# Memory & Beliefs: Evidence from the Field*

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**Abstract**

We propose a unique setting to test regularities about the recall of economic signals and the formation of subjective economic expectations in the field. For a large sample of US households, we observe the full set of prices and price changes of grocery goods purchased over a calendar year (*memory databases*) as well as their present-day recalled and expected inflation. Consistent with selective recall, observing fewer and larger (more salient) price changes leads to recall and expect higher inflation. We find evidence of proactive interference, whereby agents mistakenly recall older prices and hence lower prices than they actually paid, and retroactive interference, whereby agents rely less on the price changes stored in their memory database to form beliefs if other contexts associated with prices are cued exogenously. Our results support models of beliefs formation in which memory is a cognitive microfoundation.

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# I Introduction

After the rational-expectations revolution of the 1970s, which introduced the notion of full-information rational expectations (FIRE), economists have lost interest in studying realistic processes for the formation of perceptions and beliefs about economic variables either theoretically and empirically, despite the fact that modeling real-life mechanisms driving expectations and choices was an important agenda in economics at least since the 1950s (for instance, see Simon (1955)). Over the last two decades, though, economists have documented major violations of FIRE across a broad set of economic choices by consumers, firms, and financial institutions both in the field and in controlled environments (for instance, see Coibion and Gorodnichenko (2015)).

These violations of FIRE are not noise that washes out in equilibrium, but have been shown to produce aggregate macroeconomic effects (for instance, see Shiller (2000); Gennaioli and Shleifer (2018); D'Acunto et al. (2021); Gaballo and Paciello (2021)), which stresses the importance of studying the drivers and mechanics of the process of beliefs formation to better understand business cycles and design more effective fiscal and monetary policies. Approaching this question faces a major hurdle—the need of a disciplining framework that provides guidance and testable predictions so that that this research endeavor does not turn into what Eugene Fama famously labeled a "fishing expedition."

In this paper, we build on research in cognitive psychology to provide such a disciplining framework. We test in a field setting and with observational data a set of predictions on the processes by which human memory recalls observed signals to form beliefs deriving from regularities that cognitive psychologists have documented in laboratory settings. The bulk of our tests are based on the cognitive theory of human memory described in the comprehensive textbook treatment of Kahana (2012), some of whose features have been recently modeled and tested in economics and proposed as potential drivers of the process of beliefs formation in the field (for instance, see Mullainathan (2002); Gennaioli and Shleifer (2010); Bordalo, Gennaioli, and Shleifer (2017); Bordalo et al. (2021); Bordalo et al. (2021); Afrouzi et al. (2021), Wachter and

Kahana (2019); Malmendier and Wachter (2021) among others).

Our field setting is unique in that we can observe directly, for each agent in a representative sample of US households, a set of signals about prices we know she has seen over time as well as her recall about such price signals and her beliefs about future inflation and other macroeconomic variables, which we elicit directly in a novel survey. We observe signals about prices through scanner data that agents in the Nielsen homescan panel provide after each shopping trip. Because decision makers in this setting scan each grocery item they purchase every time they do the groceries, we know for a fact that they have seen each price signal at least once when scanning, and possibly twice if they saw the prices also while grocery shopping. This setting thus allows the econometrician to define agent-level information sets about price signals, which, for simplicity, we label *memory databases*.

Accessing this level of detail about actual price signals agents saw in the recent past allows a step further relative to the literature on experience effects, which typically studies how major economic shocks that all agents belonging to a certain cohort are assumed to have witnessed relate to their economic decisions, and compares agents from cohorts that were exposed to such shocks with unexposed agents. In our setting, experiencing a specific signal is not confounded with other dimensions that vary systematically across cohorts, such as having experienced any other shocks and events common to the same cohort that can be barely disentangled from the specific shock of interest.[1] We have direct measurement of memory databases that vary across individuals, including those who belong to the same cohort and form beliefs at the same point in time and in the same locations, and hence we can relate these individual-level databases to individual-level recall and beliefs.[2]

As a first step, we describe a set of cross-sectional properties of memory databases, which relate their size—the number of prices and price changes across subsequent shopping

[1]Malmendier and Nagel (2015) solve this identification problem by exploiting different directional predictions of the effects of experiences on cohorts over time, which though requires to observe long time series of beliefs and choices in a cross section of decision makers.

[2]The main drawback of our setting relative to a laboratory experiment is our inability to control and vary randomly the data generating process of the signals decision makers observe, which is common to any observational setting.

trips agents have observed over the 12 months before the survey. Agents who have smaller memory databases for price levels and price changes observe systematically fewer zero price changes, larger positive price changes, and a higher fraction of positive over negative price changes. All three facts are consistent with the literature on retailers' pricing strategies at high and low frequencies in macroeconomics and marketing (Nakamura and Steinsson, 2008; Eichenbaum et al., 2011).

Using these properties, we test a set of regularities about *selective recall*, whereby memory databases are not available at all times to agents, who cannot recall all the signals they have observed as if they were opening a data folder in a computer. Rather, agents recall imperfectly only some of the observed signals. Based on the properties of memory databases, agents who have smaller memory databases should, ceteris paribus, recall larger price changes, which is what we find in the data. This feature only arises for agents who declare that they do not obtain information about economic variables from traditional and social media sources and is stronger for women, whom earlier research finds have inflation expectations that are more correlated with the inflation they observe in their grocery bundles relative to men (D'Acunto et al. (2021b)).

We then move on to test the role of two fundamental features of selective recall—*salience* and *context dependence*. Salient price changes are those that are most surprising, such as those that are farther away from the status quo of zero price changes. Salience implies that, when agents are asked to recall past inflation, salient price changes stored in memory databases should be more likely to come to mind, whereas less salient price changes barely come to mind. We therefore test whether agents who observed many large and positive price changes are more likely to recall the price changes they have stored in their memory databases relative to agents who observed small price changes. We find that, indeed, the association between the price changes agents have stored in their memory databases and their recalled inflation is economically and statistically larger for agents who belong to the top of the distribution based on the average size of the price changes in memory databases, whereas the association is small for agents who have mostly stored small price changes in their memory databases.

Context dependence states that signals observed in a certain contextual environment are more likely to be recalled if the same contextual environment is cued during the recall process, and retrieving a context cues subsequent recalls (Howard and Kahana (1999)). To test for this property of recall in our observational setting, we compare the extent to which the price changes stored in memory databases come to mind to two groups of agents. The groups are formed based on the number of stores in which agents have shopped over the previous 12 months, which represent different environmental contexts in which prices and price changes were observed.

Our rationale is based on the role of context cues in associative memory and recall studied by Enke, Schwerter, and Zimmermann (2020). In our setting, when agents who always shop in the same store are asked to recall past inflation, a single contextual environment associated with all the price signals in their memory databases is cued, and hence more price changes in their memory database might come to mind. Instead, for agents who shop in many stores, asking to recall past inflation does not cue a single context. It might either cue only one of the multiple grocery stores the agent attended, to which only a fraction of the price changes in her memory database are associated, or might not cue any specific environment at all. Overall, agents who shopped in one single store should form a recall of past inflation that is more highly correlated with the price changes in their memory databases relative to other agents.

We find evidence consistent with context dependence, in that indeed the association between the average price changes in memory databases and recalled inflation is substantially higher, both economically and statistically, for agents who shopped in a single store over the 12 months before the survey than for others.

Beyond understanding the process of recall in the field, our paper aims to assess whether systematic cross-sectional differences in recall contribute to explain the large cross sectional variation in beliefs about general inflation. This aim speaks to a recent agenda that studies the role of systematic cognitive regularities in understanding beliefs formation (e.g., see Enke and Graeber (2019); Enke, Schwerter, and Zimmermann (2020)).

Expected general inflation is the variable that, according to standard models of intertemporal consumption optimization, should drive households' consumption-saving choices via the Fisher equation (higher general inflation expectations lead to lower perceived real interest rates if nominal rates are stable) and the consumer Euler equation (lower perceived real interest rates reduce agents' willingness to save and increase their willingness to consume).

We find that agents who have smaller memory databases and hence recall higher past inflation also expect higher inflation going forward. Moreover, once we add both the size of memory databases and recalled inflation as explanatory variables for expected future inflation, the correlation of database size with beliefs drops, which suggests that the size of memory databases and unobserved characteristics that might correlate with it do not provide predictive power for inflation expectations above and beyond what is captured by recalled inflation.

The predictions of selective recall for perceived inflation and beliefs formation could be consistent with several theoretical models of expectations formation in economics, including rational inattention models and other frameworks in which agents form beliefs optimally conditional on attention constraints and/or the costs of gathering unbiased information. We thus move on to assess two unique and falsifiable testable predictions from the imperfect memory framework, which we bring to field data in the third part of the paper—*proactive* and *retroactive interference*.

Proactive interference refers to result that information agents have stored in their memory databases before the time period over which they are trying to recall often comes to mind during the imperfect recall process, thus interfering and potentially leading the agent to mistakenly recall older information than the one he/she was trying to recall (Anderson and Neely (1996), Baddeley and Logie (1999), Unsworth et al. (2013)). In economics, Bordalo et al. (2022) show evidence about differences in recall across age groups during the COVID-19 pandemic that are consistent with older agents having more information stored in their memory databases than young agents, thus recalling differently and forming systematically different beliefs.

Proactive interference is quite important for the case of recalling price levels and price changes, because prices tend to increase over time and especially at medium and low frequency. For this reason, price levels stored in memory databases before the time period the agent tries to recall tend to be lower than the ones the agent should recall, and hence agents might recall systematically higher past inflation than what they truly observed. Proactive interference might thus help to explain one of the most robust facts about consumers' inflation expectations around the globe—on average, they display a systematic upward bias in inflation expectations (Weber et al. (2022); D'Acunto et al. (2022)).

We find that the agents in our setting indeed tend to recall systematically lower price levels at a specific past point in time (12 months earlier) than the actual price levels we see them having paid at the same point in time. We also find that agents who recall lower price levels indeed tend to recall higher past inflation and at the same time expect higher inflation going forward.

The second form of interference we study, retroactive interference, states that information that came to mind recently, even if from a cued context different from the one the agent is asked to recall, interferes with the recall of older information about the context the agent is trying to recall (). Economists have studied this form of interference over the last few years (for instance, see ).

To assess this feature in our setting, we designed a randomized control trial within our survey. Specifically, early in the survey, we randomly cued half of our respondents with a gas station context, that is, a context different from grocery stores in which agents are also saliently exposed to prices and prices changes. We test whether cuing agents with a price-related context different from grocery stores reduces the likelihood that agents use their recalled grocery inflation, which is based on the grocery price changes in their memory databases, when forming beliefs about future inflation.

Even if our randomized cue is early in the survey and not close to the questions about expected and perceived inflation or recall of past inflation, agents cued with gas stations make substantially lower use of recalled grocery inflation when forming their expectations about future inflation. We also verify that this reversal of the baseline positive association between recalled grocery inflation and inflation expectations is driven by cued agents in the demographic groups that tend to make higher use of recalled grocery inflation when forming beliefs—women and agents who do not gather information about price changes from the media.

Overall, our results provide field evidence consistent with a set of regularities in the process of recall of past information about price levels and price changes proposed by experimental research in cognitive psychology. These regularities also contribute to explain the large cross-sectional variation in beliefs about future price changes (inflation). Our results suggest that the cognitive processes underlying imperfect human memory might represent a viable microfoundation for new generation models of beliefs formation in economics.

# II Data

The novel source of data we employ in this paper is a new wave of the *Chicago Booth Expectations and Attitudes Survey*, which we fielded online in January 2022. We invited participation by all household members of the *Kilts-Nielsen Consumer Panel* (KNCP). We also rely on the KNCP for all the information related to households' non-durable consumption baskets and the prices they paid. Below, we describe the characteristics of these two data sets with a focus on the new survey our paper introduces to the literature.

## *A.* Kilts-Nielsen Consumer Panel (KNCP)

The KNCP is a panel of about 40,000-60,000 households. These households report two types of information to Nielsen. First is their static demographic characteristics, such as household size, income, ZIP code of residence, and marital status. The second type of information panelists report is the dynamic features of their purchases. These features include categorizations of the products they purchase, information on the outlets at which the products are purchased, and information about the per-unit price households pay for each item. To avoid measurement and reporting errors, each panelist obtains an optical scanner at home that is similar to the scanners grocery stores use to read barcodes. After each shopping trip, panelists scan the goods they purchased. The system then asks the panelist for the quantity. If the panelists purchased the good at a store for which Nielsen has a point of sales information (POS), the system automatically uses the average price for the UPC during the week of purchase to minimize the data-entry burden for the panelist. If the panelist shopped at a store without POS information, the system asks for the price of the goods before any discounts or coupons are applied. Lastly, the system asks the panelist to indicate explicitly whether the good was purchased on discount and the amount of the discount.

The KNCP contains 1.5 million unique products. The goods in the datasets include groceries, drug products, small appliances, and electronics. The sample period for which Nielsen has detailed purchase information from households cover the years 2004-2021. Geographically, the sample spans through 52 major consumer markets and nine census divisions. Nielsen estimates the dataset covers approximately 30% of overall household consumption in the US. For more details on the data, please refer to Kaplan and Schulhofer-Wohl (2017) and Argente and Lee (2017).

## *B.* Chicago Booth Expectations and Attitudes Survey

Nielsen runs short surveys on a monthly frequency on a subset of panelists of the KNCP, the online panel, but also offers customized solutions to corporations and research institutions for designing longer ad hoc surveys.

During the Spring of 2015, we designed the first wave of a customized survey consisting of 44 questions in cooperation with Nielsen—the *Chicago Booth Expectations and Attitudes Survey* (CBEAS). A central feature of the survey is that we target all household members of the KNCP. The survey consists of three sections, which build on the Michigan Survey of Consumers, the New York Fed Survey of Consumer Expectations, the Panel on Household Finances at the Deutsche Bundesbank, as well as the pioneering work of de Bruin et al. (2011) and Cavallo, Cruces, and Perez-Truglia (2017). Early waves of the CBEAS have been used in earlier research (for instance, see D'Acunto et al. (2021a); D'Acunto et al. (2021b); and Coibion et al. (2022), among others).

The first section of the survey asks a series of questions about respondents' demographic characteristics.

The second section of the survey contains questions on respondents' expectations about prices and inflation. For general inflation, we randomize between two sets of questions. The first set follows the design of the Michigan Survey of Consumers (MSC), and asks survey participants about the prices of things on which they typically spend money. The second set of questions uses a design inspired by the New York Fed Survey of Consumer Expectations (SCE), and asks specifically about inflation. We first ask individuals about their perception of past inflation, that is, inflation over the previous 12 months. We then ask them about their expectations for 12-month-ahead inflation.

The novel CBEAS wave studied in this paper was fielded in January 2022. It was tailored to assess the role of memory and recall in the formation of economic beliefs. To this aim, in addition to the original survey sections described above, we asked respondents to report their recalled inflation and price level of a specific grocery good—milk—over the previous 12 months. We focused on milk because earlier research has found that the majority of a representative set of US households reports thinking about milk when asked about their perceptions and beliefs about general inflation (D'Acunto et al. (2021b)). We can compare the recalled milk inflation and milk price level 12 months before the survey with the actual price changes of milk respondents saw in their consumption bundles across their shopping trips over the previous 12 months and the price levels of milk they actually paid, both of which we observe directly.

One might be concerned that respondents anchor their answers about price changes across questions within the survey, that is, after reporting a value for perceived general inflation they report similar values for expected inflation and recalled milk inflation. This concern will be dismissed by the hypotheses about memory and recall we bring to the data, which have specific cross-sectional predictions regarding the types of respondents for whom the strength of the correlation between recalled milk inflation, perceived, and expected general inflation should be higher. We cannot see any compelling reason why the tendency to anchor answers within surveys would vary systematically along the same exact pre-specified demographic characteristics that imply different processes of recall. Moreover, we will test predictions about how different types of price changes respondents have observed in their grocery bundles relate to a higher or lower correlation between recalled milk inflation and expected general inflation. Even here, there is no reason why the tendency to anchor should vary systematically based on the same types of observed price changes.

## *C.* Summary Statistics

We report a set of summary statistics for the main dependent and independent variables in our analysis in Table 1. We describe the full sample that enters the analysis, which includes respondents in the January 2022 CBEAS wave for whom we have no missing information about demographic characteristics and other variables. To avoid the possibility of severe outliers driving any of our results, we winsorize all continuous variables at the 1% and 99% levels.

We first provide statistics for price-change variables. The average respondent expects a one-year-ahead inflation rate of 11.46%. The average recalled milk inflation is substantially higher (18.93%) and varies more across subjects, with a standard deviation of 24.11%. This difference is not just driven by a set of outlier respondents, because even the two medians are quite different—7% for expected general inflation and 10% for recalled milk inflation.

The average price change of milk across subsequent shopping trips is 0.01% with a range that includes a negative minimum (-0.96%) and a positive maximum that is larger in absolute value (2.02%). As we will see below, the distribution of price changes observed by respondents across shopping trips is asymmetric around zero and exposure to large price increases will be important to understand households' recalled and expected inflation. We also find that about 16% of our respondents shopped for milk in only one single store in the 12 months before the survey.

In terms of demographic characteristics, men constitute slightly less than a third of the sample, which is in line with the gender distribution of earlier CBEAS waves. We observe a set of demographic characteristics not in levels but in intervals: half of the respondents belong to the top 5 income group out of a split across 27 intervals, which suggests that our respondents tend to have higher incomes than the general US population. Moreover, respondents tend to be older and the fraction of retirees is higher than in the general population—only 41% of our respondents are in the labor force. Finally, our sample is more educated that the general US population, because 39% of our respondents have a college degree, and the vast majority are White (87%). All these demographic characteristics are not only in line with earlier waves of the CBEAS but also with the average demographics of households that cooperate with Nielsen AC and have been studied by other researchers (e.g., see Kaplan and Schulhofer-Wohl (2017)).

Overall, our survey respondents appear to be more educated and wealthier than the average US individual. These features of the survey population are important, because researchers have criticized household surveys asking about inflation expectations on the basis that too many households do not know or understand the concept of inflation. To the extent that higher education is related to a higher understanding of concepts such as inflation (see D'Acunto et al. (ming)), our pool of respondents is less prone to this criticism.

# III Memory Databases

In this paper, we define *memory databases* of prices or price changes the collection of the prices or price changes of the goods agents purchase in each shopping trip over the 12 months before they are surveyed. Agents can assess price changes by comparing the price paid in a shopping trip with the one paid for the same good in the most recent previous trip, which we as econometrician can compute. Memory databases thus represent the overall set of signals about prices agents can observe and infer from one shopping trip to the next.

We do not argue that all entries of memory databases are available to agents at all points in time, as if they were data items stored in a folder of a computer's memory. Rather, below we assess various regularities about agents' imperfect recall of signals that have been documented in laboratory studies by cognitive psychologists and, more recently, economists. Memory databases should be intended as abstract objects that we can fully observe as econometricians but that are not necessarily fully observed and/or fully accessible to agents.

## *A.* Properties of Memory Databases

Memory databases vary systematically across agents. In particular, the *size* of memory databases by construction depends on how often agents shop. The memory databases of agents who shop more often will contain more price changes than the memory databases of agents who shop less often over the same period of time.

We discuss a set of features of memory databases based on their size through an illustrative example that compares two agents in our data (see Figure 1) as well as across all agents in our data (see Figure 2). To make the illustrative example easier to follow, we focus on the price changes of the most commonly purchased good in our sample (milk) across subsequent trips rather than displaying the price changes of all goods (D'Acunto et al. (2021b)).

First, agents who have larger memory databases should store more zero price changes in them, because prices only change at medium and low frequency (Eichenbaum et al., 2011). Our example of Figure 1 compares the price changes of milk observed by an agent who purchased milk about once a month (12 times in a year, Panel A) and an agent who purchased it about every other day (172 times in a year, Panel B). Black bars represent the number of times each agent observed no price change of milk across subsequent trips in which they purchased milk. And, indeed, we see that the first agent observed zero price changes only twice, that is, 17% of the times he/she shopped. Instead, the second agent observed zero price changes 147 times, that is, 85% of the times he/she shopped.

This property is a regularity of our full sample, as can be seen in Panel A of Figure 2, which is a scatterplot of the number of zero price changes of milk agents observed across subsequent trips (y-axis) against the number of shopping trips they made over the previous 12 months (x-axis). The number of zero price changes is quite low for agents who shop less than once a week, i.e. less than 52 times per year, and increases with the number of yearly shopping trips. This relationship is monotonic and non-linear: agents who shop more often appear to observe an increasingly higher proportion of zero price changes over total price changes, which is consistent with our illustrative example.

A second property derives from results in marketing, IO, and macroeconomics showing that at high frequencies prices fluctuate up and down due to temporary sales, discounts, and offers, whereas at lower frequencies price changes tend to be positive (Nakamura and Steinsson, 2008). We would therefore expect that agents with smaller memory databases tend to observe a higher fraction of positive price changes over all non-zero price changes, and that this fraction declines towards 50% for more frequent shoppers. Our example in Figure 1 is consistent with this pattern: the small-memory-database agent observed 6 positive price changes and 4 negative price changes, i.e. the ratio of positive price changes over non-zero price changes was 60%. Instead, the large-memory-database agent observed 13 positive and 12 negative price changes—the ratio was 52% for this agent. Again, we find evidence consistent with this property also when looking at the full sample (Panel B of Figure 2), which plots the fraction of positive price changes over all non-zero price changes in the memory databases of the agents in the sample against their number of yearly shopping trips. The relationship is negative, monotonic, and non-linear, and appears to converge to 50% as the number of yearly shopping trips increases.

The third property we consider is that, even when excluding zero price changes, which drive the average observed price change to zero by construction, we would expect that agents who have a larger memory database register, smaller price changes in either direction. This is because they are more likely to observe every marginal change in the prices of the goods they typically purchase. We find supporting anecdotal evidence in the example of Figure 1, whereby the frequency of price changes close to zero appears to be the same as that of price changes farther away from zero for the agent with a small memory database, whereas these frequencies are higher for smaller price changes around zero in both directions (ranging from 2 to 3 observations) and lower for larger price changes (never more than 1 observation) for the agent who shops often. Panel C of Figure 2 provides more systematic evidence from the whole sample. It plots the average absolute value of price changes of milk in agents' memory databases against the number of yearly shopping trips. We excluded zero price changes here to avoid the mechanical result discussed above. Consistent with the third property, the average absolute price change is about 30 cents for infrequent shoppers and declines monotonically and non-linearly as we move to agents that shop more often.

In the rest of the paper, we make use of these three properties to assess predictions of the limited memory framework by comparing agents with larger and smaller memory databases. This is only meaningful if the size of memory databases varies substantially across agents. The plots in Figure 2 do not provide the mass of agents across each bucket of the number of yearly shopping trips. We show in Figure 3 a fourth property of memory databases: the distribution by size is quite varied. Although the relative majority of agents shops about once a week (52 yearly shopping trips), non-negligible masses of agents exist throughout the distribution.

# IV Selective Recall

After having described memory databases, we assess whether agent use such databases to form their perceptions and beliefs about price changes in line with a set of regularities of the process of imperfect recall of signals documented by the cognitive psychology literature.

## *A.* Memory Databases and Recalled Price Changes

We start from the notion of *selective recall*, based on which agents do not recall at once all the signals to which they were exposed in the past—the full memory database, based on our terminology—as if they were opening an Excel file saved on a computer, but only recall selected signals. The very fact that some information about past signals is not available to agents implies that agents should not be able to form a perception about average past price changes that aligns exactly with the price changes they observed. Rather, agents will form a perception that is biased in the direction of the subset of signals that come to mind.

Specifically, the literature on cognitive psychology documents three regularities about the ways agents use signals stored in their memory databases for recall in laboratory experiments, which we label *correlation*, *salience*, and *context dependence*.

First, and intuitively, recalled information should correlate with the actual signals stored in agents' memory databases. In our case, verifying this basic feature is important for two reasons. On the one hand, it allows us to establish the consistency between information we collected at different points in time and in different contexts. Because most research so far has compared signals and recall within the same laboratory experiment, i.e.

signals are provided in the same setting and context in which recall happens, establishing a relationship between field-based measured signals and survey-based elicited recall is a crucial step to support the validity of our field exercise.

On the other hand, this regularity allows us to lever the properties of memory databases to predict agents' recalled inflation. Smaller memory databases include fewer zero price changes, a higher ratio of positive price changes, and larger price changes, on average. Agents who have smaller memory databases for the price changes of milk should thus on average recall higher milk inflation, because larger positive milk price changes should come to mind more to them during the recall process.

Starting with the raw data, Panel A of Figure 4 is a scatterplot of recalled milk inflation over the previous 12 months against the average price change of milk the agent has stored in her memory database over the same period of time, and denotes a positive association between these two dimensions, which is consistent with the conjecture that memory databases do include price change signals that are available to agents when recalling the price change of milk.

We then move on to test whether smaller memory databases correlate with higher recalled inflation in Table 3, where we estimate the following specification by OLS:

$$Recalled\ Milk\ \pi_i = \alpha + \beta Small\ Memory\ Database_i + X_i'\psi + \epsilon_i, \tag{1}$$

where $Recalled\ Milk\ \pi_i$ is the milk inflation agent $i$ recalls in the survey (after being asked about expected general inflation in a non-adjacent section of the survey); $Small\ Memory\ Database_i$ is a dummy variable that equals 1 for agents who have fewer than 52 price changes in their memory databases, i.e. they grocery shop less than once a week, on average, and zero otherwise; and $X_i$ is the set of individual-level demographic characteristics we observe, for which we control non-parametrically and which include: income dummies (30 groups), household size dummies, age dummies (10 groups), number of children dummies, employment status dummies, education level dummies, race dummies, dummy for Hispanic ethnicity, county size dummies (4 groups), and Census region dummies.

Consistent with our conjecture, in columns (1)-(2) of Table 2, we find that agents who hold smaller memory databases tend to recall a higher milk inflation relative to other agents, and the estimated conditional correlation is if anything higher when we keep constant the rich set of demographics we observe relative to the unconditional correlation. This result reduces the concern that relevant unobserved characteristics that might correlate systematically with the size of agents' memory databases and shape their recalled milk inflation drive the results, although of course we cannot make any definitive statement in the absence of quasi-exogenous variation in the size of agents' memory databases.

To further reduce the concern, in the rest of Table 2 we propose three heterogeneity tests. We split our respondents in groups based on the extent to which they might consider signals different from the price changes of milk in their memory databases when asked to recall milk inflation. In columns (3)-(4), we compare men and women, because D'Acunto et al. (2021b) find that women, who are the main grocery shopper in the majority of US households, are more likely to indicate they think about milk price changes than men. We find that, indeed, the association between having a small memory database is economically and statistically significant for women but not for men. Moreover, in columns (5)-(6) we compare agents who, within our survey, state that they search for information about economic variables through the media (newspapers, TV, internet) with those who state that they do not. Even in this case, the association between the size of memory databases and recalled milk inflation is higher for the group that is less exposed to signals about economic variables other than those in their memory databases. Finally, in columns (7)-(8), we compare agents who state that their main source of signals about economic variables is own shopping with agents who do not—the estimated association is higher for the former group.

### *A.1* Salience and Context Dependence

Under selective recall, more salient signals are more likely to become available to agents during the recall process relative to less salient signals. A signal about price changes is salient if it stands out relative to the status quo of no change (zero price change). Large price changes are, by definition, the farther away from zero price changes and hence should be more salient than small price changes. For this reason, under selective recall, milk price changes stored in the memory database should come to mind more easily to agents who have been exposed to more salient price changes. Instead, for agents who have been exposed to non-salient price changes, such price changes should be less likely to come to mind during the recall process. Ultimately, the correlation between the average price changes in an agent's memory database and recalled inflation should be high for agents whose memory databases include more salient price changes.

Before assessing the role of salience, we need to verify that the correlation between the average price changes agents stored in their memory databases and their recalled inflation at the time of the survey is positive. We do so in columns (1)-(2) of Table 3, where we estimate a version of equation (1) in which we replace the indicator for small memory databases with the average price change of milk observed by agent $i$. And, indeed, we find that agents who stored on average higher milk price changes in their memory databases tend to recall higher milk inflation over the previous 12 months relative to others. The size and statistical significance of this association barely change when we condition on demographics.

We then split our cross section of agents into four equal-sized groups based on the average price change of milk stored in their memory databases. Because of salience, our conjecture is that observed price changes should be more likely to come to mind during recall for agents who observed the largest price changes, on average. By contrast, agents who observed small price changes, which are not as salient, should be less likely to think about those price changes during the recall process. Therefore, the correlation between the price changes in memory databases and recalled milk inflation should be highest for agents in the top quarter based on the average size of price changes in memory databases, and should be weaker for agents in lower quarters.

We test this conjecture in columns (3)-(4) of Table 3, where the covariates of interest are dummies for the quarter of the distribution of average milk price changes to which each agent belongs. The first quarter—the bottom 25% of agents, who observed the smallest price changes of milk, are the omitted category. We find that the positive association between recalled milk inflation and milk price changes stored in one's memory database is larger, both economically and statistically, for agents who belong to the top quarter of the distribution relative to those in the bottom quarter. We detect a barely statistically and economically significant higher correlation for agents in the third quarter, while for those in the second quarter the correlation is similar to the correlation for agents in the bottom quarter.

Finally, we consider the third regularity of selective recall documented in the laboratory—context dependence. Context dependence states that signals observed in a certain contextual environment are more likely to be recalled if the same contextual environment is cued when the recall process happens.

In the next section, we will study the effects of randomly cuing a context different from grocery stores on the extent to which agents use the milk price changes stored in their memory databases to recall past inflation.[3] In this section, instead, we propose an empirical test based on comparing agents whose memory databases are formed of price changes that were all observed within the same exact context—agents who have always purchased milk in the same store over the 12 months before they took part in our survey—with agents whose memory databases comprise price changes observed in several stores, and hence in different contexts.

We base this test on the intuition that the action of asking agents to recall milk inflation might cue the context in which milk is purchased, i.e., the grocery store (Enke et al. (2020)). For agents who always shop in the same store, this action cues only one contextual environment to which all the observed price change signals are associated. Instead, for agents who shop in several stores, asking to recall milk inflation does not cue a single contextual environment. It might either cue only one of the multiple grocery stores the agent attended, to which only a fraction of the price changes in her memory database are associated, or might not cue any specific environment at all. In either case, the average price changes recorded in agents' memory databases should be more highly correlated with recalled milk inflation for agents who shopped in one single store relative to other agents.

[3] As we discuss below, we do not describe this test here because we will use it as a field assessment of the notion of *retroactive interference* in recall.

In columns (5)-(8) of Table 3, we estimate the conditional correlation of average price changes in agents' memory databases and recalled milk inflation separately for agents who bought milk always in the same grocery store (columns (5)-(6)) and agents who shopped in multiple stores (columns (7)-(8)). These two subsamples have different sizes—only 949 agents always bought milk in the same store. Consistent with the conjecture based on context dependence, we find that the correlation between the average price changes observed in memory databases and agents' recalled milk inflation is more than four times as large for single-store shoppers than for others.

## *B.* From Recall to Beliefs

Above and beyond assessing regularities about selective recall, we aim to understand whether the same features of recall also contribute to explain the cross section of expected general inflation. This question is important because in standard models of intertemporal consumption optimization inflation expectations drive households' consumption-saving choices via the Fisher equation (higher general inflation expectations lead to lower perceived real interest rates if nominal rates are stable) and the consumer Euler equation (lower perceived real interest rates reduce agents' willingness to save and increase their willingness to consume).

We first assess in the raw data whether recalled milk inflation, perceived general inflation over the previous 12 month, and expected general inflation over the following 12 months relate to each other. Figure 4 shows strong positive associations between recalled milk inflation and perceived general inflation (Panel B) as well as perceived and expected general inflation (Panel C).

Motivated by these raw-data correlations, in Table 4 we assess the mechanisms through which the properties of agents' memory databases and recall discussed so far might contribute to explain the variation of inflation expectations across agents by estimating the following specification by OLS:

$$\mathbb{E}[\pi_i] = \alpha + \beta Small\ Memory\ Database_i + X_i'\psi + \epsilon_i, \tag{2}$$

where $\mathbb{E}[\pi_i]$ are agent $i$'s reported numerical inflation expectations for the following 12 months and all other variables are the same as if equation (1).

First, because agents who have smaller memory databases recall higher milk inflation, ceteris paribus, in columns (1)-(2) of Table 4 we assess if they also tend to form higher inflation expectations. Indeed, we find that agents whose memory databases are smaller tend to form higher inflation expectations, and this correlation if anything increases once we absorb the demographic characteristics we can observe.

Second, ideally we would want to verify that this correlation is driven by agents' recalled milk inflation rather than potential unobserved characteristics that vary systematically based on the size of agents' memory databases and might shape inflation expectations. In the absence of quasi-exogenous variation, in columns (3)-(4) we add to the right-hand side of the same specification both the dummy for whether agents have small memory databases as well as their recalled milk inflation. Whereas the association between recalled milk inflation and expected inflation is positive and significant, as we would expect based on the raw-data results in Figure 4, the association between the size of memory databases and expected inflation declines and becomes statistically insignificant. Although in no way conclusive in terms of causality, at a minimum this result shows that the size of memory databases and potential unobservables correlated with it do not provide additional predictive power for agents' inflation expectations above and beyond their recalled inflation.

# V Proactive and Retroactive Interference

The predictions of the selective recall framework are not unique and our empirical evidence so far could also be consistent with alternative interpretations. For instance, with models of rational inattention whereby agents only pay attention to economic signals when such signals are readily available and cheap to extract or noisy expectations models. Moreover, the costs of extracting a milk price change signal from two subsequent observations of milk prices might be lower when the price differences are larger and hence attract more attention, which might explain why agents in the top quarter of the distribution based on average price changes of milk use such price changes more when asked to recall milk inflation.[4]

In this section, we move on to consider two predictions of the memory framework in cognitive psychology that are unique to that framework and not included in standard economic models of rational inattention—proactive and retroactive interference. Interference is the phenomenon whereby information that is alien from the one the agent aims to recall comes to mind and makes recall imperfect.[5]

## *A.* Proactive Interference

Proactive interference refers to fact that some information agents have stored in their memory databases before the time period over which they are trying to recall might come to mind during the recall process, thus interfering with recall and leading the agent to mistakenly recall older information than what he/she intended (Anderson and Neely (1996), Baddeley and Logie (1999), Unsworth et al. (2013)). In economics, Bordalo et al. (2022) show evidence about differences in recall across age groups during the COVID-19 pandemic that are consistent with older agents having more information stored in their memory databases than young agents, thus recalling differently and forming systematically different beliefs.

We can assess this possibility directly in our setting, because we asked agents to recall both milk inflation over the previous 12 months as well as the price level of milk in a shopping trip 12 months before the survey. Because we also observe the actual price paid based on agents' grocery bundles, we can compute the mistake in recall as the distance between the recalled price and the actual price paid.

Based on proactive interference, when agents are asked to recall the price level of milk they observed 12 months earlier, the price signals they stored in their memory databases earlier than 12 months before could come to mind during the recall process. Interestingly,

[4] In fact, we do not see this rational-inattention explanation as necessarily alternative to the selective recall framework in cognitive psychology. In fact, it could represent a way to model this framework in mathematical terms.

[5] Economic models of rational inattention could be extended with interference only if one modeled the recall process directly and assumed that the representative agent finds it costly to counteract the effect of interference during the recall process.

for the case of prices, contrary to other potential objects of recall, proactive interference provides a unique prediction in terms of a systematic bias in recall: Because prices tend to increase over time and especially at medium frequency, price level signals stored in memory databases more than 12 months earlier should tend to be lower than those stored 12 months earlier.

Testing this prediction is especially important in the context of inflation recall and beliefs because one of the most robust findings about households' inflation expectations across countries and over time is a systematic positive bias in expected inflation relative to ex-post realized inflation (see, for example, Weber et al. (2022)). Proactive interference represents a realistic feature of the recall process that could contribute to explain this systematic positive bias in recall in the context of prices and inflation.

Panel A of Figure 5 plots the distribution of the difference between recalled milk prices and actually paid milk prices for the agents in our sample. We note two patterns, both of which are consistent with proactive interference. First, the average and modal difference is negative—the majority of the mass of the distribution is in the negative domain. Second, we detect a fat left tail, which has no correspondence on the positive domain: a non-negligible fraction of agents recalls having paid substantially lower prices for milk 12 months earlier than the actual prices they paid.

If proactive interference was a universal feature of recall, we should detect patterns similar to those in Panel A of Figure 5 when we split our agents across demographic characteristics. We perform such splits in Figure A.2, where we plot the distribution of the difference between recalled milk prices and actually paid milk prices across the demographic characteristics we observe. We detect the two patterns described above for both men and women, older and younger agents, college and non-college educated agents, financially literate and illiterate agents, and irrespective of whether the agent is the primary grocery shopper for their household or seldom partakes in grocery chores.

Our paper mostly focuses on recalled price changes rather than price levels, because we aim to map recalled price changes into expected general inflation. For this reason, we also consider the implication of proactive interference for recalled and actual milk inflation. We verify that when asked about the milk inflation they recall to have faced over the last 12 months, agents systematically provide larger values relative to the actual inflation they have faced. Panel B of Figure 5 shows that the distribution of the bias in recalled milk inflation is asymmetric: a larger fraction of agents recalls having faced a higher milk inflation than what they did in fact face in their bundles.

The latter result is consistent with the possibility discussed above that memory, and especially proactive interference, could help explain the systematic upward bias in households' inflation expectations. We provide evidence that supports this conjecture in Panels C and D of Figure 5. Specifically, Panel C is a scatterplot of perceived milk inflation (y-axis) against the difference between recalled and actual past milk prices agents paid. We can see that the relationship is negative, and the agents who recall lower milk prices than the prices they actually paid are also those who perceive higher milk inflation. Panel D shows that this negative association extends to agents' beliefs about general inflation over the following 12 months. Even though the relationship is flatter in this case, we still find that those who mistakenly recalled lower prices of milk relative to the prices they paid are also on average those who expect higher general inflation over the following 12 months.

## *B.* Retroactive Interference

We move on to the second form of interference studied in the memory literature—retroactive interference, whereby information that came to mind recently, even if from a context different from the one the agent is asked to recall, hinders the recall of older information about the context the agent is trying to recall.

Retroactive interference arises endogenously if an agent associates the context whose information they are trying to recall to other contexts. To design a direct test of the predictions of retroactive interference in our setting, we designed a randomized control trial within our survey instrument.

### *B.1* Cuing a Context of Price Changes Different from Grocery Stores

To test the effects of retroactive interference, a random half of the agents who participated in our survey faced a question that aimed to cue a context related to price changes different from grocery price changes. The cue consisted in asking respondent the following question:

*"As far as you can recall, is there a gas station close to your home?"*

Possible responses were "Yes," "No," and "I don't know".

We designed the cue in a way that fulfills a set of properties. First, the question was asked early on in the survey, so that subjects could not guess that our hypothesis aimed to relate this question to their later answers about prices and inflation.

For the same reason, we did not ask a direct question about gas prices, but rather we cued the context of gas stations to treated subjects, so that this context (and the price changes associated with it) would be available to them during the recall process. Cuing a context to induce context-dependent recall and hence beliefs is a procedure that has been used and validated in economic research ().

Among several potential candidates for context cues, we chose the context of gas stations because gas prices are among the most often mentioned source of information about inflation by a representative set of US households we interviewed in earlier CBEAS waves (see D'Acunto et al. (2021b)). Moreover, due to their attempt to attract driving consumers, US gas stations tend to display their prices prominently and saliently on large and very visible signs on the street. For this reason, even agents who do not purchase gas regularly are exposed to gas price signals when walking or driving by gas stations. The mere cuing of a gas station context should thus make gas prices more likely to come to mind to our agents.

Note also that the cue is designed in a way that should lead to interference irrespective of an agent's answer, that is, irrespective of whether the agent claims that a gas station exists close to their domicile: in either case, the context of gas stations (any gas stations, irrespective of their locations) is cued to any agent who reads and answers this question.

### *B.2* Recall and Beliefs of Cued and non-Cued Agents

Moving on to testing the predictions of retroactive interference in our context, we note that we could not ask all agents about their recalled gas inflation over the previous 12 months alongside their recalled milk inflation, because otherwise we would have cued the gas station context to all subjects thus defying the aims of our empirical design. To the contrary, all agents are asked to recall milk inflation over the last 12 months (thus potentially being cued with the grocery store context), but we test whether recalled milk inflation has a lower correlation with the beliefs about general inflation (which were elicited before asking agents about milk inflation) for agents cued with the gas station context.

This test is an additional piece of evidence to dismiss concerns about anchoring in subsequent responses in a survey setting: if an anchoring effect exists, it should arise similarly for agents who were exposed to the gas station cue early in the survey and other agents.

We report the results in Table 5, where we estimate the following specification by OLS:

$$\begin{aligned}\mathbb{E}[\pi_i] = \alpha + \beta Recalled\ Milk\ \pi_i + \gamma Recalled\ Milk\ \pi_i \times Interfered \\ + \delta Interfered + \zeta Perceived\ Inflation_i + X_i'\psi + \epsilon_i \end{aligned} \tag{3}$$

The memory framework predicts that $\beta > 0$—the baseline effect of selective recall we have discussed above, whereby agents used their recalled milk inflation when forming beliefs about future inflation—and, based on retroactive interference, that $\gamma < 0$, that is, subjects who are cued with the gas station context should make less use of recalled grocery inflation, including milk inflation, when forming their beliefs about future general inflation. Note that the memory framework provides no prediction regarding the coefficient $\delta$—being cued with the gas station context or not has no obvious effect on the level of expected inflation. Also, as is standard in studies on the formation of inflation expectations (for instance, see D'Acunto et al. (ming)), we control directly for $Perceived\ Inflation_i$ to account for the large cross-sectional dispersion of knowledge about inflation levels among consumers.

Columns (1)-(3) of Table 5 report the results for our full sample of agents. First, in column (1), we show the baseline result that recalled milk inflation does help to predict expected general inflation, which we have not shown separately in Table 4. Moving on to columns (2)-(3), we find that, irrespective of whether we keep constant agents' demographic characteristics, agents who were interfered with the gas station cue early in the survey are substantially less likely to use their recalled milk inflation when forming beliefs about general inflation: $\hat{\gamma}$ is negative and its absolute value is only slightly smaller than $\hat{beta}$.

We interpret this result as evidence consistent with retroactive interference, because the only systematic difference between agents that were interfered and others is the cuing of the gas-station context early in the survey, which was assigned to half of the sample at random.

Confirming the validity of retroactive interference in the field has important economic policy implications: the question of whether central banks and governments can manage households' inflation expectations through communication rather than changes in policy rates, which produce substantial negative side effects on the economy, is still wide open. Our results suggest that targeted communication can help to manage households' beliefs when it reaches households and cues contexts different from those that are most readily available to their recall, such as grocery price inflation. Grocery price inflation tends to be higher and more volatile than the measures of inflation policy institutions target, which are in fact representative of households' overall consumption baskets and hence should be more appropriate to consider as a base for the formation of inflation expectations by households.

In the rest of Table 4, we present heterogeneity tests. Based on retroactive interference, the effects of cuing the context of gas stations on the use of recalled milk inflation when forming beliefs should be stronger for agents for whom grocery inflation is more likely to come to mind when forming beliefs without any prompts or cue. To the contrary, for agents to whom grocery inflation barely comes to mind anyway when forming beliefs, cuing the gas-station context should have barely any effect on their (low) use of grocery inflation when forming beliefs.

First, we not only confirm the result in D'Acunto et al. (2021b) that women are more likely to incorporate the observed inflation in their grocery bundles when forming inflation expectations, but also that the countervailing effect of retroactive interference is indeed stronger for women than for men. Similarly, the effect of interference is stronger for agents who report not attending to economic information from the media and for agents who are the main shopper for their households.

# VI Conclusion

We provide field evidence consistent with a set of processes of human memory that have been documented mostly in laboratory experiments in cognitive psychology and, more recently, in economics. Our evidence is based on a unique setting in which, alongside survey-based elicitation of agents' recalled past inflation and future inflation expectations, we observe, for the same agents, the actual price levels and price changes they have observed over the previous months.

Agents who observed higher and hence more salient price changes in the months before recalling past inflation tend to recall higher inflation as well as to form higher inflation expectations. We also find that agents who have observed a higher proportion of positive and large price changes tend to recall the price changes they have observed more than other agents. Moreover, agents who regularly shop at one single store—and hence whose observed price changes are all associated with the same contextual environment—tend to recall their observed price changes more than agents who shop at multiple stores, which is consistent with the notion of context dependence.

We also test for two regularities whereby information the agent is not trying to recall interferes with the recall process. First, we find evidence consistent with proactive interference, whereby during the recall process information that was stored before the one the agent is trying to recall comes to mind. In the context of prices and inflation, this phenomenon suggests that agents tend to recall that past prices were lower than what they actually were, which leads to recalling higher inflation than what agents actually faced. We also find evidence consistent with retroactive interference, whereby if agents are cued with a context to which they associate prices and price changes but is unrelated to their memory databases, they tend to make less use of their memory databases during the recall process.

Our results suggest that the processes underlying imperfect human memory might represent a viable microfoundation for new generation models of beliefs formation in economics. These results also motivate more empirical research aimed to assess how human memory and recall shape the formation of beliefs about both own and macroeconomic variables. Finally, these results beget research on how policy makers can exploit features of the human memory and the recall process to design fiscal and monetary policies that manage economic agents' inflation expectations effectively without causing the major economic downturns due to sudden and swift increases in policy rates by central banks. Existing research on the effects of cuing trustworthy contexts (D'Acunto et al. (2020)), tailoring policy communication to households' characteristics (Coibion et al. (2022)), and using automated advice through personal devices (robo-advising) to manage households' expectations (D'Acunto and Rossi (ming)) all represent fruitful areas in which to assess the role of human memory and recall processes.

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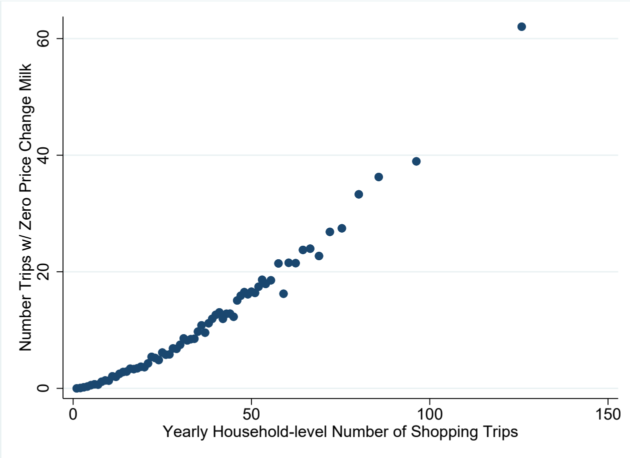
Figure 1: **Stored Price Change Signals by Size of Memory Database**

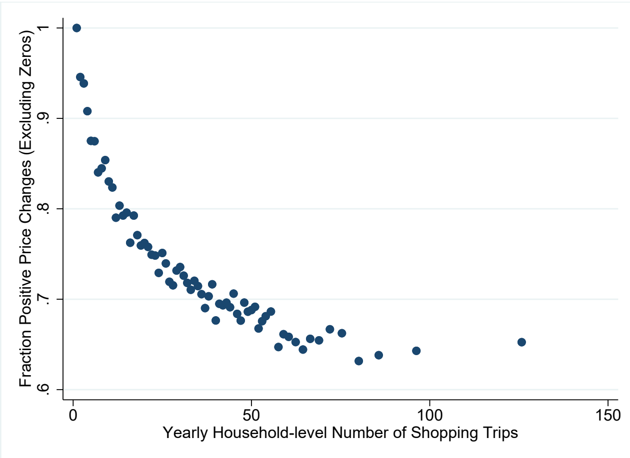

*This figure plots the distribution of the price changes across consecutive shopping trips for the most commonly purchased grocery good (milk) faced by two agents in our data, i.e., an agent that purchased milk 12 times over the 12 months before the survey (approximately once a month, Panel A) and one who purchased it 172 times (approximately every other day, Panel B).*

Figure 2: **Field Properties of Memory Databases**

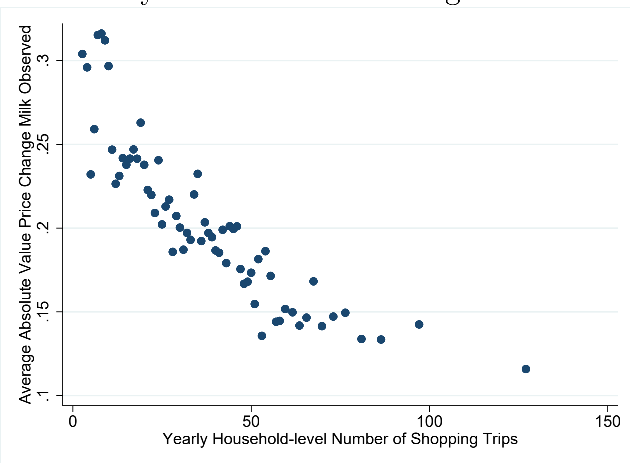
Panel A. Size of Memory Database and Number of Recorded Zero Price Changes




Panel B. Size of Memory Database and Fraction Positive Price Changes Recorded

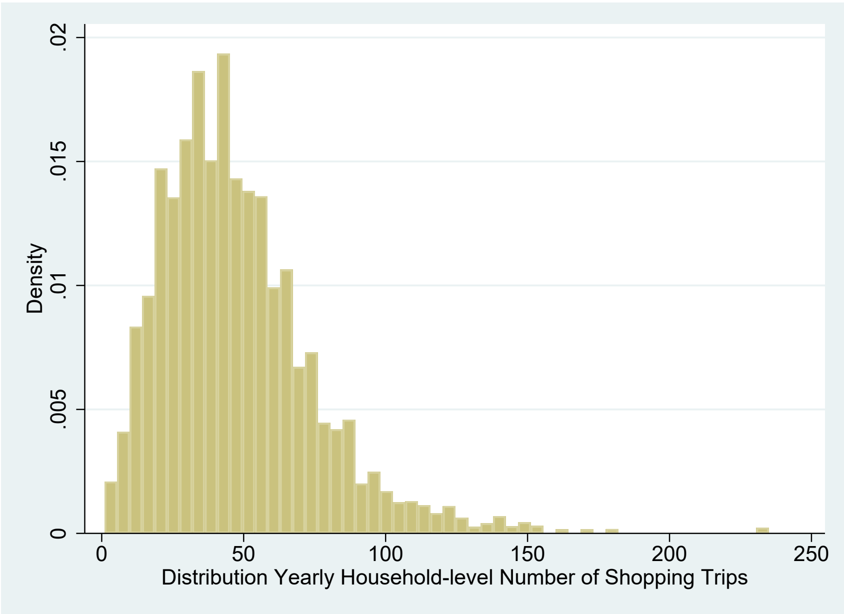



Panel C. Size of Memory Database and Average Recorded Price Changes




*This figure provides field evidence for three features of memory databases. Panel A shows that agents who have a larger memory database of price changes due to shopping more often record a higher number of zero price changes in their databases. Panel B shows that agents with larger memory databases record a fraction of positive price changes over negative price changes closer to 50%. Panel C documents that agents with larger memory databases record on average smaller price changes in absolute value—the distribution of the price changes they observe is more concentrated around zero than for agents with smaller memory databases.*

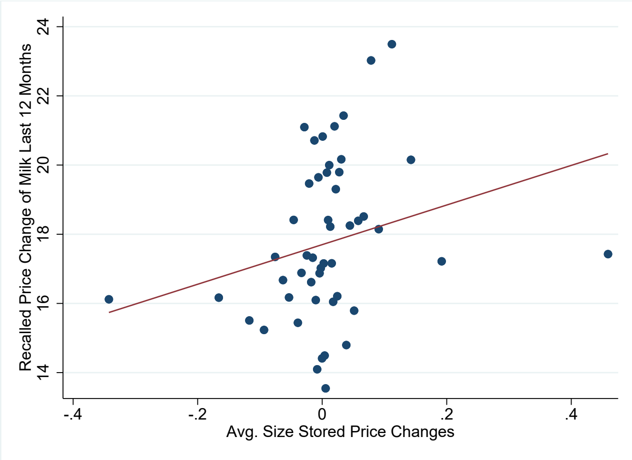
Figure 3: **Variation in the Size of Memory Databases**



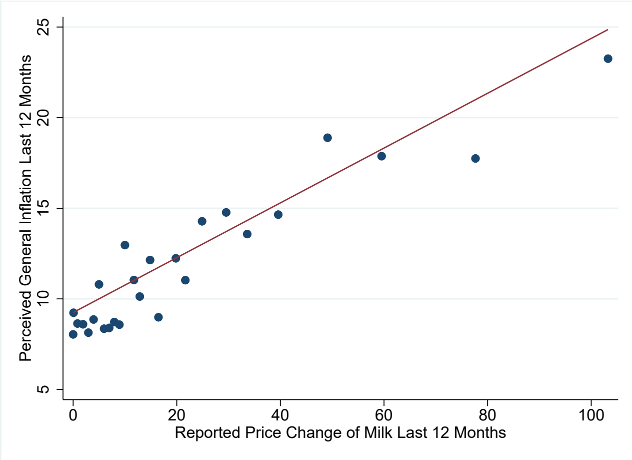

*This figure plots the distribution of the number of yearly shopping trips by individuals in our sample. A higher number of shopping trips means a higher number of price changes recorded in individuals' memory database.*

Figure 4: **Selective Recall and Beliefs Formation**

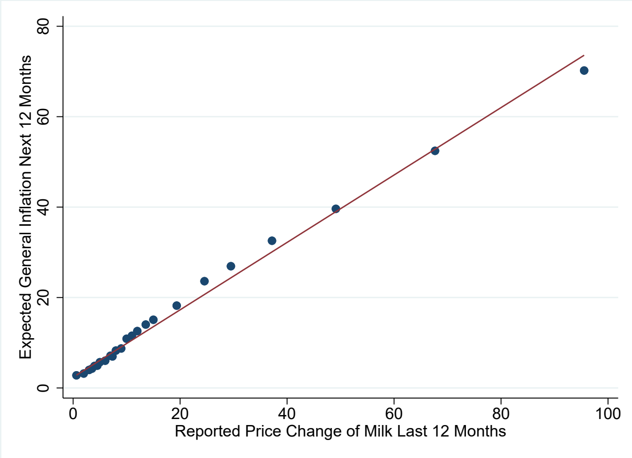
Panel A. Stored vs. Recalled Price Change Milk, Previous 12 Months




Panel B. Perceived Price Change Milk and General Inflation, Previous 12 Months



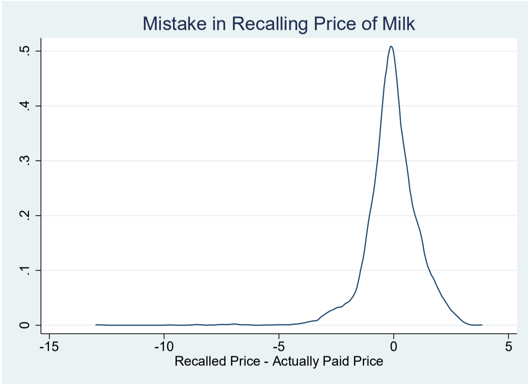

Panel C. Perceived and Expected General Inflation



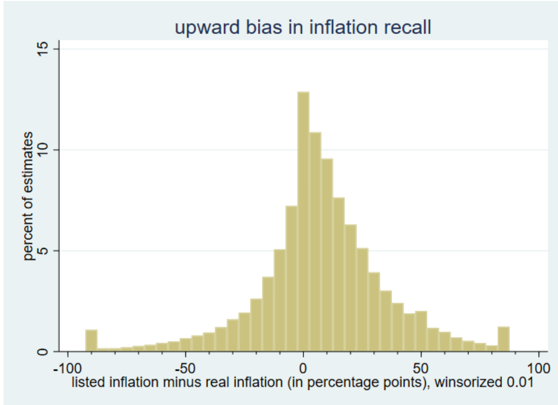

*This figure provides raw-data evidence on the relationship between: (i) stored milk price changes in individuals' memory databases and their perceived price change of milk over the previous 12 months; (ii) perceived general inflation and perceived price change of milk over the previous 12 months; and (iii) perceived general inflation and expected general inflation over the next 12 months.*

Figure 5: **Proactive Interference: Systematic Recall Mistakes and Beliefs Formation**

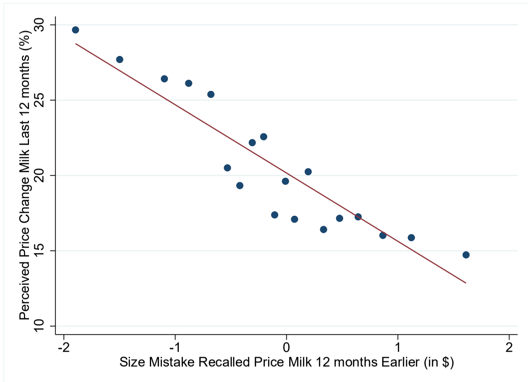
Panel A. Recall Systematically Lower (Older) Past Milk Prices



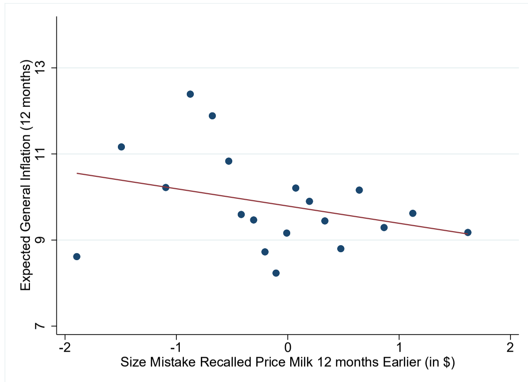

Panel B. Systematic Upward Bias in Recalled Milk Inflation




Panel C. Mistakes in Recalled Past Prices and Perceived General Inflation




Panel D. Mistakes in Recalled Past Prices and Expected Inflation




*This figure provides raw-data evidence on the role of proactive interference in recall and beliefs formation. Panel A shows that on average individuals recall lower prices of milk 12 months before the interview than the actual prices they paid 12 months before, which is consistent with them mistakenly recalling older (and hence typically smaller) prices due to proactive interference. This mistake is systematically associated with their perceived increase in the price of milk over the previous 12 months (Panel B) as well as with expected general inflation over the next 12 months (Panel C)*

Table 1: **Summary Statistics**

| | Observations (1) | Mean (2) | St. dev. (3) | Min (4) | 25th (5) | Median (6) | 75th (7) | Max (8) |
|---|---|---|---|---|---|---|---|---|
| Expected General Inflation | 6,300 | 11.46 | 15.59 | 0 | 4 | 7 | 10 | 100 |
| Recalled Milk Inflation | 6,300 | 18.93 | 24.11 | 0 | 5 | 10 | 25 | 134 |
| Avg. Price Change Milk | 6,300 | 0.01 | 0.12 | -0.96 | -0.02 | 0.001 | 0.03 | 2.02 |
| Always Same Store | 6,300 | 0.16 | 0.36 | 0 | 0 | 0 | 0 | 1 |
| Male | 6,300 | 0.29 | 0.45 | 0 | 0 | 0 | 1 | 1 |
| Household Income Group [3-27] | 6,300 | 21.15 | 5.92 | 3 | 17 | 23 | 26 | 27 |
| Household Size | 6,300 | 2.13 | 1.09 | 1 | 1 | 2 | 2 | 9 |
| Household Head Age Group [0-9] | 6,300 | 7.12 | 2.67 | 0 | 7 | 8 | 9 | 9 |
| In Labor Force | 6,300 | 0.41 | 0.49 | 0 | 0 | 0 | 1 | 1 |
| College | 6,300 | 0.39 | 0.49 | 0 | 0 | 0 | 1 | 1 |
| White | 6,300 | 0.87 | 0.33 | 0 | 1 | 1 | 1 | 1 |
| Hispanic | 6,300 | 0.05 | 0.21 | 0 | 0 | 0 | 0 | 1 |
| County Size Group [1-4] | 6,300 | 2.15 | 1.06 | 1 | 1 | 2 | 3 | 4 |

*This table reports summary statistics for the main independent and dependent variables in our running sample. Expected General Inflation is the reported numerical expectations of general inflation rates for the following 12 months. Recalled Milk Inflation is the reported recalled milk inflation over the previous 12 months. Avg. Price Change Milk is the average change the price of milk observed by the agent across subsequent shopping trips. Always Same Store is a dummy that equals 1 if the respondent purchased milk always in the same store over the previous 12 months, and zero otherwise. For the demographic variables that we observe by categories, we report the number of categories in square brackets.*

Table 2: **Selective Recall: Memory Databases and Recalled Inflation**

| *Outcome Variable:* Recalled Milk Inflation | Full Sample | | Heterogeneity | | | | | |
|---|---|---|---|---|---|---|---|---|
| | (1) | (2) | Men (3) | Women (4) | Media (5) | No Media (6) | Shopping (7) | No Shopping (8) |
| Small Memory Database | 1.573** | 2.023*** | 1.454 | 2.205** | 0.106 | 3.060*** | 2.360** | 0.853 |
| | (2.11) | (2.67) | (1.10) | (2.39) | (0.09) | (3.14) | (2.55) | (0.67) |
| Constant | 17.690*** | 7.690 | -1.487 | 6.512 | 16.840* | 3.826 | 12.810** | 1.203 |
| | (26.78) | (1.52) | (-0.15) | (0.83) | (1.90) | (0.61) | (2.07) | (0.13) |
| Demographics | | X | X | X | X | X | X | X |
| Observations | 6,300 | 6,300 | 1,799 | 4,493 | 2,351 | 3,949 | 4,467 | 1,833 |
| Adjusted $R^2$ | 0.001 | 0.030 | 0.059 | 0.031 | 0.047 | 0.038 | 0.036 | 0.048 |

*Demographics include income dummies (30 groups), household size dummies, age dummies (10 groups), number of children dummies, employment status dummies, education level dummies, race dummies, dummy for Hispanic ethnicity, county size dummies (4 groups), and Census region dummies. Standard errors are clustered at the respondent level and statistical inference is reported as follows: * 10%, ** 5%, *** 1%.*

Table 3: **Selective Recall: Memory Databases and Recalled Inflation—Salience and Context**

| *Outcome Variable:* Recalled Milk Inflation | Salience | | | | Context | | | |
|---|---|---|---|---|---|---|---|---|
| | Price Signals in Database | | | | Always Same Store | | Many Stores | |
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
| Avg. Price Change Milk in Database | 6.290*** | 5.666** | | | 19.260*** | 16.281** | 4.606* | 4.305 |
| | (2.50) | (2.26) | | | (2.58) | (2.08) | (1.73) | (1.62) |
| Q2 Avg. Price Change Milk in Database | | | 0.070 | -0.354 | | | | |
| | | | (0.08) | (-0.41) | | | | |
| Q3 Avg. Price Change Milk in Database | | | 1.518* | 0.779 | | | | |
| | | | (1.75) | (0.89) | | | | |
| Q4 Avg. Price Change Milk in Database | | | 2.485*** | 1.875** | | | | |
| | | | (2.86) | (2.15) | | | | |
| Constant | 18.940*** | 9.300* | 17.980*** | 9.097* | 19.59*** | -4.786 | 18.84*** | 13.41** |
| | (61.56) | (1.84) | (29.28) | (1.79) | (24.35) | (-0.35) | (56.57) | (2.44) |
| Demographics | | X | | X | | X | | X |
| Observations | 6,300 | 6,300 | 6,300 | 6,300 | 949 | 949 | 5,250 | 5,250 |
| Adjusted $R^2$ | 0.001 | 0.030 | 0.002 | 0.031 | 0.007 | 0.074 | 0.001 | 0.033 |

*Demographics include income dummies (30 groups), household size dummies, age dummies (10 groups), number of children dummies, employment status dummies, education level dummies, race dummies, dummy for Hispanic ethnicity, county size dummies (4 groups), and Census region dummies. Standard errors are clustered at the respondent level and statistical inference is reported as follows: * 10%, ** 5%, *** 1%.*

Table 4: **From Recall to Beliefs: Memory Databases, Recalled Inflation, and Expected Inflation**

| *Outcome Variable:* Expected General Inflation | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| Small Memory Database | 0.875* | 0.975** | 0.674 | 0.723 |
| | (1.82) | (2.01) | (1.43) | (1.52) |
| Recalled Milk Inflation | | | 0.127*** | 0.124*** |
| | | | (15.93) | (15.67) |
| Demographics | | X | | X |
| Observations | 6,300 | 6,300 | 6,300 | 6,300 |
| Adjusted $R^2$ | 0.001 | 0.055 | 0.039 | 0.090 |

*Demographics include income dummies (30 groups), household size dummies, age dummies (10 groups), number of children dummies, employment status dummies, education level dummies, race dummies, dummy for Hispanic ethnicity, county size dummies (4 groups), and Census region dummies. Standard errors are clustered at the respondent level and statistical inference is reported as follows: * 10%, ** 5%, *** 1%.*

Table 5: **Retroactive Interference: Gas-Price Cue, Recalled Milk Inflation, Inflation Expectations**

| *Outcome Variable:* Expected General Inflation | Full Sample | | | Heterogeneity | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | Men (4) | Women (5) | Media (6) | No Media (7) | Shopping (8) | No Shopping (9) |
| Recalled Milk Inflation | 0.026*** | 0.042*** | 0.037*** | 0.027* | 0.042*** | 0.025* | 0.043*** | 0.023* | 0.074*** |
| | (3.58) | (4.18) | (3.78) | (1.68) | (3.36) | (1.77) | (2.98) | (1.77) | (4.21) |
| Recalled Milk Inflation× Interfered | | -0.034** | -0.034** | -0.012 | -0.038* | -0.007 | -0.043* | -0.006 | -0.067** |
| | | (-1.97) | (-2.10) | (-0.49) | (-1.80) | (-0.30) | (-1.93) | (-0.34) | (-2.10) |
| Interfered | | -0.018 | 0.027 | -0.471 | 0.282 | 0.052 | -0.116 | -0.077 | -0.078 |
| | | (-0.01) | (0.08) | (-0.92) | (0.57) | (0.08) | (-0.25) | (-0.18) | (-0.13) |
| Perceived Inflation | 0.656*** | 0.648*** | 0.633*** | 0.685*** | 0.620*** | 0.711*** | 0.598*** | 0.610*** | 0.616*** |
| | (32.32) | (28.96) | (28.90) | (11.01) | (25.72) | (22.69) | (20.15) | (13.89) | (21.20) |
| Demographics | | | X | X | X | X | X | X | X |
| Observations | 4,618 | 4,618 | 4,618 | 1,314 | 3,299 | 1,727 | 2,891 | 2,162 | 2,456 |
| Adjusted $R^2$ | 0.640 | 0.787 | 0.802 | 0.874 | 0.826 | 0.894 | 0.824 | 0.834 | 0.845 |

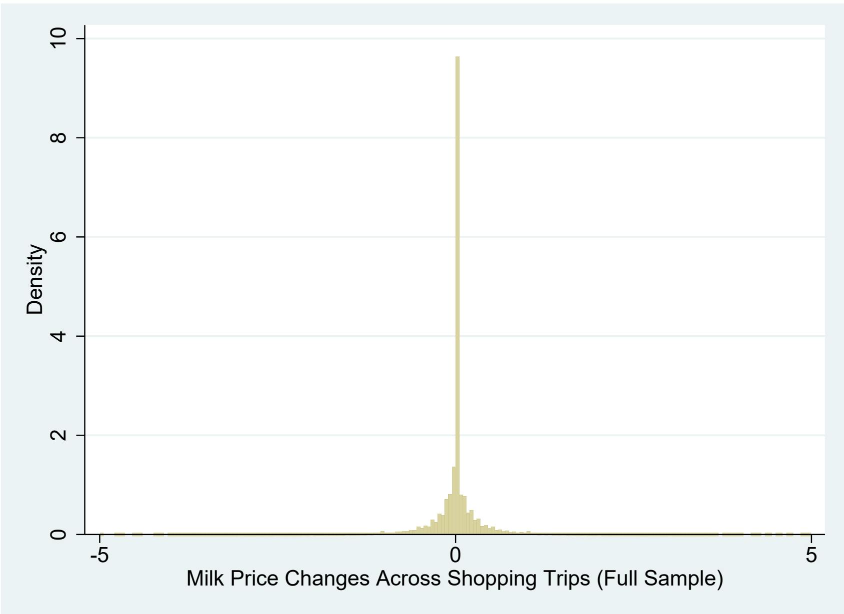
*Demographics include income dummies (30 groups), household size dummies, age dummies (10 groups), number of children dummies, employment status dummies, education level dummies, race dummies, dummy for Hispanic ethnicity, county size dummies (4 groups), and Census region dummies. Standard errors are clustered at the respondent level and statistical inference is reported as follows: * 10%, ** 5%, *** 1%.*

# Online Appendix:
# Memory & Beliefs: Evidence from the Field

Francesco D'Acunto and Michael Weber

*Not for Publication*

Figure A.1: **Distribution of Milk Price Changes Across Subsequent Shopping Trips**

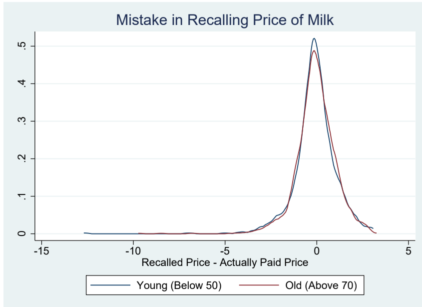



*This figure plots the distribution of the price changes of milk across asjacent shopping trips by households in our sample.*

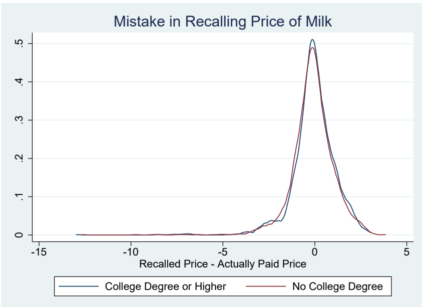
Figure A.2: **Proactive Interference: Systematic Recall Mistakes by Demographics**

Panel A. Recall Mistakes by Gender

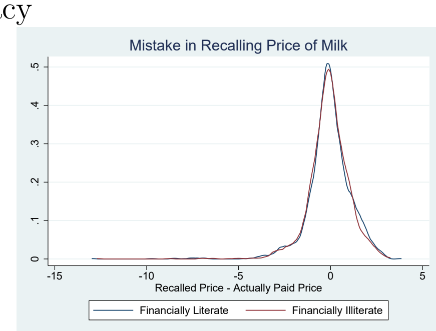

Panel B. Recall Mistakes by Age




Panel C. Recall Mistakes by College Education




Panel D. Recall Mistakes by Financial Literacy




Panel E. Recall Mistakes by Grocery Shopping Status


*This figure provides raw-data evidence on the role of proactive interference in recall and beliefs formation. Each panel shows across demographic groups that on average individuals recall lower prices of milk 12 months before the interview than the actual prices they paid 12 months before, which is consistent with them mistakenly recalling older (and hence typically smaller) prices due to proactive interference.*