 (tomorrow)**

This study consists of **two parts**. **Part 1 takes place now**, and **Part 2 will take place tomorrow** at around the same time. Part 1 and Part 2 are paid separately, and **you will receive a participation payment for each part**.

By completing both parts of the study, you will also have a chance to earn an **additional bonus of $30**.

---

**Instruction**

In the next section, you will see a series of **headlines from opinion articles about Donald Trump's tariff policy** taken from some latest new papers, presented *one* at a time. **Please review each screen carefully**. You do not need to take notes. Simply view the information as it is presented.

Some of your responses **will be selected for a bonus payment**. Please **read the information carefully**, as accurate answers may increase your bonus.

---

## Section 2: Headlines display

***Trump's Tariffs Risk Economic Turbulence and Voter Backlash***
This article is **negative** about Trump's tariffs

---

***Trump's Tariff Revenue Could Help Pay Down the Nation's $37.2T Debt***
This article is **positive** about Trump's tariffs

---

***Trump's Self-inflicted Tariff Crisis Sparks Confusion, Chaos and Questions of Competence***
This article is **negative** about Trump's tariffs

---

***Trump's Tariffs Would Smother His Economic Successes***
This article is **negative** about Trump's tariffs

---

***Economist Says Trump's Tariffs Are a 'Win-win Strategy' to Negotiate Trade***
This article is **positive** about Trump's tariffs

---

***Tariffs Can Help US Workers. But Trump's Doing Them All Wrong***
This article is **negative** about Trump's tariffs

---

***Trump's New Tariff War Is Perfectly Rational***
This article is **positive** about Trump's tariffs

---

***Trump's Tariff Victory Is Not What It Seems***
This article is **negative** about Trump's tariffs

---

***Trump's Tariff Turbulence Is Worse Than Anyone Imagined***
This article is **negative** about Trump's tariffs

---

***Trump Tariffs Will Lead to World Prosperity, Economist Says***
This article is **positive** about Trump's tariffs

---

***Look on the Bright Side of Trump's Global Tariffs***
This article is **positive** about Trump's tariffs

---

Q1. Did you write down or take pictures/screenshots/recordings of any of the information provided to you on the previous screens? Your answer will not affect your bonus payment for this study. Please answer truthfully.

- ○ Yes
- ○ No

**Section 3: Opinion and recalls**

Q2**.** This is a question to check whether you are paying attention and reading the questions carefully. Please select both "**strongly disagree**" and "**strongly agree**" to continue. Otherwise, you will leave the survey.

- ○ Strongly agree
- ○ Agree
- ○ Neither strongly agree or disagree
- ○ Disagree
- ○ Strongly disagree

**Your opinion**

Q3. [*Randomly flip the sequence of options*] Based on the opinion article headlines you just read, how would you describe the **overall** sentiment of these articles toward Trump's tariffs?

- ○ Very negative
- ○ Somewhat negative
- ○ Somewhat positive
- ○ Very positive

Q4.[*Randomly display the order of positive and negative*] Based on the opinion article headlines you just read, how many *times* was **positive** article shown to you, and how many *times* was **negative** article shown to you?

*Bonus Payment: If your answers are correct, you will receive a **£1 bonus**.*

Positive news: _____

Negative news: _____

## Section 4: Background information

Q5. What is the state of your primary residence? [*Dropdown list*]

Q6. How would you describe your present employment situation?

- ○ Working full-time (for someone or self-employed)
- ○ Working part-time (for someone or self-employed)
- ○ Not working, but would like to work
- ○ Not actively looking for work
- ○ Student, at school or in training
- ○ Other

Q7. Which category represents your total household pre-tax income during the past 12 months?

- ○ Less than $10,000
- ○ $10,000 to $19,999
- ○ $20,000 to $29,999
- ○ $30,000 to $39,999
- ○ $40,000 to $49,999

- ○ $50,000 to $59,999
- ○ $60,000 to $74,999
- ○ $75,000 to $99,999
- ○ $100,000 to $149,999
- ○ $150,000 to $199,999
- ○ $200,000 or more

Q8. Does your household hold any stock market investments?

- ○ Yes
- ○ No

Q9. What is your gender?

- ○ Male
- ○ Female
- ○ Other
- ○ Prefer not to answer

Q10. What is your age? [*Dropdown list*]

Q11. What is the highest level of school you have completed, or the highest degree you have received?

- ○ Less than high school
- ○ High school diploma
- ○ Some college but no degree
- ○ Bachelor's Degree or higher

Q12. Do you consider yourself a(n):

- ○ Democrat
- ○ Republican
- ○ Independent
- ○ None of the above

Q12a. (Conditional on choosing option Democrat or Republican) Are you a strong or moderate Democrat/Republican?

- ○ Strong
- ○ Moderate

Q12b. (Conditional on choosing option Independent or None of the above) Do you consider yourself closer to the:

- ○ Democratic Party
- ○ Republican Party

## Part 2 (one day after Part 1)

**Welcome!**

Thank you for participating in this study. This study consists of two parts. Part 1 took place yesterday and **Part 2 takes place now**. To complete the study, you will need to read all instructions carefully.

**Part 2 - Instruction**

Yesterday in Part 1, you received **a series of opinion article headlines about Donald Trump's tariffs**. This means **all of the information you received in Part 1 yesterday is relevant** for making your decisions on the following screens.

You have a chance to **win an additional bonus of up to $30** by completing this part of survey.

**Your opinion**

Q1. [*Randomly flip the sequence of options*] Based on the opinion article headlines you read yesterday in Part 1, how would you describe the **overall** sentiment of these articles toward Trump's tariffs?

- ○ Very negative
- ○ Somewhat negative
- ○ Somewhat positive
- ○ Very positive

---

**Recalls**

Q2. [*Randomly display the order of positive and negative*] Based on the opinion article headlines you read yesterday in Part 1, how many *times* was **positive** article shown to you, and how many *times* was **negative** article shown to you?

*Bonus Payment: If your answers are correct, you will receive a **£1 bonus**.*

Positive news: _____

Negative news: _____

**Belief Disagreement Experiment (Experiment 1) Questionnaire**

What is your Prolific ID? *Please note that this response should auto-fill with the correct ID.*

_____

## Section 1: Pre-experiment instruction

**Overview**
Thank you for taking part in this online experiment. Please complete the study in one sitting, without taking breaks in between, and keep your attention on the survey until the end.

**Comprehension checks**
On next pages, you will receive detailed instruction and information about the experiment. Afterwards, you will be asked to complete a few **comprehension check questions**.

**You can only participate in the experiment if you correctly complete all comprehension check questions!**

**Instruction**
In this experiment, you will see a hypothetical company with no connection to real-world firms.

The company can be either good or bad. A good company means its business goes well, while a bad company means its business goes poorly. The computer decides whether it is good or bad by flipping a fair coin.

- If Heads comes up, the company is good **(probability 50%)**
- If Tails comes up, the company is bad **(probability 50%)**

**Important**: You will not be told the outcome of the coin flip. This means you will not know directly whether the company is good or bad. Instead, you will receive multiple pieces of news about the company. **These news items are designed to help you judge whether the company is more likely to be good or bad.**

**The news**
To illustrate the process, imagine that a box contains 100 pieces of news for the company. The computer randomly draws items from this box to show you.

- **A good company has a box with 65 positive news items and 35 negative news items.**
- **A bad company has a box with 35 positive news items and 65 negative news items.**

**This means that for a good company, the probability of drawing positive news is 65%, while for a bad company it is only 35%.**

After each draw, the news item is placed back into the box before the next draw. This means that all news are drawn with replacement, so each draw is **independent and equally informative**.

**Summary**: In this experiment, you will never know with certainty whether the company is good or bad. However, you will receive helpful information. While the news are prone to some error, they are on average helpful in estimating whether a company is good or bad. **For example, if you receive multiple positive news for a company, this is of course a stronger indication that the company is actually good than if you only receive one positive news.**

---

**Communication of the news**
For the company, you will receive **multiple pieces of news** sequentially on separate screens. Each piece of news (positive or negative) will be communicated with an **event**. An event consists of a short **story** that explains why positive or negative news occurred. An illustrative **image** may appear alongside the story, **but the image itself does NOT contain additional information beyond the text.**

Events are specific to the type of news. The same event **cannot** appear for both positive and negative news. Example: You might receive a negative piece of news communicated with the event “Factory burns down.” You would then see a short description of the fire (and possibly an image). This particular event could only appear for negative news.

**Important**: **Any given event and the corresponding news could appear MULTIPLE TIMES for the company. In such cases, you would have to take into account these news multiple times (and equally strongly), regardless of whether you have seen that event before.** For example, it could happen that the company’s factory burns down twice. You would then have to take into account these news twice.

Events are also **type-specific.** An event used for positive news will never be used for negative news, and vice versa. Ultimately, **all that matters for you is how many times you receive positive and negative news**, not which events cause these news or whether the same event appears multiple times.

**Your decisions**
After you have received these pieces of news about the company, you will be asked to decide whether you think the company is good or bad.

**Your payment**
At the end of the study,

- if your guess for the company is correct, you will earn a **$0.5 bonus**
- If your guess is incorrect, you will not earn the bonus

In addition, you will receive a fixed participation payment for completing the study.

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In the next page, there will be some comprehension checks. **You can only continue the experiment if you correctly complete all comprehension check questions.**

If you are still unsure about the instructions, **please go back and read them carefully before answering the comprehension check questions**.

---

## Section 2: Comprehension checks

**Comprehension checks** [*Option sequence is randomized*]
There are seven comprehension check questions that will test your understanding of the instructions. You can only participate in the experiment if you correctly answer all questions below.

Q1. Is the following statement correct? *"The more positive news I receive for a company, the more likely it is that the company is good."*

- ○ Yes
- ○ No

Q2. Suppose one event is given by "*Factory burns down*." Which of the following statements is correct?

- ○ The event can never occur multiple times.
- ○ The event can occur multiple times as positive and negative news.
- ○ The event can occur multiple times but only as negative news.

Q3. Which of the following statements is correct?

- ○ If I have already seen an event that is associated with positive news, then I know I have already received a positive piece of news for this company.
- ○ The same event can be associated with both positive and negative news.

Q4. Suppose that you have received two negative news items for a company, both communicated with the same event. Which of the following statements is correct?

- ○ Only one of the two news should be taken into account because they were communicated with the same event.
- ○ I need to take both pieces of news into account because both were randomly and independently determined.

Q5. Suppose that you have received two positive news items for a company. Which of the following statements is correct?

- ○ I should take them into account more strongly if they were communicated with the same event than if they were communicated with different events.
- ○ I should take them into account less strongly if they were communicated with the same event than if they were communicated with different events.
- ○ It doesn't matter; I should treat both equally, regardless of whether they come from the same event or different events.

Q6. Suppose that a company is good and that the first news item about this company was positive. What does this imply for the probability that the next piece of news will also be positive?

- ○ The probability is the same as before, since the computer draws independently with replacement.
- ○ The probability is higher than before.
- ○ The probability is lower than before.

Q7. Do images shown alongside the text (story) provide additional information about whether the company is good or bad?

- ○ Yes, the image itself contains important information.
- ○ No, the image is only illustrative; all information comes from the text (story).

---

## Section 3: Group randomization

**Instruction**
First, on the following pages, you will now sequentially receive **multiple news** about the company. These news items will be shown to you on **separate screens**. You can only review each news once. **After moving forward, you will NOT be able to go back to earlier news items.**

Please pay close attention to each news item before proceeding to the next one. **Reminder**: At the end of the study, if your guess for that company is correct, you will earn a **$0.50 bonus** payment; if it is incorrect, you will not earn the bonus.

[*Respondents are randomized into one of the following 9 groups*]

**Group 1**: 18 positive news and 2 negative news
**Group 2**: 14 positive news and 6 negative news
**Group 3**: 11 positive news and 9 negative news
**Group 4**: 6 positive news and 14 negative news
**Group 5**: 2 positive news and 18 negative news
**Group 6** (Stop-and-Think): 11 positive news and 9 negative news; complete a structured recall task *before* belief elicitation

**Group 7** (Monetary Incentives): 11 positive news and 9 negative news; complete a structured recall task *before* belief elicitation; additional *surprise* compensation tied to the accuracy of their recall responses
**Group 8** (Positive Cue): 14 positive news and 6 negative news; a visual cue associated with *positive* news enhances the recall
**Group 9** (Negative Cue): 14 positive news and 6 negative news; a visual cue associated with *negative* news enhances the recall

**Positive news**



The company successfully launched a new product line that quickly attracted strong customer demand. The rollout went smoothly, and sales exceeded expectations in the first months.
**The news for the company is positive.**

**Negative news**



A major customer cancelled its contract with the company, citing repeated delivery delays and quality concerns. The cancellation will significantly reduce the company's sales and production in the coming months.
**The news for the company is negative.**

## News Sequences Across Treatment Groups

This table presents the sequence of 20 news signals assigned to each treatment group. Each signal is either positive (P) or negative (N). Treatment groups differ in the total number of positive and negative signals received: G1 (18P–2N), G2 (14P–6N), G3 (11P–9N), G4 (6P–14N), and G5 (2P–18N). In addition, Groups G6 and G7 receive the same news sequence as G3, while Groups G8 and G9 receive the same news sequence as G2.

| Position | G1 | G2 | G3 | G4 | G5 |
|---|---|---|---|---|---|
| **1** | P | P | N | P | N |
| **2** | P | P | P | N | N |
| **3** | P | N | N | N | N |
| **4** | P | P | P | P | N |
| **5** | N | P | P | N | N |
| **6** | P | P | N | N | N |
| **7** | P | P | P | N | P |
| **8** | P | N | N | N | N |
| **9** | P | P | P | P | N |
| **10** | P | P | P | N | N |
| **11** | P | P | N | N | N |
| **12** | N | N | P | N | N |
| **13** | P | P | N | P | N |
| **14** | P | P | P | N | P |
| **15** | P | N | N | P | N |
| **16** | P | P | P | N | N |
| **17** | P | N | N | N | N |
| **18** | P | P | P | P | N |
| **19** | P | P | N | N | N |
| **20** | P | N | P | N | N |

Q8. Did you write down or take pictures/screenshots/recordings of any of the information provided to you on the previous screens? Your answer will not affect your bonus payment for this study. Please answer truthfully.

- ○ Yes
- ○ No

## Section 4: Belief elicitation and recall

[*If assigned into Groups 1 to 5*]

**Your decisions**

Q9. [*Option sequence is randomized*] Based on the **news items** you just received about the company, what is your best guess about the **type of this company**?

- ○ Good
- ○ Bad

[*Randomly shown one of questions below*]

Q10v1. What do you think is the *probability* that the company is "**good**"?




Q10v2. What do you think is the *probability* that the company is "**bad**"?



**Recalls**

Q11. [*Sequence is randomized*] Based on the **news items** you just received about the company, how many *times* was **positive** news shown to you, and how many *times* was **negative** news shown to you?

Positive news: _____

Negative news: _____

Q12. Thinking back to the news items you just received, can you remember what **type of news** the 1st, 5th, 15th, and last items were?

| | Positive news | Negative news | I don't remember |
|---|---|---|---|
| 1st news | ○ | ○ | ○ |
| 5th news | ○ | ○ | ○ |
| 15th news | ○ | ○ | ○ |
| last news | ○ | ○ | ○ |

[*If assigned into Groups 6 and 7*]

**Recalls**

Q9. [*For Group 6; Sequence is randomized*] Based on the **news items** you just received about the company, how many *times* was **positive** news shown to you, and how many *times* was **negative** news shown to you?

Positive news: _____

Negative news: _____

Q9. [*For Group 7; Option sequence is randomized*] **Good news!** You have been selected to enter a *special recall challenge*. If you can accurately recall how many times positive and negative news items were shown to you for the company just now, you will earn an extra bonus of **$0.50**!

Based on the **news items** you just received about the company, how many *times* was **positive** news shown to you, and how many *times* was **negative** news shown to you?

Positive news: _____

Negative news: _____

---

**Your decisions**

Q10. [*Option sequence is randomized*] Based on the **news items** you just received about the company, what is your best guess about the **type of this company**?

- ○ Good
- ○ Bad

[*Randomly shown one of questions below*]

Q11v1. What do you think is the *probability* that the company is "**good**"?

%

0 10 20 30 0 50 60 70 80 90 100

Probability of being "good"



Q11v2. What do you think is the *probability* that the company is "**bad**"?

%

0 10 20 30 0 50 60 70 80 90 100

Probability of being "bad"



---

Q12. Thinking back to the news items you just received, can you remember what **type of news** the 1st, 5th, 15th, and last items were?

| | Positive news | Negative news | I don't remember |
|---|---|---|---|
| 1st news | ○ | ○ | ○ |
| 5th news | ○ | ○ | ○ |
| 15th news | ○ | ○ | ○ |
| last news | ○ | ○ | ○ |

[*If assigned into Groups 8 and 9*]

**Your decisions**
Q9. [*For Group 8; Showing image associated with the **positive** news; Option sequence is randomized*] Based on the **news items** you just received about the company, what is your best guess about the **type of this company**?

○ Good

○ Bad

Q9. [*For Group 9; Showing image associated with the **negative** news; Option sequence is randomized*] Based on the **news items** you just received about the company, what is your best guess about the **type of this company**?

○ Good

○ Bad

[*Randomly shown one of questions below*]

Q10v1. What do you think is the *probability* that the company is "**good**"?

%

0 10 20 30 0 50 60 70 80 90 100

| | |
|---|---|
| Probability of being "good" |  |

Q10v2. What do you think is the *probability* that the company is "**bad**"?

%

0 10 20 30 0 50 60 70 80 90 100

| | |
|---|---|
| Probability of being "bad" |  |

**Recalls**

Q11. [*Sequence is randomized*] Based on the **news items** you just received about the company, how many *times* was **positive** news shown to you, and how many *times* was **negative** news shown to you?

Positive news: _____

Negative news: _____

Q12. Thinking back to the news items you just received, can you remember what **type of news** the 1st, 5th, 15th, and last items were?

| | Positive news | Negative news | I don't remember |
|---|---|---|---|
| 1st news | ○ | ○ | ○ |
| 5th news | ○ | ○ | ○ |
| 15th news | ○ | ○ | ○ |
| last news | ○ | ○ | ○ |

## Section 5: Patience and risk-taking characteristics

**Today v.s. future**

Q13. How **willing or unwilling** are you to give up something that is beneficial for you today in order to benefit more from that in the future? Please use a scale from 0 to 10, where 0 means “completely unwilling to give up a benefit today for future" and a 10 means you are “completely willing to give up a benefit today for future”. You can also use any numbers between 0 and 10 to indicate where you fall on the scale, like 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10.

| | **Completely unwilling** 0 1 2 3 4 5 6 7 8 9 10 **Completely willing** |
|---|---|
| Willingness to give up benefit today for future |  |

**Payment today v.s. 12 months in future**

Q14. Suppose you were given the choice between receiving a payment **today** or a payment **in 12 months**. We will now present to you five situations. The payment today is the same in each of these situations. The payment in 12 months is different in every situation. For each of these situations we would like to know which you would choose. *Note: Please assume there is no inflation, i.e., future prices are the same as today’s prices.*

Please consider the following: Would you rather receive 100 dollars today or x dollars in 12 months?

The precise sequence of questions was given by the “tree” logic below.

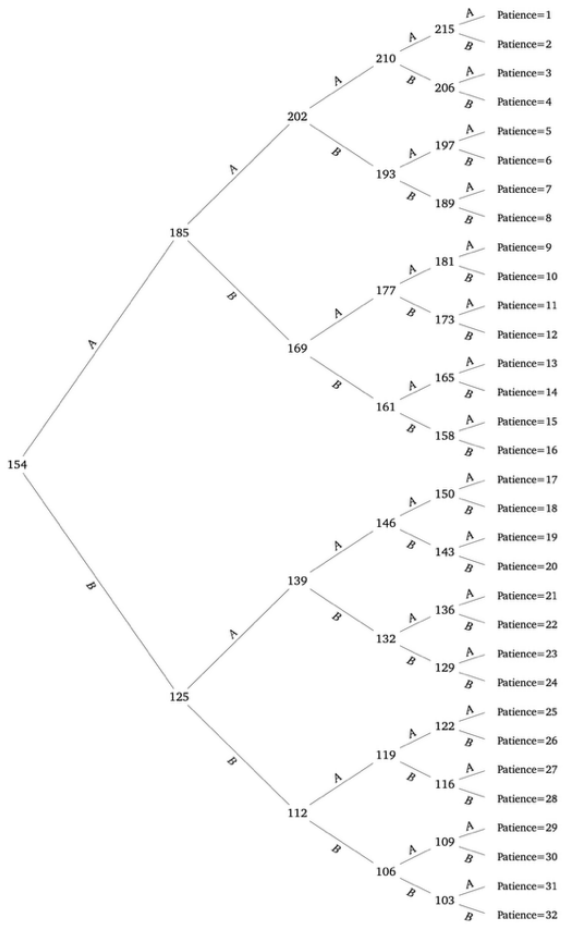



Figure 1: Tree for the staircase time task (numbers = payment in 12 months, A = choice of “100 dollars today”, B = choice of “x dollars in 12 months”. The staircase procedure worked as follows. First, each respondent was asked whether they would prefer to receive 100 dollars today or 154 dollars in 12 months from now (leftmost decision node). In case the respondent opted for the payment today (“A”), in the second question the payment in 12 months was adjusted upwards to 185 dollars. If, on the other hand, the respondent chose the payment in 12 months, the corresponding payment was adjusted down to 125 dollars. Working further through the tree follows the same logic.

**Willingness to take risks**

Q15. Please tell me, in general, how **willing or unwilling** you are to take risks. Please use a scale from 0 to 10, where 0 means “completely unwilling to take risks” and a 10 means you are “completely willing to take risks”. You can also use any numbers between 0 and 10 to indicate where you fall on the scale, like 0, 1, 2, 3, 4 , 5, 6, 7, 8, 9, 10.

**Completely unwilling** **Completely willing**

0 1 2 3 5 6 7 8 9 10

| | |
|---|---|
| Risk taking |  |

**Sure payment v.s. Draw**

Q16. Please imagine the following situation. You can choose between a **sure payment** of a particular amount of money, or a **draw**, where you would have an **equal chance** of getting amount **$300** or getting **nothing**. We will present to you five different situations.

What would you prefer: a draw with a 50 percent chance of receiving amount x, and the same 50 percent chance of receiving nothing, or the amount of y as a sure payment?

The precise sequence of questions was given by the “tree” logic below.

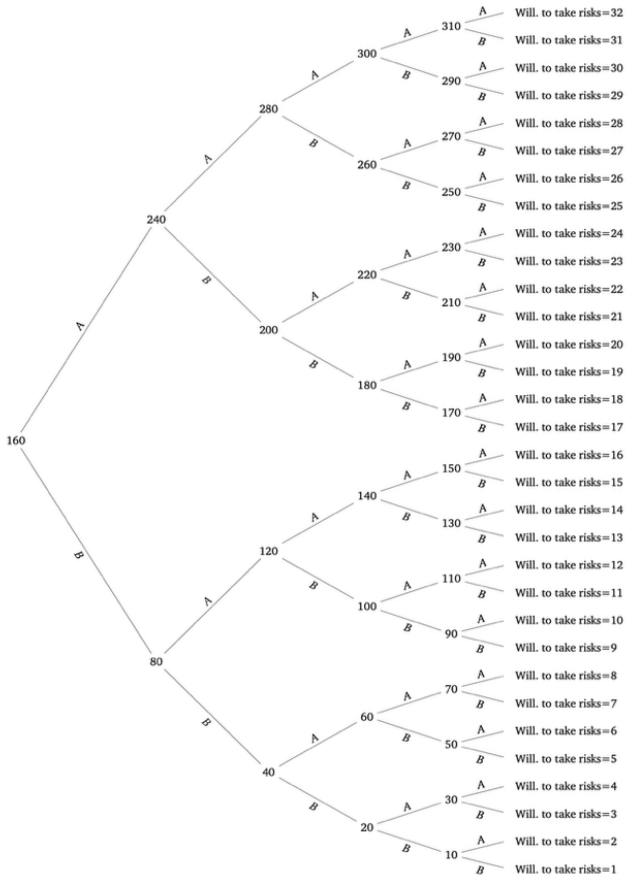



Figure 2 Tree for the staircase risk task (numbers = sure payment, A = choice of lottery, B = choice of sure payment). The staircase procedure worked as follows. First, each respondent was asked whether they would prefer to receive 160 dollars for sure or whether they preferred a 50:50 chance of receiving 300 dollars or nothing. In case the respondent opted for the safe choice (“B”), the safe amount of money being offered in the second question decreased to 80 dollars. If, on the other hand, the respondent opted for the gamble (“A”), the safe amount was increased to 240 dollars. Working further through the tree follows the same logic.

## Section 6: financial knowledge and demographics

### Your knowledge about finance

Q17. Suppose you put $100 into a saving account and the interest rate is fixed at 3% per year for the next 5 years. After 5 years, how much do you think you would have in the account if you left the money to grow?

- ○ more than $115
- ○ exactly $115
- ○ less than $115
- ○ don't know

Q18. Imagine that the interest rate on your saving account is 3% per year and inflation is 2% per year. After 1 year, how much would you be able to buy with the money in this account, compared to today?

- ○ more than today
- ○ exactly the same as today
- ○ less than today
- ○ don't know

Q10. Please indicate whether the statement is true or false: "buying a stock mutual fund usually provides safer return than buying a single company's stock"

- ○ true
- ○ false
- ○ don't know

## Background information

Q20. What is the state of your primary residence? [*Dropdown list*]

Q21. How would you describe your present employment situation?

- ○ Working full-time (for someone or self-employed)
- ○ Working part-time (for someone or self-employed)
- ○ Not working, but would like to work
- ○ Not actively looking for work
- ○ Student, at school or in training
- ○ Other (please specify) ____

Q22. Which of the following best characterizes your household?

- ○ Own our house/apartment without a mortgage
- ○ Own our house/apartment and have a fixed-rate mortgage
- ○ Own our house/apartment and have a variable-rate mortgage
- ○ Rent our house/apartment
- ○ Other

Q23. Which category represents your total household pre-tax income during the past 12 months?

- ○ Less than $10,000
- ○ $10,000 to $19,999
- ○ $20,000 to $29,999
- ○ $30,000 to $39,999
- ○ $40,000 to $49,999
- ○ $50,000 to $59,999
- ○ $60,000 to $74,999
- ○ $75,000 to $99,999

- ○ $100,000 to $149,999
- ○ $150,000 to $199,999
- ○ $200,000 or more

Q24. Does your household hold any stock market investments?

- ○ Yes
- ○ No

Q25. What is your gender?

- ○ Male
- ○ Female
- ○ Other
- ○ Prefer not to answer

Q26. What is your age? [*Dropdown list*]

Q27. What is the highest level of school you have completed, or the highest degree you have received?

- ○ Less than high school
- ○ High school diploma
- ○ Some college but no degree
- ○ Bachelor’s Degree or higher

**Belief Disagreement Robustness and Instability Experiments 2-3 Questionnaire**

What is your Prolific ID? *Please note that this response should auto-fill with the correct ID.*

_____

# Part 1

**Section 1: Pre-experiment instruction**

**Overview**

Thank you for taking part in this online study.

**Part 1 (today) and Part 2 (tomorrow)**

This study consists of **two** parts. **Part 1 takes place now, and Part 2 will take place tomorrow** at around the same time. Part 1 and Part 2 are paid separately, and you will receive a participation payment for each part. By completing both parts of the study, you will also have a chance to earn an **additional bonus of $30**.

Please complete each part in one sitting, without taking breaks in between, and keep your attention until the end.

**Comprehension checks**

On next pages, you will receive detailed instruction and information about the experiment. Afterwards, you will be asked to complete a few comprehension check questions.

**You can only participate in the experiment if you diligently complete all comprehension check questions!**

**Part 1 - Instruction**
In this experiment, you will see a hypothetical company with no connection to real-world firms.

The company can be either good or bad. A good company means its business goes well, while a bad company means its business goes poorly. The computer decides whether it is good or bad by flipping a fair coin.

- If Heads comes up, the company is good **(probability 50%)**
- If Tails comes up, the company is bad **(probability 50%)**

**Important**: You will not be told the outcome of the coin flip. This means you will not know directly whether the company is good or bad. Instead, you will receive multiple pieces of news about the company. **These news items are designed to help you judge whether the company is more likely to be good or bad.**

---

**The news**
To illustrate the process, imagine that a box contains 100 pieces of news for the company. The computer randomly draws items from this box to show you.

- **A good company has a box with 65 positive news items and 35 negative news items.**
- **A bad company has a box with 35 positive news items and 65 negative news items.**

**This means that for a good company, the probability of drawing positive news is 65%, while for a bad company it is only 35%.**

After each draw, the news item is placed back into the box before the next draw. This means that all news are drawn with replacement, so each draw is **independent and equally informative**.

**Summary**: In this experiment, you will never know with certainty whether the company is good or bad. However, you will receive helpful information. While the news are prone to some error, they are on average helpful in estimating whether a company is good or bad. **For example, if you receive multiple positive news for a company, this is of course a stronger indication that the company is actually good than if you only receive one positive news.**

---

**Communication of the news**
For the company, you will receive **multiple pieces of news** sequentially on separate screens. Each piece of news (positive or negative) will be communicated with an **event**. An event consists of a short **story** that explains why positive or negative news occurred. An illustrative **image** may appear alongside the story, **but the image itself does NOT contain additional information beyond the text.**

Events are specific to the type of news. The same event **cannot** appear for both positive and negative news. Example: You might receive a negative piece of news communicated with the event "Factory burns down." You would then see a short description of the fire (and possibly an image). This particular event could only appear for negative news.

**Important**: **Any given event and the corresponding news could appear MULTIPLE TIMES for the company. In such cases, you would have to take into account these news multiple times (and equally strongly), regardless of whether you have seen that event before.** For example, it could happen that the company's factory burns down twice. You would then have to take into account these news twice.

Events are also **type-specific.** An event used for positive news will never be used for negative news, and vice versa. Ultimately, **all that matters for you is how many times you receive positive and negative news**, not which events cause these news or whether the same event appears multiple times.

---

**Your decisions**
After you have received these pieces of news about the company, you will be asked to decide whether you think the company is good or bad.

**Part 1 - Your payment**

At the end of **Part 1**,

- if your guess for the company is correct, you will earn a **$0.5 bonus** (it will be given out after **Part 2**)
- If your guess is incorrect, you will not earn the bonus

You will receive a fixed participation payment for completing the study.

In addition, if you participate in and complete **Part 2 tomorrow**, you will receive **an additional fixed participation payment and have a chance to win a $30 bonus**.

---

In the next page, there will be some comprehension checks. **You can only continue the experiment if you correctly complete all comprehension check questions.**

If you are still unsure about the instructions, **please go back and read them carefully before answering the comprehension check questions**.

---

**Section 2: Comprehension checks**

**Comprehension checks** [*Option sequence is randomized*]
There are seven comprehension check questions that will test your understanding of the instructions. You can only participate in the experiment if you correctly answer all questions below.

Q1. Is the following statement correct? *"The more positive news I receive for a company, the more likely it is that the company is good."*

- ○ Yes
- ○ No

Q2. Suppose one event is given by "*Factory burns down*." Which of the following statements is correct?

- ○ The event can never occur multiple times.
- ○ The event can occur multiple times as positive and negative news.
- ○ The event can occur multiple times but only as negative news.

Q3. Which of the following statements is correct?

- ○ If I have already seen an event that is associated with positive news, then I know I have already received a positive piece of news for this company.
- ○ The same event can be associated with both positive and negative news.

Q4. Suppose that you have received two negative news items for a company, both communicated with the same event. Which of the following statements is correct?

- ○ Only one of the two news should be taken into account because they were communicated with the same event.
- ○ I need to take both pieces of news into account because both were randomly and independently determined.

Q5. Suppose that you have received two positive news items for a company. Which of the following statements is correct?

- ○ I should take them into account more strongly if they were communicated with the same event than if they were communicated with different events.
- ○ I should take them into account less strongly if they were communicated with the same event than if they were communicated with different events.
- ○ It doesn't matter; I should treat both equally, regardless of whether they come from the same event or different events.

Q6. Suppose that a company is good and that the first news item about this company was positive. What does this imply for the probability that the next piece of news will also be positive?

- ○ The probability is the same as before, since the computer draws independently with replacement.
- ○ The probability is higher than before.
- ○ The probability is lower than before.

Q7. Do images shown alongside the text (story) provide additional information about whether the company is good or bad?

- ○ Yes, the image itself contains important information.
- ○ No, the image is only illustrative; all information comes from the text (story).

---

**Section 3: Group randomization**

**Instruction**
First, on the following pages, you will now sequentially receive **multiple news** about the company. These news items will be shown to you on **separate screens**. You can only review each news once. **After moving forward, you will NOT be able to go back to earlier news items.**

Please pay close attention to each news item before proceeding to the next one. **Reminder**: At the end of the study, if your guess for that company is correct, you will earn a **$0.50 bonus** payment; if it is incorrect, you will not earn the bonus.

[*Respondents are randomized into one of the following 9 groups*]

**Group 1**: 18 positive news and 2 negative news
**Group 2**: 14 positive news and 6 negative news
**Group 3**: 11 positive news and 9 negative news
**Group 4** (Stop-and-Think): 11 positive news and 9 negative news; complete a structured recall task *before* belief elicitation

**Positive news**



The company successfully launched a new product line that quickly attracted strong customer demand. The rollout went smoothly, and sales exceeded expectations in the first months.
**The news for the company is positive.**

**Negative news**



A major customer cancelled its contract with the company, citing repeated delivery delays and quality concerns. The cancellation will significantly reduce the company's sales and production in the coming months.

**The news for the company is negative.**

## News Sequences Across Treatment Groups

This table presents the sequence of 20 news signals assigned to each treatment group. Each signal is either positive (P) or negative (N). Treatment groups differ in the total number of positive and negative signals received: G1 (18P–2N), G2 (14P–6N), and G3 (11P–9N). In addition, Groups G4 receives the same news sequence as G3.

| Position | G1 | G2 | G3 |
|---|---|---|---|
| **1** | P | P | N |
| **2** | P | P | P |
| **3** | P | N | N |
| **4** | P | P | P |
| **5** | N | P | P |
| **6** | P | P | N |
| **7** | P | P | P |
| **8** | P | N | N |
| **9** | P | P | P |
| **10** | P | P | P |
| **11** | P | P | N |

| | | | |
|---|---|---|---|
| **12** | N | N | P |
| **13** | P | P | N |
| **14** | P | P | P |
| **15** | P | N | N |
| **16** | P | P | P |
| **17** | P | N | N |
| **18** | P | P | P |
| **19** | P | P | N |
| **20** | P | N | P |

---

Q8. Did you write down or take pictures/screenshots/recordings of any of the information provided to you on the previous screens? Your answer will not affect your bonus payment for this study. Please answer truthfully.

- ○ Yes
- ○ No

**Section 4: First belief elicitation and recall**

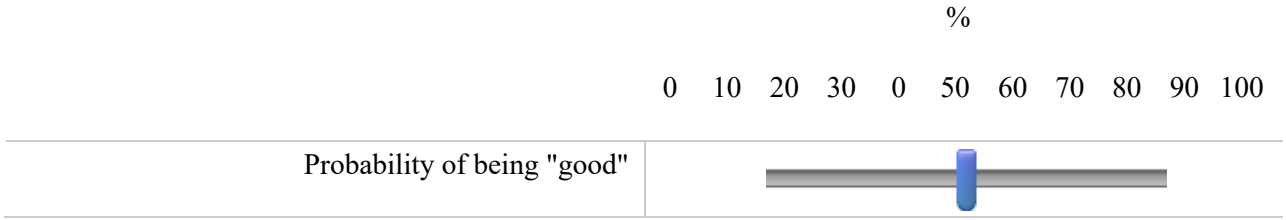
[*If assigned into Groups 1 to 3*]

**Your decisions**
Q9. [*Option sequence is randomized*] Based on the **news items** you just received about the company, what is your best guess about the **type of this company**?

- ○ Good
- ○ Bad

[*Randomly shown one of questions below*]

Q10v1. What do you think is the *probability* that the company is "**good**"?




Q10v2. What do you think is the *probability* that the company is "**bad**"?




**Recalls**

Q11. [*Sequence is randomized*] Based on the **news items** you just received about the company, how many *times* was **positive** news shown to you, and how many *times* was **negative** news shown to you?

Positive news: _____

Negative news: _____

[*If assigned into Groups 4]*

**Recalls**

Q9. [*Sequence is randomized*] Based on the **news items** you just received about the company, how many *times* was **positive** news shown to you, and how many *times* was **negative** news shown to you?

Positive news: _____

Negative news: _____

**Your decisions**

Q10. [*Option sequence is randomized*] Based on the **news items** you just received about the company, what is your best guess about the **type of this company**?

- ○ Good
- ○ Bad

[*Randomly shown one of questions below*]

Q11v1. What do you think is the *probability* that the company is "**good**"?

%

0 10 20 30 0 50 60 70 80 90 100

Probability of being "good"



Q11v2. What do you think is the *probability* that the company is "**bad**"?

%

0 10 20 30 0 50 60 70 80 90 100

Probability of being "bad"



## Background information

Q12. What is the state of your primary residence? [*Dropdown list*]

Q13. How would you describe your present employment situation?

- ○ Working full-time (for someone or self-employed)
- ○ Working part-time (for someone or self-employed)
- ○ Not working, but would like to work
- ○ Not actively looking for work
- ○ Student, at school or in training
- ○ Other (please specify) ____

Q14. Which of the following best characterizes your household?

- ○ Own our house/apartment without a mortgage
- ○ Own our house/apartment and have a fixed-rate mortgage
- ○ Own our house/apartment and have a variable-rate mortgage
- ○ Rent our house/apartment
- ○ Other

Q15. Which category represents your total household pre-tax income during the past 12 months?

- ○ Less than $10,000
- ○ $10,000 to $19,999
- ○ $20,000 to $29,999
- ○ $30,000 to $39,999
- ○ $40,000 to $49,999
- ○ $50,000 to $59,999
- ○ $60,000 to $74,999

- ○ $75,000 to $99,999
- ○ $100,000 to $149,999
- ○ $150,000 to $199,999
- ○ $200,000 or more

Q16. Does your household hold any stock market investments?

- ○ Yes
- ○ No

Q17. What is your gender?

- ○ Male
- ○ Female
- ○ Other
- ○ Prefer not to answer

Q18. What is your age? [*Dropdown list*]

Q19. What is the highest level of school you have completed, or the highest degree you have received?

- ○ Less than high school
- ○ High school diploma
- ○ Some college but no degree
- ○ Bachelor's Degree or higher

# Part 2 (one day later)

**Section 1 Instruction**

**Welcome!**

Thank you for participating in this study. This study consists of two parts. Part 1 took place yesterday and **Part 2 takes place now**. To complete the study, you will need to read all instructions carefully.

**Part 2 - Instruction**

Yesterday in Part 1, you received **several pieces of news about a hypothetical company**. This means **all of the information you received in Part 1 yesterday is relevant** for making your decisions on the following screens. On the next screen, we will ask you to recall the different types of news you received about the company and then make a guess about the company's type.

**Part 2 - Payment**

At the end of the Part 2,

- if your guess for the company is correct, you will earn a **$0.5 bonus**
- If your guess is incorrect, you will not earn the bonus

You will receive a fixed participation payment for completing this part. In addition, you have a chance to **win an additional bonus of up to $30**.

**Section 2: Second belief elicitation and recall**

[*If assigned into Groups 1 to 3*]

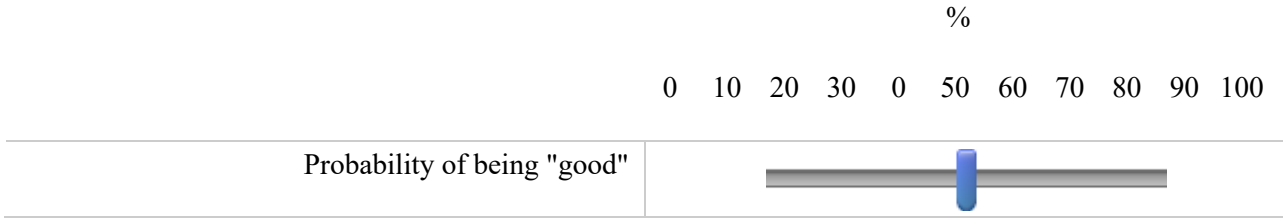
**Your decisions**

Q1. [*Option sequence is randomized*] Based on the **news items** you just received about the company, what is your best guess about the **type of this company**?

- ○ Good
- ○ Bad

[*Randomly shown one of questions below*]

Q2v1. What do you think is the *probability* that the company is "**good**"?




Q2v2. What do you think is the *probability* that the company is "**bad**"?




**Recalls**

Q3. [*Sequence is randomized*] Based on the **news items** you just received about the company, how many *times* was **positive** news shown to you, and how many *times* was **negative** news shown to you?

Positive news: _____

Negative news: _____

[*If assigned into Groups 4]*

**Recalls**

Q1. [*Sequence is randomized*] Based on the **news items** you just received about the company, how many *times* was **positive** news shown to you, and how many *times* was **negative** news shown to you?

Positive news: _____

Negative news: _____

**Your decisions**

Q2. [*Option sequence is randomized*] Based on the **news items** you just received about the company, what is your best guess about the **type of this company**?

- ○ Good
- ○ Bad

[*Randomly shown one of questions below*]

Q3v1. What do you think is the *probability* that the company is "**good**"?

%

0 10 20 30 0 50 60 70 80 90 100

Probability of being "good"



Q3v2. What do you think is the *probability* that the company is "**bad**"?

%

0 10 20 30 0 50 60 70 80 90 100

Probability of being "bad"



**Quantitative Belief (AR(1) Process) Experiments 4-5 Questionnaire**

# Part 1

## Section 1: Instruction

**Overview**
Thank you for taking part in this online study.

**Part 1 (today) and Part 2 (tomorrow)**

This study consists of **two parts**. **Part 1 takes place now**, and **Part 2 will take place tomorrow** at around the same time. Part 1 and Part 2 are paid separately, and **you will receive a participation payment for each part**.

By completing both parts of the study, you will also have a chance to earn an **additional bonus of $30**.

---

**Instruction**

In the next section, you will see a series of **data points generated from a stable process**, presented one at a time. **Please review each screen carefully**. You do not need to take notes—simply view the information as it is presented.

Some of your responses in this section **will be selected for a bonus payment**. Please **read the information carefully**, as accurate answers may increase your bonus.

---

## Section 2: Data display *[Respondents are randomized into one of 3 groups]*

***Group 1:*** *Show 20 data points generated from an AR(1) process with (mu = 5, rho=0.1, sigma=0.5)*
***Sequentially display in separate screens: 5.69, 5.62, 4.97, 5.40, 5.38, 5.47, 4.90, 5.02, 4.65, 4.77, 4.60, 5.21, 5.55, 5.29, 4.75, 5.97, 5.20, 5.28, 5.03, 4.17***

***Group 2:*** *Show 20 data points generated from an AR(1) process with (mu = 5, rho=0.9, sigma=0.5)*
***Sequentially display in separate screens: 4.19, 4.13, 4.14, 4.17, 5.26, 5.37, 5.05, 5.60, 5.90, 6.47, 6.12, 4.94, 5.45, 5.11, 5.74, 5.20, 5.34, 5.17, 5.02, 4.56***

***Group 3:*** *Show 20 data points generated from an AR(1) process with (mu = 5, rho=0.9, sigma=5)*
***Sequentially display in separate screens: 17.45, 11.54, 7.38, 11.37, 8.14, 2.37, -2.26, 8.06, 10.33, 4.65, 1.18, -3.32, 0.35, 5.88, 3.00, 2.36, 2.35, 4.96, 6.63, 0.51***

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Q1. Did you write down or take pictures/screenshots/recordings of any of the information provided to you on the previous screens? Your answer will not affect your bonus payment for this study. Please answer truthfully.

- ○ Yes
- ○ No

Q2**.** This is a question to check whether you are paying attention and reading the questions carefully. Please select both "**strongly disagree**" and "**strongly agree**" to continue. Otherwise, you will leave the survey.

- ○ Strongly agree
- ○ Agree
- ○ Neither strongly agree or disagree
- ○ Disagree
- ○ Strongly disagree

**Section 3: Background information**

Q3. What is the state of your primary residence? [*Dropdown list*]

Q4. How would you describe your present employment situation?

- ○ Working full-time (for someone or self-employed)
- ○ Working part-time (for someone or self-employed)
- ○ Not working, but would like to work
- ○ Not actively looking for work
- ○ Student, at school or in training
- ○ Other

Q5. Which category represents your total household pre-tax income during the past 12 months?

- ○ Less than $10,000
- ○ $10,000 to $19,999
- ○ $20,000 to $29,999
- ○ $30,000 to $39,999
- ○ $60,000 to $9,999
- ○ $50,000 to $59,999
- ○ $60,000 to $7,999
- ○ $75,000 to $99,999
- ○ $100,000 to $19,999
- ○ $150,000 to $199,999
- ○ $200,000 or more

Q6. Does your household hold any stock market investments?

- ○ Yes
- ○ No

Q7. What is your gender?

- ○ Male
- ○ Female
- ○ Other
- ○ Prefer not to answer

Q8. What is your age? [*Dropdown list*]

Q9. What is the highest level of school you have completed, or the highest degree you have received?

- ○ Less than high school
- ○ High school diploma
- ○ Some college but no degree
- ○ Bachelor's Degree or higher

## Section 4: Estimate and recalls

### Your estimate

Q10. Based on the data you just observed, what is your best estimate of the **average** of the series of data?

*Bonus*: After the study, answers will be compared to the true average of the data series you just observed. The **10% of participants with the most accurate answers** will each receive a **$5 bonus**.

Average of the series: _____

### Recalls

Q11. Please enter any values from the data series that you remember seeing earlier. You may enter as many values as you can remember.

Data observation #1: _____ %
Data observation #2: _____ %
Data observation #3: _____ %
Data observation #4: _____ %
Data observation #5: _____ %
Data observation #6: _____ %
Data observation #7: _____ %
Data observation #8: _____ %
Data observation #9: _____ %
Data observation #10: _____ %

Q12. Do you need more space?

○ Yes

○ No

Q13. [Display if Q11 = Yes]

Data observation #11: _____ %
Data observation #12: _____ %
Data observation #13: _____ %
Data observation #14: _____ %
Data observation #15: _____ %
Data observation #16: _____ %
Data observation #17: _____ %
Data observation #18: _____ %
Data observation #19: _____ %
Data observation #20: _____ %

## Part 2 (one day after Part 1)

Q2.1 **Welcome!**

Thank you for participating in this study. This study consists of two parts. Part 1 took place yesterday and **Part 2 takes place now**. To complete the study, you will need to read all instructions carefully.

**Part 2 - Instruction**

Yesterday in Part 1, you received **a series of** data points generated from a stable process. This means **all of the information you received in Part 1 yesterday is relevant** for making your decisions on the following screens. You have a chance to **win an additional bonus of up to $30** by completing this part of survey.

You have a chance to **win an additional bonus of up to $30** by completing this part of survey.

**Your estimate**

Q1. Based on the data you observed yesterday in Part 1, what is your best estimate of the **average** of the series of data?

*Bonus*: After the study, answers will be compared to the true average of the data series you received yesterday in Part 1. The **10% of participants with the most accurate answers** will each receive a **$5 bonus**.

Average of the series: _____

**Recalls**

Q2. Please enter any values from the data series that you remember seeing yesterday in Part 1. You may enter as many values as you can remember.

Data observation #1: _____ %
Data observation #2: _____ %
Data observation #3: _____ %
Data observation #4: _____ %
Data observation #5: _____ %
Data observation #6: _____ %
Data observation #7: _____ %
Data observation #8: _____ %
Data observation #9: _____ %
Data observation #10: _____ %

Q3. Do you need more space?

- ○ Yes
- ○ No

Q4. [Display if Q11 = Yes]

Data observation #11: _____ %
Data observation #12: _____ %
Data observation #13: _____ %
Data observation #14: _____ %
Data observation #15: _____ %
Data observation #16: _____ %
Data observation #17: _____ %

Data observation #18: _____ %
Data observation #19: _____ %
Data observation #20: _____ %