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CENTRAL BANK COMMUNICATION AND HOUSE PRICE EXPECTATIONS

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ABSTRACT

We study how US consumers' house price expectations respond to verbal and non-verbal communication about interest rate changes using several large online surveys. Verbal communication about interest rate hikes leads to little response of average house price expectations but large heterogeneity among household groups. Communication about rate hikes combined with a simple explanation of the mortgage rate channel causes large downward revisions to house price expectations. Consumers interpret heterogeneously Chair Powell's voice tone and body language at the press conference which significantly influence their house price expectations. More negative evaluations are associated with larger upward revisions to house price expectations.

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A data appendix is available at http://www.nber.org/data-appendix/w31232

1 Introduction

In recent years, the literature on consumer expectations has grown rapidly. This growth reflects policymakers' heightened emphasis on monitoring and managing expectations, as well as new datasets and methodological advancements that facilitate investigation of expectations formation. For example, researchers have increasingly turned to randomized control trials (RCTs) to learn about the causal determinants of consumer inflation expectations (Fuster and Zafar (2023), Armantier, Nelson, et al. (2016), Binder and Rodrigue (2018), Binder (2021a), and Coibion, Georgarakos, Gorodnichenko, and Weber (2021)). Many studies show that *how* monetary policy decisions are communicated, and *by whom*, matters for macroeconomic expectations and behavior of the private sector (Coibion, Gorodnichenko, and Weber (2022), D'Acunto, Fuster, and Weber (2022)). Recently, Gorodnichenko, Pham, and Talavera (2022) show that even the *non-verbal* communication, or tone of voice, of a Fed Chair during a press conference can significantly influence financial markets.

In this paper, we conduct three online surveys to study how US consumers' house price expectations respond to verbal and non-verbal communication about interest rates. We are interested in consumer house price expectations for several reasons. First, prior research has documented an important role of house price expectations in driving actual house prices (Adam, Kuang, and Marcet (2012) and Glaeser and Nathanson (2017)). Second, house price fluctuations can contribute to business cycle fluctuations (Iacoviello (2005)). The housing sector is closely associated with leveraged borrowing and chains of loans which make it vulnerable to large adverse shocks. The 2007-8 financial crisis demonstrates how house price crashes can lead to financial instability and economic contraction. Third, there are ongoing debates about role of monetary policy in the housing boom and bust cycle (Taylor (2007), Williams (2016), and Adam and Woodford (2021)). Recently, the Reserve Bank of New Zealand has adopted house price sustainability as an objective of monetary policy. So it is important to understand whether and how monetary policy affects house price expectations. Finally, for most United States households, housing is the most important component of wealth. Thus, actual and expected house price changes have the potential to play a major role in consumption and investment decisions.

This paper fills two gaps in the literature. First, there is little research on how economic policies influence housing market expectations. A recent survey article on housing market expectations in the *Handbook of Economic Expectations*, Kuchler, Piazzesi, and Stroebel (2022), contains no research work on this topic. The paper studies how consumer house price expectations respond to communication of interest rate changes and consumers' familiarity with associated mechanisms. Second, while Gorodnichenko, Pham, and Talavera (2022) provide an objective measure of voice tone of the Fed Chairs at press conferences by machine learning techniques and analyze its effects on financial variables, it is unclear how private agents interpret the non-verbal communication by the Fed Chairs at press conferences.

The paper documents consumers' heterogeneous *subjective* interpretations of non-verbal communication of an interest rate hike by the Federal Reserve Chair Jerome Powell (voice tone and body language) and provides new evidence that the heterogeneous interpretations influence their house price expectations.

Our first survey is an RCT in which respondents are randomly assigned to one of three treatment groups or the control group. Prior to receiving the information treatment, all respondents provide their forecasts of national house price changes over the next 12 months, their inflation perceptions and expectations, their expectations and perceptions of the federal funds rate, and their response to a hypothetical investment question. The first treatment group is only told the level of the current federal funds rate. The second treatment group receives the same information, and also information about the projected federal funds rate over the next three years and in the longer run, from the Summary of Economic Projections. The third treatment group receives the same information as the second group, as well as a brief explanation of the mortgage rate channel of monetary policy. Respondents then provide their posteriors for the expectations of the variables of interest. At the time we conducted the survey, the federal funds rate was projected to rise from 0.1 percent to a longer-run rate of 3 percent. We find that the explanation of the mortgage rate channel is crucial for communication about interest rates to have an effect on consumers' house price expectations, and inflation expectations. Only the third treatment group, which received this explanation, revised their expectations significantly and in the theoretically-consistent direction in response to information about future increases in the federal funds rate. We also use the information treatments as instruments for house price expectations, and show that as house price expectations increase, consumers allocate a larger share of hypothetical money to a housing-indexed fund.

We follow up with the respondents to our first survey about nine months later. Running a follow-up survey is less common in the literature on expectations formation, but is quite important. A follow-up survey can lessen concerns related to priming or experimenter demand effects, since these confounding factors tend to be short-lived (Haaland, Roth, and Wohlfart (2022)), and provides important evidence about the persistence (or lack thereof) of treatment effects. In our case, we find that treatment effects are more muted, but do persist, even after such a long period.

Our second survey includes hypothetical vignettes in which we ask respondents to predict future house prices under different scenarios for future monetary policy. In the baseline scenario, participants are asked to imagine that the FOMC announces that it will keep the federal funds rate unchanged in the next meeting. In the shock scenario, respondents imagine that the FOMC *unexpectedly* raises the federal funds rate by 1 percentage point (p.p.). We use the difference between house price expectations under the shock and baseline scenarios as an estimate of the causal effect of an interest rate increase on households' expectations. We find that respondents have highly heterogeneous beliefs about the effects of an interest

rate increase on house prices and we explore why this is the case. We use both open-ended and multiple choice questions to elicit the mechanisms that are on respondents' minds when coming up with the prediction in the shock scenario, and we also ask about their personal experiences with different mechanisms, motivated by other studies that demonstrate the importance of personal experiences in consumer expectations formation (Malmendier and Nagel (2015), Kuchler, Piazzesi, and Stroebel (2022), and Binder and Makridis (2022)). We find that both mechanism-recall and personal experiences help explain respondents' beliefs about the effects of interest rates on house prices. Consistent with the results of our first survey, respondents who describe a mortgage rate mechanism are more likely to expect lower house prices under the shock scenario than under the baseline scenario. Moreover, highly-educated respondents are far more likely to describe a mortgage rate mechanism.

Our third survey is an RCT which studies the response of consumer house price expectations to part of Chair Powell's speech at a recent press conference. The treatments are designed to allow us to distinguish between the effects of his wording, tone of voice, and visual appearance or body language. Prior to receiving the information treatment, all respondents provide their forecasts of house price changes over the next 12 months, expectations of 1-year ahead inflation, perceptions of current and recent changes in the policy interest rate, and 1-year ahead expectations of the policy interest rate. Respondents are randomly assigned to one of three treatment groups or the control group. The first treatment group receives a part of the *transcript* of the speech by Chair Powell which contains the announcement of the Fed's decision on an interest rate hike and comments on recent economic conditions in the US. The second treatment group listens to an *audio* recording of the same speech. The third treatment group views and listens to a *video* recording of the same speech. Three questions test respondents' understanding of the contents of the speech. Respondents then provide their posterior expectations and perceptions of the variables of interest. They also evaluate whether the wording, tone of voice, and body language of the Fed Chair send a positive or negative signal about future US economy (depending on the group to which they are assigned).

We find that tone of voice and visual appearance significantly affect consumer house price expectations, above and beyond the effects of the text of the speech. Respondents evaluate heterogeneously the voice tone and body language of Chair Powell at the press conference which significantly influence their house price expectations. Most respondents think that his tone of voice and body language send a non-positive signal about future US economy. More negative evaluations of the voice tone or body language are associated with larger upward revisions to house price expectations. This survey also includes a follow-up survey, two weeks later, in which we find that treatment effects are highly persistent after two weeks.

Our results have important implications for monetary policy and central bank communication. They suggest that communication about current and future policy rates may not

have the intended effect on household expectations unless consumers are aware of the mechanisms through which rate changes are intended to affect economic outcomes. Our results also suggest that current public understanding of the effects of monetary policy and the drivers of housing prices varies notably across households. Insofar as house price expectations affect household investment decisions, this heterogeneity in informedness could lead to investment misallocation by some households and could exacerbate inequality. Finally, they suggest that in central bank communication, it is not only the words, but also *how they are said*, that matters for household expectations.

2 The effects of information treatments on expectations

In the Wave 1 randomized controlled trial, our main target is understanding how communications about monetary policy shape households' expectations of house prices and other related macroeconomic variables. Our survey experiment is designed to identify the causal effects of information provision on consumers with diverse prior beliefs.

2.1 Data and survey design

In Wave 1, we conduct an information-provision randomized controlled trial (RCT). The survey was open from February 21 to 22, 2022, inviting around 3,000 participants on Amazon MTurk. Recruiting online panels via Amazon MTurk is commonly used research practice in economics and other social sciences and results in more nationally representative samples than result from typical convenience sampling (Berinsky, Huber, and Lenz (2017), Casler, Bickel, and Hackett (2013), and Levay, Freese, and Druckman (2016)). Each participant is randomly assigned to the control group or one of three treatment groups which receive different pieces of true information about current or future interest rates. The experimental setup consists of three stages:

Baseline stage: We collect demographic information including gender, education, employment status, age, marital status, family composition, total pre-tax household income, and homeownership and mortgage payment status. We then solicit participants' beliefs about inflation, the federal funds rate, mortgage rates, and house prices. To solicit perceptions of inflation over the past 12 months and expectations of inflation over the next 12 months, we follow the procedure of the Federal Reserve Bank of New York's Survey of Consumer Expectations (SCE), which asks respondents to assign probabilities to inflation outcomes occurring in pre-specified bins. We ask participants if they have ever heard news about the Federal Reserve, and then ask for their perception of the current federal funds rate, perception of the current fixed-rate 30-year mortgage interest rate for someone with a good credit score, and prediction of the 12-month-ahead mortgage rate. Next, participants are asked to forecast the national house price change over the next 12 months, and to

report how certain they are about their forecast. We check participants' perceived linkage between the federal funds rate and house prices by asking whether house prices will increase, decrease, or stay the same when the Federal Reserve starts to raise the federal funds rate. Finally, we ask participants a hypothetical investment question following Armona, Fuster, and Zafar (2019): if they had $1,000 to invest for one year, how would they split the money between a savings account paying 2% interest and a fund that pays a return equal to the annual growth in the nationwide house price index.

Treatment stage: Participants are randomly assigned, with equal probability, into one of 4 groups: 1 control group and 3 treatment groups. Respondents in the control group do not receive any new information. Each treatment group receives a different piece of information, in which all statistical facts and projections are directly taken from the latest Summary of Economic Projections of the Federal Open Market Committee (FOMC). Treatments are designed to help disentangle the effect of communication of monetary policy projections, as a part of forward-guidance strategy, on households' expectations of future house prices. The treatments are reported in Table 1. Table A.1 of Appendix confirms that treatment assignments are not predictable from respondents' observable attributes. We design the treatments progressively, so that Treatment 2 (T2) contains the information from Treatment 1 (T1), and Treatment 3 (T3) contains the information from T2. This allows us to identify the impact of the additional information on households' expectations.

Table 1: Control and Information Treatment Groups in Wave 1

Group	Description
T0	**Control group**
T1	**Current policy rate** "The interest rate set by the Federal Reserve, known as the Federal Funds rate, is currently at 0.1%."
T2	**Current policy rate and projected rate hikes** "The interest rate set by the Federal Reserve, known as the Federal Funds Rate, is currently at 0.1%. One forecast from the Federal Reserve is that the Federal Funds Rate will increase to 1.1% in 2022, 2.1% in 2023, 3.1% in 2024 and 3% in the longer run."
T3	**Current rate, projected rate hikes and explaining the mortgage rate channel** "The interest rate set by the Federal Reserve, known as the Federal Funds Rate, is currently at 0.1%. One forecast from the Federal Reserve is that the Federal Funds Rate will increase to 1.1% in 2022, 2.1% in 2023, 3.1% in 2024 and 3% in the longer run. An increase in the Federal Funds rate will increase the mortgage rate. Higher mortgage payments will deter prospective home-buyers and force some existing home-buyers to sell. This increase in sellers and decline in buyers will cause house prices to fall."

Final stage: Respondents are asked again for their "best guess" expectations of nationwide house price changes over the next 12 months, with the question worded differently to avoid them having to answer the exact same question twice. We also elicit their best-guess forecasts for the mortgage interest rate in 12 months, and their point prediction of inflation over the next 12 months. Finally, we ask respondents to reconsider their investment strategy of splitting $1,000 between the savings account and the housing index-based fund. To help participants recall their pre-treatment answers and avoid cognitive overload when making post-treatment predictions, we also remind respondents of their prediction from the corresponding pre-treatment question in a note under each post-treatment question.

To make sure our results are not driven by extreme outliers, we drop roughly 3% observations with inflation or house price growth expectations above 100% or below -100%. We construct survey weights to match the US joint distribution of household marriage status, gender, and household income using the Current Population Survey, 2021 Annual Social and Economic (ASEC) Supplement conducted by the Bureau of the Census for the Bureau of Labor Statistics and report the joint distribution in Table A.2 of Appendix.

2.2 Sample characteristics and external validity

Panel A in Table 2 displays the demographic characteristics of our full (weighted) sample, the control group, and the three treatment groups. The characteristics of the full sample generally closely match the characteristics of the US population. The median age of our respondents is around 38.1, similar to 38.7 in the 2019 American Community Survey (ACS). The median annual income of $65,712 reported in ACS is within the median income category of our sample, ranging from $60,000 to $72,000. In our sample, 58% of respondents are homeowners and out of homeowners, around 52% are recent mortgage payers, which is similar to (but slightly below) the corresponding value of 60.7% from the ACS. The distribution of regions where respondents reside resembles the national representative sample studied by Armona, Fuster, and Zafar (2019): 14.2% Northeast, 23.5% Midwest, 39.5% South and 22.7% West states in our sample and 15.8%, 21.5%, 38.4% and 24.4% in their sample, respectively. The noticeable divergence between our sample and the US population is that about one third of our respondents received at least a Bachelor's degree, versus only 15.6% in the ACS. This is typical with samples drawn from MTurk, and may be partly attributed to a strong correlation between level of education and computer literacy or internet access in the US population. Columns (2)–(5) of this panel demonstrate that the demographic characteristics are not substantially different across the four groups, since random treatment assignment largely preserves a balance between the four groups. Column (6) reports p values from the one-way Analysis of Variance (ANOVA) test of equality of each row variable across the four groups, which confirms the similarity of respondents' observable characteristics across these groups.

Table 2: Sample characteristics, descriptive statistics in Wave 1

	Full sample	**Control**	**T1**	**T2**	**T3**	***P-value***
	(1)	(2)	(3)	(4)	(5)	(6)
Observation	3,056	790	740	780	746	
Panel A: Personal background						
Female	56.5%	57.5%	56.0%	56.3%	56.3%	0.99
Age (in years)	38.1	38.0	38.0	38.1	38.1	0.98
	(10.9)	(10.9)	(10.5)	(11.2)	(10.8)	
Above Bachelor's degree	30.3%	31.6%	29.3%	28.6%	31.7%	0.61
Homeowner	58.0%	61.5%	53.0%	57.2%	59.9%	0.23
Employed	81.3%	78.5%	80.1%	82.7%	84.0%	0.55
Unemployed	4.3%	4.7%	4.7%	4.3%	3.4%	0.90
HH Income $<$ \$90,000	59.6%	62.4%	58.8%	59.3%	57.5%	0.73
HH Income $<$ \$60,000	34.1%	35.9%	35.2%	31.2%	33.7%	0.46
Total household number	3.3	3.3	3.3	3.3	3.2	0.21
Total household number <5	85.9%	84.6%	84.8%	85.6%	88.8%	0.43
Paying mortgage	29.9%	30.4%	29.3%	30.3%	29.4%	0.21
Census region location:						
Northeast	14.2%	15.1%	14.4%	12.7%	14.7%	0.58
Midwest	23.5%	23.1%	21.6%	24.7%	24.7%	0.39
South	39.5%	40.8%	40.0%	40.0%	37.3%	0.63
West	22.7%	21.0%	24.1%	22.6%	23.3%	0.50

	Full sample	**Control**	**T1**	**T2**	**T3**	***P-value***
	(1)	(2)	(3)	(4)	(5)	(6)
Panel B: Perceptions & Expectations						
Expected national house price change,	11.81	11.51	12.51	11.79	11.43	0.72
over next 12 months	(19.88)	(19.20)	(20.34)	(19.81)	(20.19)	
Expected federal funds rate,	2.46	2.41	2.59	2.50	2.37	0.20
future 12 months	(1.90)	(1.96)	(1.97)	(1.86)	(1.82)	
Expected 30-year fixed-rate mortgage	5.89	5.95	5.85	5.92	5.83	0.98
interest , future 12 months	(5.64)	(5.55)	(5.79)	(5.55)	(5.69)	
Expected inflation, future 12 months	10.70	10.55	10.94	10.97	10.56	0.85
	(15.73)	(14.83)	(15.38)	(16.94)	(15.78)	
Perceived federal funds rate, current	1.14	1.05	1.26	1.14	1.13	0.56
	(1.22)	(1.13)	(1.30)	(1.24)	(1.22)	
Perceived 30-year fixed-rate mortgage	3.85	3.83	3.81	3.96	3.79	0.61
interest , current	(2.61)	(2.64)	(2.46)	(2.74)	(2.58)	
Perceived inflation, past 12 months	4.04	4.02	3.81	4.04	4.27	0.41
	(5.08)	(5.19)	(5.27)	(4.90)	(4.96)	

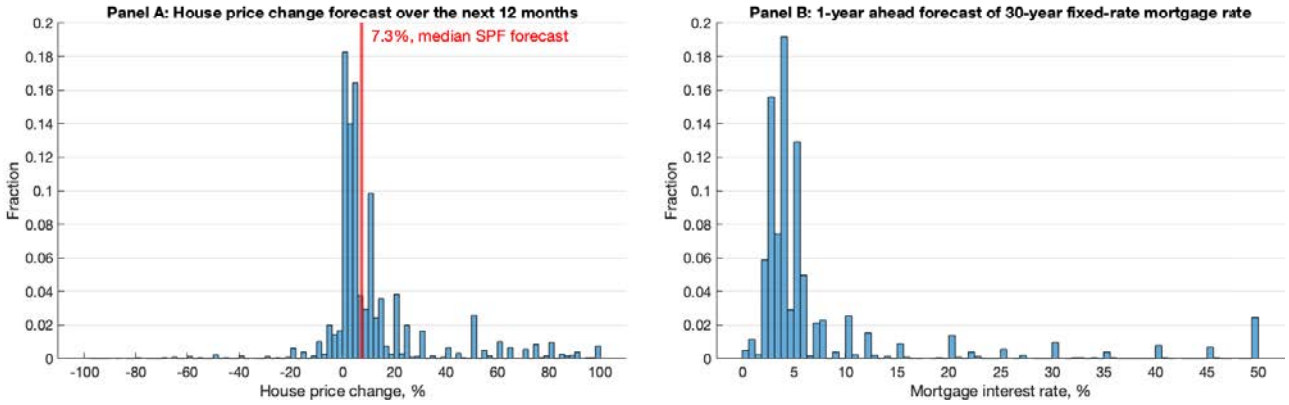
Notes: the mean value of continuous variables are reported. Average perceived current funds rate, current mortgage rate, inflation over past 12 months are calculated using elicited distributions, where middle-point values in each distributional range are used to calculate average. Standard deviations are in parentheses. Expectations in Panel B are winsorized at bottom and top 2.5 percent. Sampling weights are used to match the joint distribution of household marriage status, gender and household income using the latest national characteristics reported by Current Population Survey, 2021 Annual Social and Economic (ASEC) Supplement conducted by the Bureau of the Census for the Bureau of Labor Statistics. Column (6) in both panels reports the p-value of one-way ANOVA test of equality of each row variable across the four groups.

In the pre-treatment module, respondents are asked about their expectations about US economy over the next 12 months and perceptions of past or current economic condition. Panel B of Table 2 reports the summary statistics of these expectations and perceptions. The mean house price change expectation is around 11.8% and the median is 5.0% (not reported in the table for brevity). The latter is similar to the corresponding number in other household surveys. For instance, the median forecast of house price growth rate in February 2022 is 5.7% from the Survey of Consumer Expectations (SCE) managed by the Federal Reserve Bank of New York. Respondents on average expect the 30-year fixed-rate mortgage interest rate to be 5.89% over the next 12 months, higher than the average perception

about current mortgage rate (3.85%). Panel A of Figure 1 displays the distribution of pre-treatment house price change expectations. The distribution is quite dispersed; the standard deviation is 19.88% in the full sample (even after winsorizing the bottom and top 2.5%). Panel B displays the distribution of expected mortgage rates in 12 months, which is also dispersed with a standard deviation of 5.64%. The evidence suggests significant cross-sectional heterogeneity in beliefs about housing markets.

Moreover, respondents report an average inflation expectation of 10.7% over the next 12 months and a median inflation expectation of 6.0% in the pre-treatment section; the latter is identical to the median one-year ahead inflation expectation from the SCE in February 2022. Panel C of Figure A.1 in Appendix displays the distribution of inflation expectations over the next 12 months. Respondents, on average, perceive current federal funds rate to be 1.14%, which is higher than the actual federal funds rate of 0.1% when the survey was implemented. Column (6) of Panel B reports p values from the one-way ANOVA test, showing that the prior beliefs and perceptions are not significantly different across the four groups.

Figure 1: Distributions of pre-treatment expectations about housing markets



Notes: the figure shows distributions of expected house price change over the next 12 months and 1-year ahead forecasts of 30-year fixed-rate mortgage interest rate. The vertical line in Panel A shows the corresponding median forecast of house price change in the Survey of Professional Forecasters (SPF) in February 2022.

Figure A.2 in Appendix plots correlations between house price change expectations and expectations of inflation or mortgage rate changes in Panel A and B, respectively. Table A.3 in Appendix demonstrates the correlates of pre-treatment house price change expectations. Both the table and figure suggest a significant positive (or negative) association between expectations of house price changes over next 12 months and 1-year ahead expectations of inflation (or the mortgage rate change) over one year.

2.3 Average effects of information treatments on beliefs

Our primary interest is how different monetary policy communication treatments influence respondents' expectations. To quantify the average effect of each treatment, we regress

expectation revisions on each treatment using the following specification:

$$\text{Revision}_i \quad = \quad a_0 + \Sigma_{j=1}^{3} a_j \times \mathbb{1}\{i \in \text{Treatment}_j\} + \phi C_i + \epsilon_i, \tag{1}$$

where i indexes respondents and j indexes treatments. Revision_i is calculated as $E_i^{post}Y - E_i^{pre}Y$, which measures revisions to respondent i's expectation of variable Y after the treatment. $\mathbb{1}\{i \in \text{Treatment}_j\}$ is an indicator function which equals 1 if respondent i receives treatment j. C_i is a vector of individual and household demographic characteristic control variables.[1] Inclusion of these control variables can mitigate potential imbalances across arms and allow us to estimate treatment effects more precisely. The coefficient a_0 measures the average expectation revision in the control group (which do not receive new information). Including the control group is important because respondents' pre- and post-treatment expectations are elicited using questions with different wording. So the control group serves to capture any effect driven by the change of wording. For $j = 1, 2, 3$, the coefficient a_j measures the average expectation revision in groups T1, T2 and T3, respectively, relative to the control group. Because posterior expectations are elicited right after the information treatment, this specification examining the average revision provides a direct benchmark for assessing the effectiveness of each treatment on influencing expectations, with no change in other conditions.

Table 3 reports the average revisions to house price change expectations (columns (1) - (2)) and inflation expectations over the next 12 months (columns (3) - (4)), without and with the demographic controls, respectively for the four groups.[2] We report results from the main-wave survey here and the follow-up survey in Section 2.5. All treatment effects reported are relative to the control group. Columns (1) and (3) do not include demographic controls. Columns (2) and (4) include but do not report demographic controls (see Footnote 1 for details); the average treatment effects are little affected by including demographic control variables or not.

Recall that group T1 was informed about current federal funds rate, group T2 was communicated with current federal funds rate and a projected path of rate hikes, and group T3 was communicated with the same information as T2 but was additionally explained the mortgage rate channel that links federal funds rate to house prices. In columns (1) and (2), communicating current policy rate to group T1 leads to insignificant average revisions to house price expectations. Moreover, communicating about the current policy rate and projected rate hikes to group T2 leads to insignificant downward revisions to house price change expectations by 1.08 p.p., as is reported in column (1). The evidence suggests that

[1] Individual characteristics are gender, age, age squared, employment indicator and education (indicator variable for each group), marriage status (indicator variable for each marriage status) and parental duty (indicator variable for having children). Household characteristics are pre-tax household income (binned; indicator variable for each bin), household size (indicator variable for each size), census region (indicator variable for each region).

[2] We also construct real house price change expectation by calculating as the difference between respondents' house price change expectations and inflation expectations. Results are reported in Table A.4 in the Appendix.

simply communicating the current federal funds rate or additionally including projected rate hikes does not effectively move down respondents' house price expectations.

Table 3: Average treatment effects on house price and inflation expectations - Main wave

	House price expectations Main wave		**Inflation expectations** Main wave	
Revision$_i$	(1)	(2)	(3)	(4)
Control	0.350	-1.867	-1.108	-1.918
	(0.435)	(3.452)	(1.025)	(3.961)
Treatment effects relative to control:				
T1 (current policy rate)	0.219	0.173	0.316	0.288
	(0.952)	(0.963)	(1.109)	(1.097)
T2 (current policy rate and rate hikes)	-1.080	-1.023	-1.749	-1.952
	(0.670)	(0.673)	(1.258)	(1.239)
T3 (current policy rate, rate hikes, and explaining mortgage rate channel)	-7.006***	-6.944***	-3.231***	-3.259***
	(0.675)	(0.655)	(1.220)	(1.209)
Demographics		✓		✓
Observations	3,039	2,989	3,009	2,945
R-squared	0.05	0.07	0.01	0.02

Notes: regressions use sampling weights. Robust standard errors are in parentheses. ***, **, * denote statistical significance at 1, 5 and 10 percent levels.

By contrast, communicating about interest rate hikes combined with explaining the mortgage rate channel leads to significant downward revisions to house price change expectations. In Column (2) the effect size for T3 is 6.94 p.p. Explaining the mortgage rate channel plays a major role for reducing these house price expectations: the difference in the coefficients for T2 and T3 is about 6 p.p.

Similarly, for inflation expectations, revisions to inflation expectations are not statistically significant in group T1 or T2. However, in group T3, explaining the mortgage rate channel leads to a downward revision to 1-year-ahead inflation expectations by 3.26 p.p. in column (4). Overall, communicating interest rate hikes combined with explaining the mortgage rate channel can effectively and significantly reduce average house price expectations and inflation expectations.

Heterogeneity across demographic groups. We examine if the revision to house price expectations varies across different demographic groups (see Table A.5). In response to treatment T2, mortgage payers significantly revise their house price expectations downward, while non-mortgage payers on average revise little their house price expectations. Comparing T3 and T2, explaining the mortgage rate channel leads to lower house price expectations for both mortgage and non-mortgage payers but has a much larger effect on non-mortgage

payers. Respondents with and without a college degree revise their house price expectations in opposite directions upon receiving T2. Heterogeneity in expectation revision could resulted from respondents with different demographics holding systematically different prior beliefs, differences in trust towards experts, and different understanding of treatments.

Treatment effects on investment decisions. We also investigate the link between respondents' house price expectation revisions and investment behavior, as a consequence of information treatments, following Armona, Fuster, and Zafar (2019). In our main-wave survey, respondents are asked to allocate $1000 for one-year investment between a housing-index fund with an annual return which equals the growth rate of home prices and a savings account (with a 2% annual interest rate) in both pre- and post-treatment sections. We find a positive association between house price change expectations and the share of investment in the housing fund for both pre- and post-treatment scenario. Moreover, instrumental variable estimation suggests a 1 p.p. upward revision to 1-year ahead expected house price growth is significantly and positively associated with 0.66% increase in housing funds investment. The findings confirm and are comparable with the evidence of a strong relationship between house price expectations and investment behavior, as shown in Armona, Fuster, and Zafar (2019). More discussions can be found in Appendix B.

Alternative specification. As is shown in Coibion, Georgarakos, Gorodnichenko, Kenny, et al. (2021), Coibion, Georgarakos, Gorodnichenko, and Weber (2021), and Coibion, Gorodnichenko, and Weber (2022), information treatments can influence the weight placed to prior beliefs by respondents when they assess new information and make posterior predictions. If an information treatment is deemed more credible by respondents, they should place more weight on the new information and reduce the weight on the prior when producing posterior predictions. In Appendix A.1, we employ this Bayesian-updating specification and find that T3 is found to be more credible by respondents. Even respondents with relatively large prior about house price growth significantly reduce their growth expectation after receiving T3 treatment.

2.4 Information shock, prior knowledge and expectation revisions

On average, explaining the mortgage rate channel (T3) leads to a significant downward revision to house price change expectations, whereas the effect of T2 is quite muted. This section demonstrates a reason for this muted average response is that respondents with different priors updating their expectations in opposite directions. In addition, we analyze the role for prior knowledge of the channel between interest rate and house price in expectation updating.

Information shock and expectation revisions. First we follow Haaland, Roth, and Wohlfart (2022) and define the difference between the 1-year-ahead professional forecast of the federal funds rate (1.1%) in the treatment and individuals' prior belief of funds rate in the next 12 months as the information "shock" for groups T2 and T3.

Table 4: **Information shock and revisions to house price expectation**

Dependent variable	|Revision|	Revision	Revision
	(T2+T3)	(T2)	(T3)
	(1)	(2)	(3)
|Shock|	1.208***		
	(0.246)		
T3×|Shock|	-0.094		
	(0.263)		
T3	2.328***		
	(0.605)		
Shock		1.478***	-1.187***
		(0.194)	(0.109)
Shock × Knowledge of interest		-5.048***	0.487
rate-house price channel		(0.455)	(0.322)
Knowledge of interest		-4.438***	-0.445
rate-house price channel		(1.209)	(1.014)
Prior	✓	✓	✓
Demographics	✓	✓	✓
Observations	1,483	751	732

Notes: regressions use sampling weights. Robust standard errors are in parentheses. ***, **, * denote statistical significance at 1, 5 and 10 percent levels.

To examine if the size of the treatment effect is larger for those with a larger information shock, we regress the size of revisions to 1-year-ahead house price change expectations on the size of the information shock using OLS:

$$\begin{aligned} |\text{Revision}_i| &= \alpha_0 + \alpha_1 |\text{Shock}_i| + \alpha_2 \mathbb{1}\{i \in \text{Treatment}_3\} * |\text{Shock}_i| \\ &\quad + \alpha_3 \mathbb{1}\{i \in \text{Treatment}_3\} + \alpha_4 \text{Prior}_i + \Phi X_i + \eta_i, \end{aligned} \tag{2}$$

where Revision_i is the revision to house price change expectations, $|Y|$ corresponds to the magnitude of variable Y, and X_i is a set of control variables. We also control for respondents' prior expectations and perceptions about the current funds rate. This specification quantifies the impact of the magnitude of the information shock on the magnitude of revision. $\mathbb{1}\{i \in \text{Treatment}_3\}$ is an indicator function that equals 1 if a respondent is assigned into treatment group T3; otherwise it equals 0 if a respondent is assigned into group T2. α_1 captures the extent to which revisions to house price expectation in the T2 depend on the information shock. α_2 measures the difference of responsiveness of house price expectation revision to information shock between T2 and T3.

Column (1) of Table 4 shows that T2 and T3 respondents who receive a larger information shock make bigger revisions to house price expectations in the main wave. This suggests

that treatment effects reported in Table 3 are driven by actual changes in beliefs instead of priming or experimenter demand effects. In addition, the magnitude of responsiveness to the information shock is not noticeably different between T2 and T3 groups, since α_2 is not statistically significant. A 1 p.p. information shock about the federal funds rate leads to a house price expectation revision with magnitude around 1.21 p.p.

Direction of expectation revisions and the role of prior knowledge. Next, we examine whether respondents' prior knowledge about the interest rate-house price linkage is associated with heterogeneous revisions to house price expectations.[3] In the pre-treatment section, we asked respondents, *"If the Federal Reserve starts to increase federal funds rate, how would you anticipate national house prices?"* Response options include: "house prices will increase", "house prices will decrease", "house prices will stay the same", and "don't know". In economic models with houses, such as user cost models and dynamic general equilibrium models (see e.g. Fuster and Zafar (2021), Glaeser, Gottlieb, and Gyourko (2013), and Poterba (1984)), a higher interest rate will generally cause house prices to fall. Therefore, if a respondent selects "house prices will decrease", we code them as having prior knowledge of the interest rate-house price linkage. About 20% of respondents have this knowledge.

To show the effect of having this prior knowledge on house price expectation revisions, we interact the information shock with a dummy variable that indicates if a respondent has this prior knowledge. Column (2) of Table 4 demonstrates that there exists significant heterogeneity in the direction of expectation revision among T2 respondents with and without the prior knowledge. As column (2) suggests, a positive information shock leads to a significant upward house price expectation revision for T2 respondents without the prior knowledge in the main-wave survey. On the contrary, if T2 respondents have this prior knowledge, they significantly reduce their house price change expectations when facing a positive information shock. This explains the muted average treatment effect of T2 in Table 3, as a result of T2 respondents with different prior knowledge updating their expectation in opposite directions. Since T3 respondents are explained about the mortgage rate channel, column (3) demonstrates that even for respondents without the prior knowledge, they still significantly reduce their house price expectation given a positive information shock.

2.5 Persistence of effects

To examine the persistence of the effect of information treatments, respondents were re-invited to complete a follow-up survey about nine months later, on 19th November 2022.

[3]In the pre-treatment section, respondents are asked about a question related to mortgage rate right next to the question about house prices. This serves as a subtle contextual cue that reminds them of the potential influence of mortgage rate on house prices. Since we equally cued all respondents from different treatment groups about the mortgage rate channel, this largely removes the possibility that some respondents know the mortgage rate channel but this channel escaped from their mind when they are making predictions. In this case, the only difference between treatment T2 and T3 is the explanation about the mortgage rate channel.

As in the main wave, the follow-up questionnaire asks respondents their 1-year ahead expectations of inflation, house price changes, and other macroeconomic variables. Around one third of main-wave respondents participated in the follow-up survey. Table 5 reports the persistence of the treatment effect using the follow-up sample.

Table 5: Persistence of treatment effects and information shock

Panel A	**House price expectations**		**Inflation expectations**	
Revision_i	(1)	(2)	(3)	(4)
Control	-2.217***	-6.268*	0.180	1.159
	(0.458)	(3.530)	(0.197)	(2.115)
Treatment effects relative to control:				
T1 (current policy rate)	0.492	0.202	0.143	0.243
	(0.885)	(0.876)	(0.508)	(0.512)
T2 (current policy rate and rate hikes)	0.525	0.115	0.193	0.188
	(0.644)	(0.646)	(0.385)	(0.391)
T3 (current policy rate, rate hikes, and explaining mortgage rate channel)	-1.252*	-1.343*	-0.640*	-0.659*
	(0.727)	(0.738)	(0.341)	(0.352)
Demographics		✓		✓
Observations	1,021	1,005	1,021	1,005
R-squared	0.01	0.05	0.01	0.03
Panel B	|Revision| (T2+T3) (1)	Revision (T2) (2)	Revision (T3) (3)	
|Shock|	0.353			
	(0.307)			
T3×|Shock|	0.295			
	(0.389)			
T3	-0.778			
	(0.738)			
Shock		0.133	-0.571**	
		(0.188)	(0.223)	
Shock × Knowledge of interest rate-house price channel		-2.615***	-0.137	
		(0.393)	(0.289)	
Knowledge of interest rate-house price channel		-2.348**	-2.806***	
		(0.940)	(0.797)	
Prior	✓	✓	✓	
Demographics	✓	✓	✓	
Observations	506	250	256	

Notes: regressions use sampling weights. Robust standard errors are in parentheses. ***, **, * denote statistical significance at 1, 5 and 10 percent levels.

Persistence of treatment effect. Columns (1) and (2) of Panel A of in Table 5 suggest that in the follow-up survey, on average, there are significant downward revisions to house

price change expectations in the control group, relative to the main survey conducted nine months ago. This is likely due to large hikes of federal funds rate between the main wave and follow-up survey and that the US housing markets were cooled down. The treatment effect of T3 is significantly dampened which may not be surprising given the substantial downward revision to house price expectations in the control group. Nevertheless, the downward revision to house price expectation in T3 group is still significantly lower than that for the control and other two treatment groups (after nine months). This shows that the explanation of the mortgage rate channel in T3 has a persistent treatment effect and to some extent, changes the "mental model" of its respondents. Although the treatment effect of T3 on inflation expectation revision is also noticeably dampened in the follow-up wave, it still leads to a significant downward revision by 0.66 p.p. in column (4), showing a persistent effect of the explanation in T3.

Persistence of effect of information shock. Panel B of Table 5 shows the effect of information shock on the house price expectation revisions in the follow-up sample. Column (1) demonstrates that the overall effect of the magnitude of information shock on respondents' house price expectation is not persistent in the pooled sample of T2 and T3 from the follow-up survey. Further, column (2) shows that the effect of the information shock is not persistent for T2 respondents without the prior knowledge about the relationship between interest rate and house price (about 80% of respondents), whereas its effect is persistent (but dampened) for respondents with the prior knowledge. Column (3) shows the effect of information shock is persistent in the follow-up survey for T3 respondents.

3 Hypothetical vignettes and house price beliefs

In Wave 2, we introduce hypothetical vignettes in which we ask our respondents to predict future house prices under different possible scenarios for future monetary policy. Andre, Pizzinelli, et al. (2022) use a similar vignette approach to study the effects of economic shocks on inflation and unemployment expectations.

3.1 Data and survey design

Wave 2 includes around 700 participants from the US on MTurk from March 3rd to 4th 2022. Respondents provide the same demographic information as in Wave 1 and sample weights are constructed in the same way. The characteristics of the weighted Wave 2 sample match those of the US population and Wave 1 closely. For instance, around 53.4% respondents are female, the average age is 38.8, around a quarter of respondents have above Bachelor's degree and the median household income is \$6,000 - \$7,499. The distribution of respondents' home regions is 13.15% from Northeast, 22.48% from Midwest, 38.52% from South and 25.85% from West.

Table 6: Hypothetical Vignettes in Wave 2

Vignettes	Description
S1	**Federal funds rate stays constant** "Imagine that the federal funds rate stays constant. That is, in its next meeting, the Federal Open Market Committee announces that it will keep the interest rate unchanged at 0.1%. The committee announces it does so with no changes in their assessment of the economic conditions."
S2	**Federal funds rate rises unexpectedly** "Imagine that the federal funds rate is unexpectedly 1 percentage point higher. That is, in its next meeting, the Federal Open Market Committee announces that it is raising the interest rate from 0.1% to 1.1%. The committee announces it does so with no changes in their assessment of the economic conditions."

All participants receive non-technical definitions and most recent values of the federal funds rate and US nationwide house price (i.e., over the past 12 months), ensuring that participants are making predictions based on common definitions and information. Then we introduce two hypothetical vignettes (detailed in Table 6) about how the FOMC may handle interest rates in its next meeting. Each vignette follows the same structure. Under the *baseline* vignette, participants are asked to imagine that the FOMC announces that it will keep the federal funds rate unchanged in the next meeting. Then we record their expectations about the future house price change over the next 12 months. Under the *shock* vignette, respondents are asked to imagine that the FOMC *unexpectedly* raises the federal funds rate by 1 p.p., then are invited to predict the future house price change over the next 12 months. Respondents indicate the expected house price change on a slider that ranges from -100% to 100% in both scenarios. The default position of the slider is the value of the nationwide house price change over the past 12 months.[4] The sliders ease the task for our respondents and reduce noise and cognitive strain.

Our main outcome of interest is respondents' expectations about the effect of an interest rate hike on future house prices, i.e. the *gap* between house price predictions from the shock and the baseline scenario. Eliciting expectations under both a baseline and a shock scenario cancels out divergent beliefs about baseline trend of the US economy, allowing us to directly measure the causal effects of the interest rate hike on households' expectations.

Next, we directly elicit the *mechanisms* on respondents' minds when coming up with predictions in the shock scenario. An open-ended question asks them to write a few sentences to summarize the main considerations on their mind for making a forecast when the federal funds rate unexpectedly increases, while a multiple choice question allows them to select all mechanisms on their mind from a list of 9 options, including mechanisms from the

[4]To ensure the exogeneity of the rate hike, we inform respondents that Fed raises the federal funds rate even though its evaluation of future economic conditions does not change, as in Andre, Pizzinelli, et al. (2022).

perspective of demand side (e.g. home buyers and mortgage payment), supply side (e.g. house developers), and others (see the questionnaire in Appendix C). Some of the options imply an increase and others a decrease in future house prices. The multiple choice question comes after the open-ended question to avoid interference of the choices from the multiple choice question on the mechanisms recalled in the open-ended question. Finally, we ask about respondents' personal or family's/friends' experience with each of the corresponding mechanisms from the multiple choice question, where options include "no experiences", "a few experiences", "some experiences", "many experiences", or "a lot of experiences".

3.2 Preliminary facts

Figure A.3 in Appendix illustrates the distribution of respondents' house price change expectations over the next 12 months in the baseline scenario (Panel A) and shock scenario (Panel B), and of revisions to house price change expectations from the baseline to shock scenario (Panel C). The mean expectation of house price changes in the baseline is 27.8% and the mean in the shock scenario is slightly lower and 26.7%.[5] The average house price change expectations are affected little by the unexpected interest rate hike, as the mean revision to house price change expectations is -1.1%. The house price change expectations are very dispersed in both baseline and shock scenarios and so are revisions to the expectations.[6] One pattern is that the shock scenario distribution has fatter tails (a larger variance) than the baseline distribution, which suggests a large heterogeneity in interpreting the interest rate hike and the associated revisions to house price change expectation.

3.3 Mechanism recall

Figure 2 summarizes answers to the open-ended question regarding mechanisms on respondents' minds when forecasting house prices under the shock scenario, using a word cloud with a maximum of 2-gram.[7] The size of each word reflects its relative frequency of appearance in the texts typed by respondents. Word cloud can facilitate our analysis in two ways. First, it gives us an indication of the potential channels that are most likely to be recalled by respondents. Second, it is a form of relevant robustness check for the multiple-choice question to elicit mechanisms on respondents' mind. Later we show the consistency of mechanisms

[5]The mean house price change expectations are much higher than the mean pre-treatment house price change expectation in Wave 1 (11.81%). A main reason may be that in Wave 2, all respondents are provided information on the growth rate of national house prices in the past 12 months, which is 19.1%. Note that the mean house price growth forecasts for Wave 2 reported here is unwinsorized. If we winsorize the expectations at top and bottom 2.5%, the average house price growth forecasts for the baseline and shock scenarios are 27.83% and 26.99% respectively (which are close to the corresponding unwinsorized means).

[6]Figure A.4 in Appendix suggests a strong positive correlation between house price change expectations in the baseline and shock scenarios.

[7]In computational linguistics, an n-gram is a sequence of consecutive n items from a given sample of text or speech. In our context, the items are words (also called shingles). Word cloud draws out sequences of n words that most frequently appear in the text.

recalled between the open-ended question and the multiple-choice question. From the word cloud, *mortgage* (and related, such as *mortgage rate*, *loan* and *borrow money*) and *inflation* are the two words that appear most frequently in the open-ended texts. This shows that the most commonly recalled mechanisms between the interest rate hike and house prices are mortgage rate channel and inflation channel.

Figure 2: Word cloud - thoughts most frequently on respondents' mind

Turning to the multiple choice question on mechanisms. We list 9 potential channels that might come up to respondents' mind when they were making house price prediction in the shock scenario. Particularly, respondents are asked:

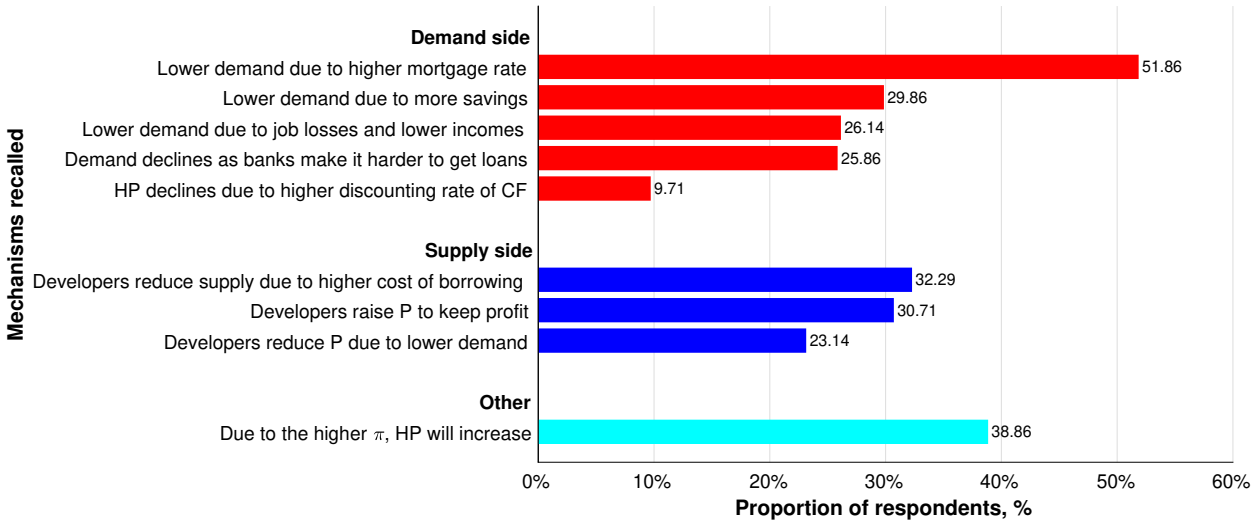
"The following statements describe thoughts you might have on your mind while making your predictions for scenario 2 (federal funds rate rises). Did you have any of these thoughts on your mind? Please tick all that you have on your mind."

Then a list of 9 channels is provided, which consists of a variety of channels associated with demand side (i.e. home buyers) and supply side (i.e. house developers), and of mechanisms implying a higher house price in the future (e.g. inflation) and implying a lower house price (e.g. less demand). Respondents are allowed to choose multiple channels on top of their mind. The full wording of the channels can be seen in the questionnaire presented in Appendix C.

Figure 3 illustrates the proportion of respondents who have each channel on their mind

when they make house price predictions in the shock scenario.[8] The mortgage rate channel and inflation channel are the two most commonly recalled mechanisms by respondents. More than half of respondents (about 52%) think about the lower demand for houses due to higher mortgage interest rates. Around 39% of the respondents view that a higher inflation will drive up house prices. The channel regarding the discounting rate of cash flow is the least recalled channel by fewer than 10% respondents. Section C.1 demonstrates the heterogeneity in recalling mechanisms between mortgage and non-mortgage payers.

Figure 3: Mechanisms on top of respondents' head when making house price change prediction in the shock scenario (federal funds rate unexpectedly increases)



Notes: this figure shows selected propagation channels on respondents' minds when they make their predictions, using Wave 2 data. Respondents can select the channels from a list. The figure reports the proportion of respondents selecting each of the 9 mechanisms. The full wording of the channels is available in Appendix.

To avoid random clicking and ensure the quality of the responses, respondents are required to spend at least 150 seconds on this question before they go on to the next question. Further, the quality of the responses is checked as follow and deemed rather reasonable. First, text analysis outcomes from the open-ended question are highly aligned with the responses to the multiple-choice question, reflecting a desirable level of robustness of the channels that most commonly appear on respondents' mind. Second, the order of these mechanisms from the most to the least commonly recalled is quite different from the order in the list in the survey questionnaire. For instance, the inflation channel appears in the middle of the list, while it is the second most commonly recalled. This demonstrates that respondents indeed went through all options in the list before they decide to choose. Third, respondents are allowed to choose *"None of the above."* No respondent selects *"None of the above"* and any of the listed channels at the same time, suggesting respondents did not randomly click the options.

[8]Figure A.5 in Appendix shows the distribution of the total number of mechanisms recalled by respondents. The number of mechanisms recalled across all respondents has an average of 2.88 and a standard deviation of 1.71.

3.4 Mechanism recalls and house price predictions

How do recalled mechanisms influence respondents' expected house price (HP)? We show that revisions to expected house price change largely depend on recalled mechanisms in the shock scenario when the Federal Reserve unexpectedly raises the policy interest rate. The 9 listed mechanisms are categorized into two types. Type 1 implies a lower house price (e.g., mortgage rate channel) and type 2 implies a higher house price growth (e.g., inflation channel) in the shock scenario. Then, for each individual respondent, we calculate two standardized sums of mechanisms recalled according to the type, i.e. HP(+) implying a higher house price and HP(−) implying a lower house price, respectively. We then analyze the relation between recalled mechanisms and the direction and size of revisions to house price change expectations.

Table 7: Relation between recalled mechanisms and revisions to nominal house price change expectations

	Directional expected HP change revision		**Expected HP change revision**	
	(1)	(2)	(3)	(4)
Standardized sum of mechanisms				
HP (+)	0.251***	0.229***	2.801***	2.535***
	(0.041)	(0.042)	(0.914)	(0.949)
HP (−)	-0.164***	-0.194***	-2.705***	-3.314***
	(0.042)	(0.044)	(0.828)	(0.971)
Demographics		✓		✓
Observations	697	689	697	689
R-squared	0.11	0.17	0.03	0.09

Notes: robust standard errors are in parentheses. ***, **, * denote statistical significance at 1, 5 and 10 percent levels.

Columns (1) and (2) of Table 7 report OLS estimation results when the dependent variable is the directional revision to expected house price changes from the baseline to the shock scenario.[9] Columns (3) and (4) report OLS estimation results when the dependent variable is the size of revisions to expected house price changes. Recalling a larger number of mechanisms that imply higher (or lower) house prices is positively associated with a bigger likelihood of revising their house price expectations upward (or downward) and a higher (or lower) prediction of house price change expectations in the shock scenario. For instance, recalling one more (standardized) mechanism implying house price increases is associated

[9]If a respondent revises house price change expectation downward (or upward) in the shock scenario, the directional change is coded with value -1 (or value 1). If they do not change the expectation, the direction is coded with value 0. Regressions use sampling weights. See Footnote 1 for demographic characteristic controls. Estimation results are robust if ordered probit or ordered logit models are used, which are reported in Table A.18 of Appendix.

with a 2.801 p.p higher prediction of house price changes and recalling one more mechanism implying house price declines is associated with 2.705 p.p lower prediction of house price changes (see column (3)), ceteris paribus.

The role of personal experience and associative memory. After eliciting respondents' mechanism recalls, they are asked to report the level of their personal experience with each of channel. We find that respondents are more likely to recall a certain mechanism if they have a higher level of personal experience with it. For instance, mortgage payers are more likely to recall the mortgage-rate channel and more likely to revise their house price expectation downwards, as well as make a larger downward revision to house price expectations, when there is an unexpected increase in the federal funds rate. More details are reported in Appendix C. The fact that those with a recent experience of paying a mortgage are more likely to recall the mortgage rate channel is in line with associative memory: the hypothetical change in interest rates acts as a cue that triggers respondents' recall of their recent personal experience of paying a mortgage, which in turn shapes their thoughts and predictions in the forecasting task. This confirms the findings of Andre, Pizzinelli, et al. (2022) in the context of house price expectations.

4 Non-verbal central bank communication

This section examines the impact of central bank communication on consumers' house price expectations. We find that non-verbal communication (voice tone and body language) significantly influences consumer house price expectations. Respondents make heterogeneous evaluation on the voice tone and body language of Chair Powell at the press conference which significantly influence their house price expectations.

4.1 Survey design

In Wave 3, we conduct an RCT where respondents are randomly assigned into four groups (one control and three treatment groups). The survey was open from January 23 to 24, 2023 and inviting around 2,000 participants on Prolific, which is a UK-based platform for online subject recruitment explicitly designed for survey research.[10] Many economists recently recruit respondents from Prolific (e.g. Saccardo and Serra-Garcia (2023) and Exley and Kessler (2022)) to study behaviors of general public. Participants in the treatment groups receive different forms of information from Federal Reserve Chair Jerome Powell's December 2022 press conference, in which he announced the decision to raise the federal funds rate by 0.5 p.p. Figure A.6 in Appendix summarizes the survey flow. Below we outline the main stages and design of the survey.

[10]Prolific website: `https://www.prolific.co`.

Pre-treatment and monetary policy perception. At the start of the survey, respondents receive information regarding the recent US economic situation (GDP growth and unemployment).[11] Then, respondents are asked for their 1-year-ahead expectations of house price growth and inflation, their perceptions of federal funds rate in November and the Fed's monetary policy decision in December (i.e. *change* in the federal funds rate), and predictions of the federal funds rate in 12 months. Similar to Wave 1, we also ask respondents about their prior knowledge about the relationship between the federal funds rate and house prices, i.e., whether house price will increase, decrease or not change, following an increase in federal funds rate.

Script, audio and video treatments of FOMC speech. Then, respondents enter into the treatment stage. For the first treatment group, respondents are invited to read a part of the December 2022 *speech script* by Chair Powell at the press conference in which he announces a 0.5% interest rate hike. They are subject only to the wording of the speech, but not the tone of voice or body language of the Chair.[12] Respondents in the second treatment group are asked to listen to the *audio clip* of the speech, and thus are subject to both the wording of the speech and the tone of voice. For the third treatment group, respondents watch the *video clip* of the speech and are subject to the influence of the wording of the speech, the tone of voice, and the speaker's body language (including facial expressions).[13] Such treatment design allows us to isolate the average impact of wording, tone of voice, and body language by comparing different treatment groups. To incentivize the respondents in treatment groups, we design three questions asking about details of the speech. Respondents are informed that if they can answer all three questions correctly, bonus payment will be given.[14] We paid the bonus one day after the completion of the survey. The control group does not receive any additional information.

Post-treatment and signal evaluations. Afterwards, respondents are asked for their 1-year ahead expectations of inflation, the federal funds rate, mortgage rates, and house price changes. They are then presented with a series of structured questions that evaluate the signals conveyed by the wording of the speech, voice tone and body language of the speaker accordingly. The signals range from "*very negative*" to "*very positive*". At the end of the survey, we collect a standard set of personal/household characteristics, similar to

[11] The information about GDP growth and unemployment are same as in the speech made by Chair Powell at the December press conference. This information provision is to ensure that all respondents have same information set about recent GDP growth and unemployment so that the relevant information in speech treatments does not create information "shock" to respondents. We also inform respondents of the definition of inflation and recent rate of inflation (same as in the speech) before eliciting their prior expectations.

[12] Note that the speech clip chosen in treatments does not contain any information about the actual *level* of interest rate. Instead, only the *change* in interest rate is provided in the treatments. In this way, treatment-group respondents only receive information surprise *(shock)* about the *change* in policy interest rate by the latest monetary policy decision.

[13] Details about the speech treatments can be found in Appendix F.1.

[14] The first question is easy and asks the interest rate decision made by the Federal Reserve in this speech. We randomize answer options provided to respondents. About 98% of respondents answer this question correctly.

previous waves.

Follow-up survey. We conduct a follow-up survey 2 weeks after the completion of the main wave of survey and on 6th February 2023. Around 75% main-wave respondents participate in the follow-up survey. We re-elicit their 1-year ahead expectations of house prices, inflation and other variables.

4.2 Household sample

The characteristics of Wave 3 sample are similar to US population and statistics of previous waves. For instance, the average age is 41.2, around 20% of respondents have above Bachelor's degree and the median household income is \$60,000 - \$72,000. The distribution of respondents' home regions is 18.45% from Northeast, 19.55% from Midwest, 41.25% from South and 20.75% from West. Panel A (and B) of Table A.6 in Appendix summarizes the personal and household characteristics (and pre-treatment perceptions and expectations) in each group. The pre-treatment mean 1-year ahead expectation of national house price growth is around 2.1%. Figure A.7 in Appendix displays the distributions of households' perception and expectations. We test whether there is a significant difference about characteristics and pre-treatment perceptions and expectations across the four groups and do not find any significant difference. Compared to Wave 1, pre-treatment house price growth expectations and inflation expectations are much lower and federal funds rate rate perceptions and expectations much higher.

4.3 FOMC speech treatments on house price expectations

The most direct way to evaluate the treatment effect of different speech treatments is to look at the average revision to house price change expectations by each treatment group. Table A.7 in Appendix illustrates the average treatment effect on revisions to house price change expectations across different treatment groups in both main-wave and follow-up samples. All three treatment groups report a significant upward revision to house price change expectations following the treatment. On average and relative to the control group, the treatment group receiving video speech treatment has the largest upward revision to house price change expectations of 4.71 p.p. (relative to the control group). Next comes the audio treatment group (2.76 p.p.) and the speech script group (1.20 p.p.). The treatment effects are persistent and of similar magnitude in the follow-up sample. Alternatively, following the econometric specification of Coibion, Georgarakos, Gorodnichenko, Kenny, et al. (2021), Coibion, Georgarakos, Gorodnichenko, and Weber (2021), and Coibion, Gorodnichenko, and Weber (2022), we assess the impact of different speech treatments on the weight placed to prior beliefs by respondents in the sense of Bayesian updating. All three information treatments significantly reduce the weight placed to the prior by respondents. More discussion can be found in Appendix A.2.

A further key step to examine the effect of information treatments on household expectations is to identify the impact of speech wording, speaker's voice tone and body language, separately. To this end, we employ the following specification:

$$\begin{aligned} \text{Revision}_i \quad = \quad & \beta_0 + \beta_1 Text_i + \beta_2 Voice_i + \beta_3 Body_i + \alpha_1 \text{Shock}_i \\ & + \alpha_2 \text{Shock}_i \times \text{Knowledge}_i + \alpha_3 \text{Knowledge}_i + \alpha_4 \text{Prior}_i + C_i \Phi + \epsilon_i, \end{aligned} \tag{3}$$

where $Text_i$ indicates that respondent i is exposed to the wording of the speech, $Voice_i$ indicates exposure to the tone of voice of the speaker, and $Body_i$ indicates exposure to the speaker's body language. For example, the video speech treatment group is exposed to all three (text, voice, body), while the speech script treatment group is exposed to only text. In addition, we also include the information shock, Shock_i, received by respondent i, as respondents adjust their expectations upon receiving the information shock. Information shock is constructed by calculating the difference between the actual monetary policy decision, i.e. raising interest rate by 0.5 p.p., announced by Chair Powell in December 2022 (and in the first sentence of all speech treatments) and the respondent's perceived change in interest rate that we collected in the pre-treatment section.[15] Knowledge_i indicates if the individual respondent has the prior knowledge about the linkage between interest rate and house prices as in Wave 1. An interaction term between Shock_i and Knowledge_i is included to distinguish how respondents with different prior knowledge update their house price expectations in response to an information shock. We also include households' prior expectations and a vector of individual and household demographic characteristic variables, C_i.[16] ϵ_i is an idiosyncratic error term.

Treatment effects of wording, voice and body language. Column (2) of Table 8 reports the estimation results without considering the effect of respondents' prior knowledge. On average, exposure to the text treatment significantly increases house price expectations by about 0.62 p.p. The effect of voice is more than twice that of text, around 1.40 p.p. The effect of the body language is the largest of all, raising respondents' expectations by around 1.96 p.p. In addition, a positive information shock, i.e., an underestimation of the change in policy interest rate in December, brings down respondents' house price expectation significantly. These treatment effects are persistent, as is reported in Column (5) for the follow-up sample.

Prior knowledge and information shock. In columns (3) and (6) of Table 8, we show that the information shock has a heterogeneous impact on the direction of revisions to house price change expectations for respondents with or without prior knowledge about the linkage between interest rate and house prices, in both main-wave and follow-up samples.

[15] Since the control group does not receive any information treatment, it receives no information shock, i.e. its information shock takes value of 0.

[16] Additionally, respondents' prior inflation expectation is included to control for information *shock* about inflation from speech treatments.

In particular, we interact information shock with an indicator variable that equals 1 if a respondent has the prior knowledge. With a positive information shock, respondents with the prior knowledge significantly revise their house price change expectations downward, while those without the prior knowledge revise the expectations upward by a small magnitude on average.

Table 8: Treatment effects of FOMC wording, voice and body language on house price expectations

	House price expectations					
	Main wave			Follow-up		
Revision	(1)	(2)	(3)	(4)	(5)	(6)
Treatment exposure						
Text	1.286***	0.620*	0.926***	1.163***	0.803**	1.046***
	(0.346)	(0.357)	(0.333)	(0.386)	(0.408)	(0.385)
Voice	1.475***	1.397***	1.113***	1.149**	1.091**	0.997**
	(0.470)	(0.466)	(0.401)	(0.479)	(0.477)	(0.417)
Body	1.946***	1.962***	1.855***	1.432***	1.481***	1.307***
	(0.525)	(0.524)	(0.464)	(0.517)	(0.517)	(0.461)
Shock		-0.422***	0.605***		-0.232**	0.496***
		(0.118)	(0.105)		(0.117)	(0.119)
Shock × Knowledge of interest rate-house price channel			-2.655***			-1.818***
			(0.213)			(0.207)
Knowledge of interest rate-house price channel			0.976***			2.192***
			(0.311)			(0.337)
Constant	-3.181	-3.399	-1.604	-3.258	-3.403	-2.153
	(2.782)	(2.823)	(2.486)	(2.846)	(2.878)	(2.557)
Prior	✓	✓	✓	✓	✓	✓
Demographics	✓	✓	✓	✓	✓	✓
Observations	2,000	2,000	2,000	1,494	1,494	1,494
R-squared	0.09	0.10	0.28	0.10	0.11	0.26

Notes: robust standard errors are in parentheses. ***, **, * denote statistical significance at 1, 5 and 10 percent levels.

4.4 Association between signal evaluations and house price expectations

To understand the differential effects of speech wording, tone of voice, and body language, we use respondents' answers to the structured questions regarding their evaluations of the signals conveyed by these speech components.[17] For instance, respondents who view the video are asked, *"In your opinion, what signal does his facial expression or body language*

[17]To be specific, the script treatment group is asked about their evaluation of the signal sent by the wording/script of the speech. The audio treatment group is asked to evaluate the signal sent by both wording/script and voice tone of the speaker. Finally, the video treatment group is additional asked about the signal sent by body languages of the speaker.

send regarding the future US economy?" The options are "Very negative signal", "Somewhat negative signal", "Neutral signal", "Somewhat positive signal" and "Very positive signal", which are coded with values from -2 to 2, respectively, so positive values correspond to positive signal evaluations. Appendix Figure A.8 displays distributions of respondents' signal evaluations of each component. Regarding the wording of the speech script, 41.1% of respondents find it negative, 34.4% find it neutral and 24.6% find it positive. Regarding tone of voice, 39.5% of respondents find it negative, 49.0% neutral and 11.5% positive. Regarding body language, 38.4% find it negative, 56.7% neutral and 4.9% positive. In general, most respondents have non-positive interpretations of all speech components, and are especially unlikely to have a positive interpretation of the speaker's body language.

Table 9: Signal evaluations of FOMC wording, voice tone and body language on house price expectations

	House price expectations					
	Main wave			Follow-up		
Revision	(1)	(2)	(3)	(4)	(5)	(6)
Signal evaluation						
wording	-1.465***	-1.413***	-1.164***	-1.631***	-1.595***	-1.252***
	(0.239)	(0.235)	(0.210)	(0.239)	(0.238)	(0.216)
Voice tone	-2.160***	-2.170***	-1.767***	-1.504***	-1.482***	-1.370***
	(0.411)	(0.405)	(0.357)	(0.421)	(0.420)	(0.371)
Body language	-2.269***	-2.215***	-2.108***	-1.906***	-1.882***	-1.707***
	(0.679)	(0.667)	(0.614)	(0.660)	(0.653)	(0.604)
Shock		-0.636***	0.318***		-0.412***	0.239**
		(0.103)	(0.095)		(0.102)	(0.106)
Shock × Knowledge of interest rate-house price channel			-2.460***			-1.638***
			(0.201)			(0.195)
Knowledge of interest rate-house price channel			0.596**			1.761***
			(0.301)			(0.323)
Constant	3.154	2.432	3.181	-0.294	1.029	1.490
	(2.620)	(2.694)	(2.432)	(0.360)	(2.673)	(2.437)
Prior	✓	✓	✓	✓	✓	✓
Demographics	✓	✓	✓	✓	✓	✓
Observations	2,000	2,000	2,000	1,494	1,494	1,494
R-squared	0.18	0.20	0.35	0.20	0.22	0.34

Notes: robust standard errors are in parentheses. ***, **, * denote statistical significance at 1, 5 and 10 percent levels.

Table 9 reports the association between signal evaluations and revisions to house price change expectations, controlling for the impact of the information shock and prior knowledge, as well as demographic characteristics. Respondents' evaluations of all three speech treatment components - wording, tone of voice, and body language - are significantly and negatively associated with revisions to house price expectations. For instance, if respondents find the signal conveyed by the body language of the speaker more negative, they

meaningfully revise their house price expectation upward more aggressively. It holds true for the signal from the wording and voice tone as well. This negative association between signal evaluations and house price (or general price level) expectations might be explained as follows.[18] First, during this period of high inflation, in his speeches, Chair Powell explains that the aim of the Fed's rate hikes is to bring inflation back down to its 2 percent target. Respondents who interpret the wording, tone of voice, or body language as negative likely believe inflation is still not under control (i.e. far above its target) and, as a result, might revise their house price and inflation expectations upwards following a perceived negative signal. Second, at the end of the survey, we directly asked respondents whether higher house prices would make them (or their family) better or worse off. Around 60% of respondents answered that they would be worse off with higher house prices. These respondents might associate negative signals with negative events, i.e. higher house prices in future.

5 Discussion and Conclusion

The paper provides new evidence on how US consumers' house price expectations respond to interest rate changes and communication about interest rate changes. We have shown that on average, expectations of national house price growth are affected little by communication about current and future interest rates. However, there is significant heterogeneity across households groups with different demographic characteristics and personal experience and knowledge. For instance, more educated consumers and mortgage payers tend to revise house price growth expectations downward following interest rate hikes, while others tend to revise upward or predict little changes.

Communication about interest rates has much larger effects on house price expectations when combined with a simple explanation of the mortgage rate channel. This is especially the case for less-educated households and non-mortgage payers, and suggests that central bank communication has more predictable effects when the recipients of the communication have knowledge of key mechanisms at play. We have also shown that personal experiences, such as experiences of paying a mortgage, are closely associated with the mechanisms that come to mind when a respondent considers the effects of monetary policy on house prices. This is consistent with a larger literature that highlights the crucial role of personal experiences in expectations formation.

[18] We also find similar association between signal evaluations and inflation expectations. See Table A.10 in Appendix. We cross-validate our results using the dataset of Michigan Surveys of Consumers (MSC). In MSC questionnaires, two questions are asked: "ECONOMY GOOD/BAD NEXT YEAR - Now turning to business conditions in the country as a whole -- do you think that during the next 12 months we'll have good times financially, or bad times, or what?" and "PRICES % UP/DOWN NEXT YEAR - By about what percent do you expect prices to go (up/down) on the average, during the next 12 months?" The evidence from MSC also suggests that there is significantly negative association between evaluation of future economy and inflation expectation: if respondents believe future economy is going to be bad, they would generally believe inflation would be higher. Higher expected inflation could result in higher expected house price growth, as we have shown in Wave 2 survey in Section 3.4.

We note that even when mechanisms are explained, communication about interest rate changes may have a smaller effect on consumer expectations than common models would predict. Most empirical studies find that 1 p.p. increase in the federal funds rate leads to 5.7% – 10.4% fall in house prices after two years (see Table 1 of Williams (2016)). Similarly, Fuster and Zafar (2021) show that the semi-elasticity of house prices with respect to mortgage rate changes in user cost models imply that when the mortgage rate is 5.5%, a 1 p.p. increase in the mortgage rate reduces house prices by 5.3% to 8.5%. This semi-elasticity is generally a decreasing function of the mortgage rate in this type of model, so a 1 p.p. mortgage rate hike should have an even larger effect on house prices when the initial mortgage rate is lower. At the time of our Wave 1 survey, the mortgage rate was 3.9%, implying that a 1 p.p. interest rate hike should reduce house prices by 5.8% to 9.9%, and a 3 p.p. hike should reduce house prices by at least 17%, assuming mortgage rates move one-for-one with the federal funds rate. Our results in Wave 1 and 2 show that consumer expectations of house prices do not respond nearly as much as actual house prices. In the hypothetical vignettes, for example, we find that a 1 p.p. unexpected increase in federal funds rate reduces house price expectations by just 1.1%.

Finally, we have provided additional evidence, supplementing recent work by Gorodnichenko, Pham, and Talavera (2022), that consumers respond to their own interpretation of the tone of voice and visual appearance of policymakers, and not just the words that they say. Outside of the experimental setting, consumers who are exposed to central bank communications via different media formats– text, audio, or video– may revise their expectations by different magnitudes.

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