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Igniting Deliberation in High Stake Decisions: A Field Study

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Abstract

We conduct a large scale randomized field experiment to study whether providing recipients – 42,454 Chinese households in a rural area – with information on the costs of a real decision they make can help to improve the quality of their choices. The decisions are of high financial impact, as the objects of deliberation – air conditioners – have upfront prices exceeding the average monthly salary of a household. Besides providing nominal cost information, we conduct two additional treatments, where we either present the same information by making the real opportunity costs salient, or by administering the information via a quiz. The former aims at facilitating the comparison of effective costs, while the latter aims at enhancing attention and cognitive involvement. We find that providing cost information substantially affects the choices made, and reduces the decision mistakes, in particular in the two additional treatments.

Keywords: Information provision, Opportunity costs, Decision mistakes, Involvement, Energy Efficiency

JEL: D12, D83, L68, Q41, Q48

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1 Introduction

In most economic decisions, an adequate cost-benefit analysis plays a central role for making the right choices. Conducting such an analysis requires sufficient factual information about the choice alternatives, alongside with cognitive efforts to evaluate this information relative to the own needs. Various studies have shown that people reach suboptimal decisions because they fail to collect all relevant information, or because they fail to adequately process the available information in an economically viable manner (see, e.g., Hossain and Morgan, 2006; Chetty et al., 2009; Lacetera et al., 2012; Jessoe and Rapson, 2014; Allcott and Taubinsky, 2015; Bhargava et al., 2017; Kaufmann et al., 2018). For example, calculating the opportunity costs associated with a durable good, such as a lightbulb, requires to anticipate the energy savings over the projected life span, which means accounting for electricity costs, usage pattern or lifetime relative to differences in the upfront prices between various devices.

In this article, we report a field study that we conducted to assess whether providing qualified information, aimed at helping people in evaluating the cost information provided by the market about durable goods, can improve the quality of choices. Our study exploits a recent policy intervention in rural China. The background is summarized as follows. In view of the problems associated with air pollution, the Chinese government has required that coal-burning stoves for household heating purpose need to be replaced by an electricity-based technology, such as air-conditioners (AC's), which can be used for cooling and heating purposes. These products were offered by various suppliers in the market, and lump-sum subsidized by the government to ease the financial burden imposed on less well situated households.

The alternatives in the market differ in their upfront prices and usage costs, e.g., due to different levels of energy efficiency. Therefore, depending on electricity consumption, different alternatives may be optimal for different households. Specifically, AC's were available in two levels of energy efficiency across different brands. AC's with the higher efficiency level consume less energy per hour, but also come at a higher upfront price. Therefore, evaluating which efficiency level is optimal for a household requires a careful deliberation about the anticipated usage.

Our study is earmarked by the fact that the purchase of an AC imposes a severe impact on most households' annual budgets: already the upfront prices of the products in the market exceed the average monthly salary in the study population, even after deducting the subsidy. If the objects at stake involve only a small fraction of the household's budget, it seems reasonable that comparative cost evaluations may be prone to mistakes, reflecting that people do not engage in a comprehensive deliberation, as the possible decision mistake seem not to be of substantial harm. By contrast, one could think that the level of attention or cognitive effort is augmented in such circumstances compared to decisions between products in low-involvement categories.[1] In such a case, interventions aimed at improving the evaluation of the available information seem to become redundant, as the market already provides enough incentives for people to "think things through". Our field study provides a test of this conjecture.

We used a randomized control trial to study whether the provision of qualified information regarding the projected usage costs affects the purchase decisions made by the households, and in particular also helps them improving their choices. Our study involves four conditions - a base condition and three treatment conditions. Villages were randomly assigned to one condition.

In the control condition, the residents of the villages received no information other than what was made available by the market suppliers. In the three treatment conditions, we provided villagers with factual information about the AC usage costs. This information was aimed at facilitating the cost comparisons between the two different levels of energy efficiency. This information consisted of paradigmatic calculations, that exemplify the average opportunity costs of acquiring a less efficient AC for various projected activity periods. As such, our information interventions did not convey new facts – all the information we used in the calculations were available in the market.

We provided this information to villagers in three slightly different ways. In the "Pure Information" treatment, we simply stated the opportunity costs at face value in nominal terms. The two other treatments were inspired by different underpinnings, but both were aimed at improving the quality of the required deliberations about the effective costs.

Most villagers in our study are endowed with limited education – about 80 % of the householders did not go to high school, and more than one third did not go to middle school. One concern we had is that villagers may have problems transferring the opportunity cost calculations we provide in "Pure Information" to their decision situation, given the educational situation and the fact that the information features nominal usage costs expressed in large and fairly abstract numbers.[2] Therefore, in the "Milk" treatment we simply expressed the opportunity costs in units of an economic good they were highly familiar with from everyday life: Milk.

[1]For example, theories of optimal information acquisition, such as rational inattention or optimal consumer search, commonly predict a higher effort to scrutinize if the stakes at decision are high, making decision errors less likely to occur, ceteris paribus, compared to situations with low stakes.

[2]Similar problems have been observed in other contexts (Frederick et al., 2009).

Another concern we had is that villagers may be discouraged by the information load imposed by the campaigning firms, and fail to use sufficient cognitive efforts and attention for adequately processing the cost information in response, despite the high stakes of the decisions. Our third treatment therefore seeks to lure the households into the necessary deliberations in a playful manner. Various psychological studies have indicated that people adopt their intended behavior if they previously become more involved into the subject (Gollwitzer and Sheeran, 2006; Hettema et al., 2005; Carrera et al., 2018). Inspired by this literature, we presented the factual cost information as a quiz to the households in the "Involvement" treatment. The idea is that a quiz with a reward for correct answers may induce people to engage in the required cost calculations, which itself raises interest and familiarity with the matter more than if the same information is just passively displayed to them.

The data of our field experiment shows that the information treatments significantly affected the purchase behavior. In particular, the more energy-efficient AC is less and the less efficient AC more often chosen in treated villages relative to control villages. We assess whether these changes are likely to reflect improvements in the individual household's welfare by various measures.

First, we use the data of electricity consumption in control villages and an ex-post survey we conducted to infer threshold levels, in terms of AC activity hours or energy consumption, below which the more efficient AC constitutes a dominated option. We find that a clear majority of households indeed have an activity pattern below these thresholds, supporting that the observed shift in purchases improves household welfare, at least on average.

Second, we identify a subsample of households, across treatment and control villages, for which the purchase of the more efficient AC most likely constitutes a decision mistake, as this type of AC is dominated by the less efficient AC in terms of total expenditures. The data confirms that the likelihood of such decision mistakes is significantly reduced under our information treatments, which again supports that the observed changes have improved household welfare. In addition, we find that this effect is driven by our behavioral treatment variations, which suggests a powerful role for such interventions to improve the quality of choices.

The remainder is organized as follows. We discuss the relevant literature in Section 2. Section 3 describes the design of the field experiment and derives our main hypotheses. In Section 4 we explain the implementation of the field experiment in detail, and Section 5 presents the empirical results; Section 6 concludes.

2 Related Literature

There is a sizable literature on the effects of providing lifetime energy costs on consumers' purchases of durable goods, such as washing machines (Deutsch, 2010b), televisions (Heinzle, 2012), freezers and tumblers (Kallbekken et al., 2013; Stadelmann and Schubert, 2018), water heaters (Newell and Siikamäki, 2014; Allcott and Sweeney, 2017), cooling appliances (Deutsch, 2010a; Davis and Metcalf, 2016), lighting (Allcott and Taubinsky, 2015), or refrigerators (Houde, 2018).[3] We contribute to this literature in at least four ways: 1) We conduct a pure field study with real purchase decisions rather than a laboratory experiment; 2) The decisions that need to be made are of high stakes; 3) We consider two behaviorally motivated treatment variations of providing the same factual information to households; 4) Our data allows to access whether the decisions made are improved, rather than just altered, due to the information provided. In the following, we outline each of these aspects.

First, given that most existing papers on the topic are laboratory studies not based on actual purchase decisions, we regard it as important to empirically study information effects in case of non-artificial decisions that involve real purchases. We use a randomized control trial approach to approximate the degree of control that is a characteristic of laboratory studies, allowing for a causal interpretation of the empirical findings.

Second, the decision tasks in the existing literature we are aware of mostly deal with low-involvement products, where the expenses involve a rather negligible portion of a household's budget. By contrast, the decisions in our study impose very high stakes, as the purchase, e.g., of an AC exceeds the average monthly salary available to the villagers. We think of this aspect as noteworthy, because it is intuitively conceivable that people do not engage in information-seeking and mental deliberation if the choice alternatives, and the possible decision mistakes, are small relative to the overall available budget. Such a behavior could change if the alternatives under consideration are expensive.[4] At the very least, it seems fair to challenge whether one can extrapolate previous findings to the case of high stakes.

Third, we consider two refinements to providing merely factual information about the prospec-

[3]Several papers examine the effects of information provision on purchase decisions in contexts other than energy-using durables, see, e.g., Dranove and Jin (2010) or Allcott and Sweeney (2017).

[4]It is a common result in models of optimal information acquisition that information-seeking increases, ceteris paribus, if the corresponding stakes are higher.

tive opportunity costs of the alternatives in the market. In parts, this is motivated by the fact that most households in our study lack high-school education, and we conjecture that the sheer provision of numerical cost information may not be amenable for everyone. The two treatment variations we conduct are meant to address this concern, where we kept the factual information ultimately provided to households constant.

In the first variation, we phrased the cost information in terms of (forgone) milk consumption, which is a real commodity known to the villagers from everyday life. This approach is largely motivated by research in social psychology and economics, which has shown that people commonly neglected opportunity costs and focus on information that is salient at the point of making purchase decisions (Thaler, 1980; Frederick et al., 2009).[5] Read et al. (2017) find that when highlighting the opportunity costs of choosing smaller and sooner options, people become more patient, or Persson and Tinghög (2020) report on substantial opportunity cost neglect in a survey experiment about public policy.

The second variation is based on the premise that people may fail to pay sufficient attention to complex decision tasks.[6] A recent literature demonstrates that enhancing cognitive involvement may increase attention and help people to take desirable actions (Gollwitzer and Sheeran, 2006; Hettema et al., 2005; Carrera et al., 2018). For example, Nickerson and Rogers (2010) show in a field experiment that cognitively involving people to thinking about their concrete voting plan can increase the turnover, or motivate people to take vaccinations (Milkman et al., 2011) or preventive screenings (Milkman et al., 2013). Our treatment variation therefore seeks to enhance the cognitive involvement by administering simple, incentivized exercise questions that motivate the villagers to engage in cognitive operations to obtain, by themselves, the relevant cost information, rather than just passively noting these numbers as they are provided to them.

Fourth, several papers proceed under the assumption that acquiring a more energy-efficient product is optimal for a given consumer.[7] By contrast, our data allows us not only to unpick whether information provision affects the purchase decisions, but also whether it is likely to improve household welfare.

[5] A related finding is that the decisions made change if people are induced to think in real rather than nominal terms (Shafir et al., 1997; Fehr and Tyran, 2001).

[6] While previous literature has found evidence of limited attention (see, e.g., Chetty et al., 2009; Lacetera et al., 2012), few studies have investigated how to increase consumer's attention to increase their welfare.

[7] A notable exception is the study by Allcott and Taubinsky (2015), who conduct an artificial field experiment with low-involvement products – incandescent lightbulbs versus compact fluorescent light bulbs (CFL's) – on a survey platform. They estimate a pretreatment demand curve to elicit the welfare effects of a CFL subsidy or ban.

3 Description of the Field Experiment

Domestic heating is regarded as a major source of pollution in northern China due to the heavy reliance on coal or firewood by rural villagers (Duan et al., 2014; Liu et al., 2016). In 2017, the Chinese government started to require that rural villagers phase out coal burning stoves and switch to electric heating. This policy included subsidizing the upfront prices of air-conditioners or electric heaters available in the market by a one-time, non-cumulative lump-sum subsidy of 1000 RMB ($\approx$ USD 151) (Barrington-Leigh et al., 2019).[8]

Our study took place in 107 villages in northern Henan Province around the time period where the subsidy was implemented. When the subsidy policy started, each household was allowed to buy one of the subsidized products, either an air-conditioner (AC) or a heater. All products were available in all villages of our study. The available AC's and heaters differed in their brands and types. Specifically, there were three types of air-conditioners in three different brands with prices ranging from 2199 to 6699 RMB (340 - 1036 USD), as well as ten types of heaters in six different brands with prices range from 190 to 2000 RMB (29 - 309 USD). AC's have the advantage that they can also be used for cooling. More importantly, other than heaters, the available AC's come in two different levels of energy efficiency, which makes a careful consideration of the usage costs important. Therefore, we focus mostly on the purchase patterns in case of AC.

3.1 Comparing AC's

Each AC brand offered its AC in two variations with respect to energy efficiency, where efficiency level 1 ("AC1") is more efficient than efficiency level 2 ("AC2"), and thus consumes less electricity per unit of usage time for a given endowment with horsepower. On average, the power difference between the two efficiency levels is about 0.1 kilowatt-hour. Whether AC1 constitutes a cheaper option for a given household, in terms of overall costs, depends on the differences in the upfront prices relative to the savings in electricity expenditures due to its higher level of energy efficiency. The upfront prices are directly available in the market, while the usage costs depend on the energy efficiency levels, the local climate (Auffhammer, 2014; Auffhammer and Mansur, 2014), income, and household habits (Li et al., 2018).

We obtain a threshold, in terms of usage hours, above which AC1 is the cheaper option by applying the standard concept of degree days, which we shall outline in the next paragraph.

[8]The subsidy applied equally for the purchase of an air-conditioner or heater, and as such was not relevant for the choice between the various products as analyzed by this paper.

The main idea is to first obtain the number of relevant heating and cooling days in a given time period, and then use these numbers to calculate the average usage hours or the kwh per activity day that are minimally required to compensate for the higher upfront prices of the more efficient AC.

Degree Days The concept of degree days is a common way to estimate the relationship between household energy consumption and temperature. It is based on the aggregate deviations of daily mean temperatures relative to a base temperature for the summer and winter seasons, respectively. The underlying idea is that a household's energy consumption becomes sensitive to changes in outdoor temperatures only once the daily mean temperature is higher (lower) than the summer (winter) base temperature (Thom, 1952, 1954; Cheng et al., 2018). The degree days then are calculated as the aggregate number of heating days (NHD), where the daily mean temperature falls below the base temperature in winter, and the number of cooling days (NCD), where the daily mean temperature exceeds the base temperature in summer.

To apply the concept of degree days, one needs to fix appropriate base temperatures for the summer and winter seasons that take into account the local climate and the peculiarities of the Chinese region regarding heating and cooling. It is known that sensible estimates for the base temperatures vary across geographical regions, and depend on regional economic circumstances or on climate conditions (Spinoni et al., 2015). For example, the base temperature for heating and cooling are 15 °C and 22 °C, respectively, in the United Kingdom (Kendon et al., 2017).[9] To obtain reasonable estimates of the NHD and the NCD for the region of our study – villages in Northern China – we took into account the most commonly used base temperatures in studies with Chinese data, the local climate characteristics, and the wealth level of villagers.

For the winter season, we used 5 °C as base temperature. This is the level at which indoor heating starts by the Chinese heating policy (MCPRC, 2003),[10] and other energy studies for China have used this as base temperature as well, e.g., Shi et al., 2016, 2018). Because rural poverty may gradually be reduced as the economy develops, it is conceivable that villagers might have a higher heating demand when adjusting to better living conditions (Luo et al., 2020). Therefore, we also considered 15 °C, the lower criteria for heating in Europe, as an alternative base tem-

[9] See UK Government). In the US, these numbers are 18.3 °C for both seasons (Hansen et al., 1998). In case of Europe, it is common to use 16 °C or 18 °C for the winter and 22 °C for the summer season (Zachariadis and Pashourtidou, 2007; Bessec and Fouquau, 2008).

[10] There are two conditions for room heating according to the Chinese policy on the code for Design of Heating Ventilation and Air Conditioning (GB50019-2003): (1) only areas with more than 90 days of below 5 °C in an annual cycle from September 1 to August 31 can be heated; (2) the heating stars/ends when temperature is below/above 5 °C for a continuous 5 day period.

perature for the winter season. We mainly use this specification to check the robustness of our results (the main results continue to hold). For the summer season, we proceeded similarly and set the base temperature to 26 °C.[11] This is close to the level used by other studies in China (Li et al., 2018; Cheng et al., 2018).

Using the local daily temperatures, we calculate the number of heating days for base temperature 5 °C (NHD5) and base temperature 15 °C (NHD15), as well as the number of cooling days for base temperature 26 °C (NCD) for the year 2017 and 2018. The corresponding results are summarized in Table 1.

Table 1: Degree Days

	NHD5	NHD15	NCD	Total AC using days (NHD5 + NCD)	Total AC using days (NHD15 + NCD)
2017	79	147	59	138	206
2018	80	140	70	150	210

Notes: NHD: number of heating days, NCD: number of cooling days. Since the heating season in Northern China lasts from November to March, we only consider the daily mean temperatures in November, December, January, February, and March (2017-2018) for calculating NHD5 and NHD15. Likewise, we use the daily mean temperatures in the summer months June, July and August in 2017 and 2018 for calculating NCD.

Threshold Level We use the degree days in Table 1 to estimate the average costs for AC usage with a standard back-of-the-envelope calculation. The average difference in the upfront price between the AC1 and AC2 available to the villagers is 998 RMB (≈ USD 151). The mean efficiency gain of 0.1 kilowatt-hours is the efficiency differences between an AC1 and an AC2 averaged over all brands. Further, the electricity price is regulated by the government and fixed to 0.56 RMB (≈ USD 0.085) per kilowatt-hour for the area and duration of our field study. As all AC's come with an eight-year warranty, we assume an average life span of 8-year for an AC.

By Table 1, the average annual number of degree days (= days on which heating or cooling takes place) based on the NHD5 criteria is about 145 days. That is, to make the more efficient AC1 worthwhile, a household has to use its AC for at least 15.36 hours per degree day over eight years.[12] This duration can alternatively be expressed as a threshold level in terms of electricity consumption. For example, the most efficient AC among all AC1's available in the market consumes about 1.3 kilo-watt per hour of heating. Based on the NHD5 calculation from

[11] According to the code for Design of Heating Ventilation and Air Conditioning (GB50019-2003), cooling days start when the out-door air temperature exceeds 26 °C.

[12] That is $\frac{998}{0.56*0.1*145*8} \approx 15.36$. Likewise, there are about 200 degree days using the NHD15 criterion, implying that a household needed to use its AC for at least 11.1 hours per day over eight years to compensate for the difference in the upfront price.

above, a household thus should use more than $15.36 * 1.3 \approx 20$ kilo-watt hours per heating day in order to make the purchase of this AC worthwhile.[13]

The above calculations suggest that AC1 is the favorable option, in terms of total expenditures, for heavy-using households. In other words, a household needs to anticipate a substantial amount of heating and cooling demand in order to compensate for the disadvantage of AC1 in terms of the upfront price. Whether many households in our study are above the threshold making AC1 the favorable option is an empirical question. We shall return to this central question in Section 5.2, where we use historical data on electricity consumption to infer a subset of households for which AC1 constitutes a dominated option in terms of overall expenditures.

3.2 Confusion and Information

The main surmise of our study is that some households may misestimate the relevant cost differences between AC's of different energy efficiency levels, leading to suboptimal decisions. More specifically, we assume that processing complex information, such as the comparative costs of the various AC's, can lead to *confusion* – the occurrence of unsystematic evaluation mistakes – that, nevertheless, can systematically bias decisions away from the optimal choice.[14] As counter measures, we propose that the provision of information which facilitates the relevant comparisons, or which activates the cognitive involvement of households can reduce the scope of confusion. We present a formal model of agent confusion capturing these notions in Appendix B. This model provides a background for the information treatments we conduct, and its main idea is outlined next.

Confusion Complex decisions involve comparing two or more choice options consisting of many attributes. Such comparisons consume mental resources, and can be subject to perception mistakes, as the human brain does not posses infinite mental capacities (Payne et al., 1993). In case of our study, the households need to compare the total anticipated costs of AC's that differ in their energy efficiency. The costs of an AC consists of two components: The upfront price and an anticipated usage cost. The upfront price is a single number and directly accessible by the households in the marketing data. By contrast, deriving the appropriate usage costs

[13] We do not include any discount factor or interest rate in our calculations, mainly for simplicity and because interest rates were essentially zero at the time of our study. We note that heavy discounting, e.g., due to strong myopia, would bias the threshold favoring AC1 upwards - a point to which we shall return in the empirical analysis again.

[14] Such a notion of confusion is well-founded in the psychological or the marketing literature; see Hefti et al. (2020).

involves mental operations such as forward-thinking and calculus. This makes the comparison of the usage costs between different AC's prone to evaluation mistakes.

We think of the extent to which evaluation mistakes in comparisons between the usage costs can occur as the household's *state of confusion*. The state of confusion congregates all aspects that matter for forming a comparison as well as the overall attention the brain devotes to processing these aspects, and we refer to the particular aspects as the various sources of confusion. In our study, we conjecture that a major source of confusion is that people have difficulties assessing the relevant opportunity costs of the products, e.g., because they have problems working with large money numbers, or because they fail to understand the real value of such money amounts. That is, they may over- or underestimate the true economic advantage of an AC with a higher energy efficiency due to an erroneous evaluation of the real opportunity costs.

Information Interventions Our central contention is that the evaluation mistakes are not invariants, but can be alleviated if confusion in the various sources is reduced, or if the amount of attention dispatched to information processing can be increased. Regarding the former, providing the households with information that helps them to evaluate and compare the relevant usage costs should therefore reduce confusion, which makes decision mistakes less likely to occur.[15]

Specifically, we provide households with various sample calculations that are based on the products in the market and illustrate the average opportunity costs associated with using the less efficient AC (see Section 4.3 for details). From the perspective of normative economics, rational consumers should consider the real opportunity cost of different options in order to make the best purchase decision. For an AC1, the true value of its energy savings is reflected in the potential purchasing power of the energy savings relative to AC2. However, it is been shown that people tend to misestimate or even ignore opportunity costs when making a purchase decision (Frederick et al., 2009).

In the "Pure Information" treatment – our baseline information intervention – we simply express these opportunity costs in monetary units. In our other two treatment variations, we provided the same information about the opportunity costs in a slightly different way.

[15] In the model, a reduction of confusion due to an information intervention is formalized by assuming that (i) the largest perception errors cannot occur anymore and (ii) the relative odds of those perception errors that can still occur remain constant. The latter is reasonable if the perception errors are an intrinsic consequence of the brain, in thus that the statistical principle driving their dispersion cannot be altered by our simple, one-shot information intervention. We show that whenever the confusion of one or several sources diminishes in the above manner, the chance of making a decision mistake due to misperception must decrease.

As all information treatments provide the same factual information about the opportunity costs, the decision quality should be improved in all information treatments. By "increased decision quality", we mean that the chances of a household to correctly identify whether AC1 or AC2 is the cheaper option given the energy consumption of the household should be larger. Hypothesis H_I summarizes this conjecture.

($\mathbf{H_I}$) Information Effects *The decision quality increases in all information treatments relative to the control villages.*

In view of the educational situation in the villages, understanding the relevant opportunity costs may be a particularly daunting task, even if explicit information about their nominal values has been made available. Therefore, we suppose that if these numbers are converted into quantities of a good known to the villagers from everyday life, this can facilitate the processing of information about opportunity costs and further reduce confusion. In the "Milk" Treatment, we express the opportunity costs in terms of the everyday commodity milk.[16] As the "Milk" Treatment provides the villagers with the same factual information as the "Pure Information" treatment, but expresses this information in quantities which, as we conjecture, are easier to evaluate, we hypothesize that the decision quality in the "Milk" treatment exceeds the one from "Pure Information".

($\mathbf{H_{II}}$) Milk Treatment *The decision quality in the "Milk" treatment exceeds the one in the "Pure Information" treatment.*

Another concern we have is that people might not allocate sufficient attention to the cost comparison. Therefore, a treatment that can involve people to thinking more, or more carefully, about the relevant costs may reduce confusion and improve decisions. In the "Involvement" treatment, we pose the opportunity costs as a quiz challenge, rather than just displaying these numbers to people. The conjecture is that it makes a difference whether people obtain certain insights as a consequence of their own efforts and reflection, rather than just passively consuming the same information.[17] We therefore hypothesize that the decision quality increases in the "Involvement" Treatment relative to "Pure Information".

($\mathbf{H_{III}}$) Involvement Treatment *The decision quality in the "Involvement" treatment ex-*

[16] At the time of the study, one box of milk was about 35 RMB (USD 5.4). Milk was very popular among local residents, and it was one of the most common presents that villagers made to others.

[17] According to the theory of "Rational Inattention", the allocation of attention is under the full control of a decision-maker, and chosen in an optimal manner. As the Involvement treatment does not provide new factual information relative to the other information interventions, but seeks to activate household's attention, we would not expect the "Involvement Treatment" to affect the decision quality relative to "Pure Information" from the perspective of rational inattention (see Appendix B.4).

ceeds the one in the "Pure Information" treatment.

Note that while we predict the Milk and Involvement treatments to outperform Pure Information, we do not have an ex ante hypothesis about the ranking between the Milk and Involvement treatments. The reason is that the former is aimed at facilitating information processing in a particular aspect, while the latter focuses more on influencing the overall attention and involvement, and it is an empirical question which effect is stronger.

4 Implementation

In this section, we outline the implementation of the field study. We begin by describing the randomization procedure (Section 4.1), and then present the time line of our study (Section 4.2). In Section 4.3, we explain how we implemented the information intervention based on the hypotheses from Section 3.2. Finally, Section 4.4 presents details on our ex post survey.

4.1 Randomization

The sample of our field study encompassed 42,454 valid household contact numbers for 107 villages, which are located in seven townships. A township is a collection of villages that are geographically close to each other. The seven townships are under the jurisdiction of Anyang City, which is the northernmost city of Henan Province in China.

To test our main hypotheses, we partition the population into three treatment groups – one for each information intervention – and a control group, which receives no additional information from us. We form these four groups by a standard randomization procedure (Duflo et al., 2007), stratified in three dimensions in 2018: the size of the population, the number of households, and the average annual disposable income per capita at the township level. Table 2 provides the outcome statistics of our randomization. We checked the validity of our randomization by comparing all means across the four groups, and find no evidence that the groups differ in one or more characteristics (see Appendix A.1).

Table 2 shows that the average annual disposable income per capita was 13,405 RMB (2073 USD) in 2018, i.e., 1.117 RMB (173 USD) per month. This is only about half of the price of the cheapest air-conditioner *after* subsidization, showing that the decision to purchase an AC clearly involves high stakes.

Table 2: Sample composition

Variables	Full Sample Mean (1)	Control Mean (2)	Pure Information Mean (3)	Milk Mean (4)	Involvement Mean (5)
Number of households	390.4	384.5	366.6	402.2	405.3
	(239.6)	(273.2)	(200.0)	(196.5)	(278.4)
Population size	1552.8	1566.6	1462.2	1578.3	1590.0
	(890.1)	(978.5)	(774.3)	(814.3)	(997.3)
Income (in RMB)	13405.5	13213.6	13541.6	13457.6	13450.6
	(914.8)	(930.1)	(935.5)	(923.6)	(888.7)
Number of townships	7	7	6	7	7
Number of villages	107	30	23	27	27

Notes: Column 1-5 display sample means in the full sample, control group, and the three information treatments; standard deviations are in parentheses. "Number of households" and "Population size" are at the village level. "Income" refers to the average annual disposable income per capita at the township level in Chinese currency (RMB). "Number of township" shows that almost all groups contained villages from each township.

4.2 Time Line

Our study took place during the period from 1st of June 2019 to November 3rd 2019. Events occurred as follows. On June 1st, the government communicated the information about the phase-out policy of coal to villagers, and the different companies started to promote their products. The villagers could purchase any product at any time before October 1st 2019 to collect the one-time subsidy of 1000 RMB.

We implemented our information treatments using first SMS messaging and later leaflets. The actual SMS containing the treatment information was sent over 6 days from June 16-22. Our SMS campaign thus was completed before all the subsidized products were made available to villagers. During August 5-6, we visited all villages (expect for those in the control group), and provided the households with the rewards if they answered the questions pertaining to our SMS campaign correctly (see below). In addition, we distributed leaflets of energy saving information to villagers who were at home. These leaflets contained exactly the same information as used in the SMS of the various treatments. To help those illiterate to overcome reading difficulties, we used figures to present the energy saving information on the leaflets.

To draw the villagers' attention to our SMS campaign, we hung posters in the village's committee office on June 14, announcing that villagers were to receive an SMS from researchers at ShanghaiTech University with information regarding the energy efficiency of the AC products in the market. Additionally, this information was broadcasted by the committee's offices of the villages. Finally, we conducted the ex post survey in the villages on October 3-8, after the subsidy policy expired. We obtained the purchase data from the local government on November

3, 2019.

4.3 Information Intervention

Two days after the broadcast announcement by the village office, we started sending text messages to households in the treatment villages through an SMS platform. For each treatment, we provided information on the average energy savings due to using a more efficient AC in three hypothetical scenarios that only differ in the assumed frequencies of usage (high, medium, and low). For each scenario, we sent three messages per day to each household.

Specifically, we sent a first SMS containing the information of a certain scenario in the morning, followed at noon by a question SMS about the information SMS sent in the morning. We then sent the solution to the question on the same day in the evening. The villagers who correctly answered the SMS question by messaging back prior to receiving the solution obtained a reward of 2 RMB, which we paid to them in cash during our visit in August. On the last day of the SMS interventions, we sent an SMS containing the same question as at noon of the second day. The villagers who answered this final question correctly were entitled to receiving a soap during our visit in August.

We used this question-reward procedure in all information treatments to maximize the chance that the SMS were considered by the villagers. In this respect, our ex-post survey indicates that about half of the villages in the relevant sample received the SMS and found the information to be helpful (see Appendix A.2).

Information Provided The information we provided in all information treatments was aimed at making villagers aware of the possible energy-savings induced by AC1 relative to AC2 depending on various usage patterns. The calculations we provided to the households were based on the average difference in energy efficiency of the offered products, and thus contained no information that was not available to the villagers.

We calculated the monetary value of energy savings over 1 year (short-term) and 8 years (long-term) for daily usages of 12, 16, and 20 hours, given that a household uses its AC for 200 days per year.[18] In the Pure Information treatment, we provided this information to the households by separate SMS on subsequent days. More specifically, on the first day, households received information about the cost saving over 1 and 8 years for a daily usage of 20 hours over 200 days. On the second and third day, they received similar information using 16 and 12 hours of daily usage, respectively. As an example of the precise information we provided,

[18]The amount of 200 activity days is close to the number of relevant degree days (see Table 1).

the households in the Pure Information treatment received an SMS in the morning of the first day, stating that if a household were to use an AC with the higher efficiency level (AC1) for 20 hours on 200 days per year, then this household could save 225 RMB per year relative to using an AC with the lower efficiency level (AC2).[19]

We conveyed the same factual information via SMS in our other two information treatments. The key differences are as follows. In the "Milk" Treatment, we simply expressed the cost-savings in units of milk. In the "Involvement" Treatment, we guided villagers to think about how to calculate the average energy-savings if an AC1 was purchased. Specifically, we required them to do the relevant savings calculations in each of the three scenarios by themselves. To this end, we provided them in the morning SMS with a sample calculation, that states the amount of money saved by using AC1 instead of AC2 for 1 hours in each of 200 days. Then, we asked them in the noon SMS to deduce how much money they could save if they were to use the AC for 12, 16 or 20 hours, respectively. Note that we ask the same question at noon in all three treatments. The only difference is that, in the Involvement Treatment, the villagers had to figure out the underlying calculations by themselves from the morning SMS, while they could simply read the morning SMS again in the other two treatments.

A sample of the texts we used in each information treatments can be found in Appendix A.5. The leaflets we distributed in early August contained exactly the same information as the respective treatment SMS (see Appendix A.4). We used leaflets, besides SMS, to maximize the number of villagers that became aware of our information campaign.[20]

4.4 Follow-up Survey

In a third visit to the villages (October 2019), we conducted a follow-up survey in 68 villages including control and treatment villages. In total, 1245 villagers participate in the survey, where 364 were from 16 control villages, 230 were from 14 villages in the Pure Information treatment, 283 were from 19 villages in the Milk treatment, and 333 of them were from 19 villages in the Involvement treatment.[21]

In the survey, we asked whether households in the treatment groups received, could under-

[19] The average energy saving for using AC1 rather than AC2 is 0.1 kwh, and the electricity price was fixed to 0.56 RMB per kwh during our study. Thus, a household saves $200 * 20 * 0.1 * 0.56 \approx 225$ RMB per year.

[20] Our data does not allow us to distinguish between the information effects due to SMS or leaflets.

[21] 35 surveys had partly unrecognizable information, and thus were excluded from our analysis.

stand, and trusted the information we provided to them.[22] Further, we asked about the factors that they viewed important in their purchase decisions, and about demographic variables such as the number of children at home, monthly family income, households' time preferences, and the education level. We also elicited households' willingness to pay for an AC1 relative to AC2 using a second price sealed-bid auction. Moreover, we obtained the supposed frequencies of AC usage in summer and winter.

Finally, we followed Allcott and Taubinsky (2015) and asked households what they believe the intention of our information intervention is in order to assess whether our results could be driven by a mere demand effect. We found that participants' answers were strongly dispersed, speaking against a commonly perceived intention of the study; see Appendix A.2. Jointly with the facts that the decisions are not artificially created and involved high stakes, we view it as highly unlikely that the results we find are significantly biased by a demand effect.

5 Empirical Results

The empirical results are organized as follows. We analyze the purchase behavior in treatment and control villages in Section 5.1 graphically and by means of a standard regression framework. In Section 5.2 we study whether the observed changes are likely to reflect an improvement in individual welfare, by first exploiting data about the average heating consumption in the control group and our survey data (Section 5.2.1), and then by identifying a subsample of households for which the purchase of an AC1 most likely constitutes a decision mistake (Section 5.2.2).

5.1 Information Effects on AC purchases

Our main conjecture is that the villagers have difficulties with evaluating the cost information available in the market when choosing their subsidized product. Therefore, the provision of information aimed at facilitating the comparison of costs between AC's with different efficiency levels should help the villagers identify which product best fits their needs. This contrasts to the standard tenet from microeconomics, where decision-makers are capable of processing all available information in a uniformly identical way, or at the very least behave "as if" they could. Under this premise, information that is essentially a convex combination of already available information should not induce any systematic effects on the decisions made.

[22]In the ex post survey, we asked villagers to evaluate which AC was cheaper in terms of total costs for a given daily usage pattern over 8 years. The survey data shows that among the villagers who confirmed to receive our SMS a significantly larger fraction was able to correctly answer this survey question compared to the control group.

Therefore, a first elementary test of our conjecture is to see whether our information treatments have any effect at all on the purchase decisions relative to the control group. If our conjecture is correct, then we should be able to observe a change in the purchase patterns of the treated villages relative to the control group.[23]

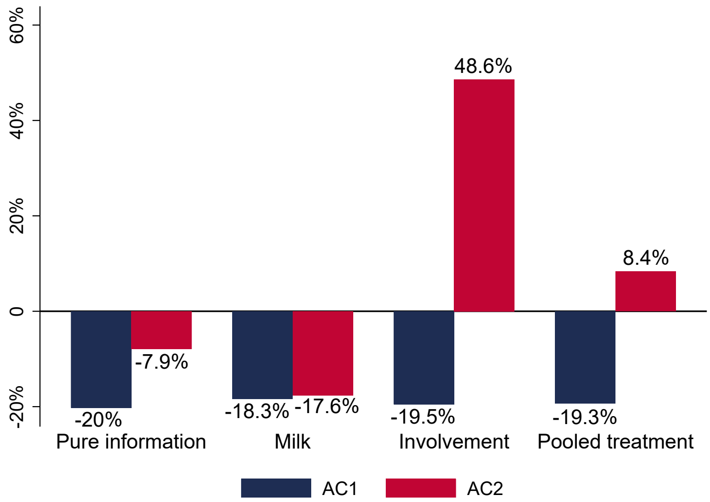

Figure 1: Relative differences of AC choices compared to control group

Notes: Bar plot of relative differences △% between treatemnt and control villages. The 'Pooled treatment' aggregates all information treatments.

Figure 1 displays the differences in AC purchases of the treatment groups relative to the control group.[24] For example, the first blue bar on the left shows that AC's of the higher efficiency level (i.e., AC1) are purchased 20% less often in the Pure Information treatment compared to the control villages. The figure suggests that the information treatments had an impact on AC purchase behavior. We next use a standard regression framework that can account for unobserved village effects and other control variables to assess in a reliable way whether our information intervention altered the purchase behavior.

5.1.1 Pooled Regression Evidence

Figure 1 suggests a substantial change in purchase behavior due to our information interventions. To corroborate this visual impression, we next report the estimation results from a Multinomial Logit (MNL) regression framework that allows us to make more reliable statements about the

[23] Note that this is a purely positive prediction, while our conjecture is normative. Thus, a mere change of behavior cannot support our basic conjecture without additional information – in principle, the change in purchases could also result because our information intervention confused households further. This is the topic of Section 5.2.

[24] We delete purchases with incomplete record, which is either due to missing meter ID or missing record of efficiency level. This gave us a total of 42,454 purchases for analysis. In total, there were 11,913 purchases from villages of the control group, 9165, 10,744, and 10,632 purchases from villages in the Pure Information treatment, Milk treatment, and Involvement treatment, respectively.

possible shifts in the purchase patterns.

Each purchase decision is coded either as "AC1", "AC2" or "Heater". In all estimations, the dependent variable is the purchase decision, where "Heater" serves as the base group. We included two control variables in all regressions: the (subsidized) upfront price of the acquired product, and the electricity consumption by each household; both in logs.[25] We include the former as the products of the different brands vary in their upfront prices, e.g., reflecting differences in horsepower or in the precise degree of energy efficiency. Regarding the latter, we seek to control for household electricity consumption that is not related to heating or cooling behavior, as this varies between households and is most likely correlated with household preferences, size or disposable income. Therefore, we include $Log(E + 1)$ as control variable in our regressions, where $E \geq 0$ is the monthly electricity consumption of a household in October 2019.[26] Finally, we also included township fixed effects to control for possible unobserved heterogeneity at the township level.

In our first test, we assess whether the choices of AC1 and AC2 are different in treated villages relative to those in the control villages, by pooling together all information treatments. The results are reported in **Panel A** of Table 3. The variable of interest is "*Information Treatment*", which is a dummy variable indicating whether the household belongs to one of our three information treatments; robust standard errors at the household level are in parentheses. Columns 1 and 2 display the estimates of the probability for choosing an AC1 or an AC2, respectively, relative to choosing a heater in the control group. Columns 3-5 report the corresponding average marginal effects. These estimates show that the purchase behavior is significantly and substantially different in the treated villages compared to the control group.

First, Column 4 shows that villagers in the treatment groups were on average 1.23 percentage points less likely to choose an AC1 relative to a heater, which is significant at the 1%-level. To gauge the magnitude of this effect, we use the purchase probability of AC1 in the control villages as base probability, which is 11.8 percentage. Thus, information provision actually decreases the probability of acquiring an AC1 by about 10.4 percent, which we deem a substantial effect.[27]

[25] We use the Log-transformation as this is common with skewed variables (see, e.g., Chen et al., 2017).

[26] The average daily temperature of the local area in October 2019 was 15.5 °C implying at most a very low demand for heating. Moreover, October is the month right after the completion of subsidy policy, where the subsidized products most likely are not used yet. Therefore, the monthly electricity consumption in October 2019 was likely to be associated with energy demand other than heating or cooling.

[27] Such an effect size is compatible with other field studies related to information. For example, Chen et al. (2017) find that the information effect of social comparison on driving behavior is about 5%; Cai et al. (2009) find that providing information about the ranking of the most popular dishes could increase dish demand by 13 to 20 percent.

Second, Column 5 reveals that the likelihood of purchasing the less efficient AC2 is increased by 0.3 percentage points among the villagers in the treatment groups; this effect is statistically significant at the 5%-level. In terms of magnitudes, this amounts to an increase by 25% relative to the control group.

Result 1 (Average Information effect) *The average purchase behavior was significantly different in the treatment villages compared to the control group. Specifically, we estimated that the fraction of AC1 purchases diminished by about* 10%*, while the fraction of AC2 purchases increased by about* 25%*, relative to the control group.*

In sum, the data shows that overall the information treatments had a substantial effect on the purchase decisions. As mentioned at the outset, such evidence cannot by itself confirm that information provision actually has improved the quality of choices. Nevertheless, it is consistent with an implication of Hypothesis $\mathbf{H_I}$ in thus that we would expect to observe some shift in purchases if information actually were to reduce the amount of evaluation mistakes.

Columns 6-10 repeats the previous analysis. The only difference is that in Columns 1 - 5 we exclude 6814 households whose electricity consumption in October 2019 was missing.[28] For reasons of completeness and robustness, we also conducted all regressions with the full sample of households, where we replaced the missing observations of electricity consumption with 0, and added a missing indicator for each missing observation. The estimations in Columns 6-10 broadly confirm the findings summarized in Result 1.

Column 3 shows that villagers in the treatment group have a higher likelihood of acquiring a heater relative to the control group. As we do not have an ex ante conjecture about heaters, we discuss this findings in relation to our general interpretation of the empirical results in Appendix A.3. We further remark that it is vital to include heaters in the MNL framework from the statistical viewpoint, despite that our information treatments were entirely aimed at AC's. Heaters were among the feasible choice options, and not including them could cause a selection problem.

Panel B of Table 3 shows the effects of the three information treatments separately relative to the control group. With respect to AC1, we find that only the Milk and Involvement treatments have statistically significant effects on reducing the probability of buying an AC1. The -1.82 (-1.1) percentage points estimate of the Milk (Involvement) treatment in column 4 corresponds

[28]The missing electricity consumptions data from October 2019 to March 2020 indicates that these households were most likely not living there during winter time. Thus, we have no information on how much electricity they would have consumed otherwise. Further, we found that the households with missing data were balanced across the various treatments and the control group.

to a 15.4 (9.3) percent decrease in the choices of AC1. By contrast, column 5 shows that the Pure Information treatment and Involvement treatment increase the likelihood of purchasing AC2 by 0.33 percentage points (27.5% increase) and 0.7 percentage points (58.3% increase), respectively, while the average marginal effect of the Milk treatment is not statistically different from zero. In sum, this shows that the various information treatments seem to have different effects on the purchase behavior. We consider these differences in greater detail in the next section.

5.1.2 Comparing Information Treatments

By Hypotheses $\mathbf{H_{II}}$ and $\mathbf{H_{III}}$, the decision quality in the Milk and Involvement treatments should exceed the one in Pure Information. In the spirit of the last section, we would therefore expect to observe some differences in the respective purchase patterns. To assess this basic conjecture, we compare the purchase probabilities of AC1 and AC2, respectively, with the ones of the Pure Information treatment, using the same MNL framework as before. The results are summarized in Table 4.[29]

We find that AC1 purchases are significantly lower in the Milk treatment compared to Pure Information: The chance of acquiring an AC1 is 1.6 percentage point lower on average; this effect is significant at the 1% level. We also observe that the chance of purchasing AC1 is 0.64 percentage points lower in the Involvement treatment, but this effect is only weakly significant.

Regarding AC2 purchases, we find strong statistical evidence that the Involvement treatment increases the likelihood of acquiring AC2 relative to Pure Information: The chance of buying an AC2 is 0.42 percentage points higher than in Pure Information. The Milk treatment shows only weak evidence for a change of behavior.

Taken together, the evidence in Table 4 reveals some significant differences in the purchase behavior in the Milk and Involvement treatment relative to Pure Information. Further, these findings reinforce the baseline tendency we observed in Result 1 that providing qualified information empirically reduces AC1 purchases and increases AC2 purchases.

[29] The estimations in Table 4 excludes households where we did not have data for the energy consumption in October 2019. The results are robust to including all households, similar to the specifications used in Columns 6-10 of Table 3.

Table 3: The effect of information provision on the decision of AC purchases

			Average Marginal Effect					Average Marginal Effect		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Variables	AC1	AC2	Heater	AC1	AC2	AC1	AC2	Heater	AC1	AC2
Panel A: Effect of the pooled information treatments										
Information Treatments	-0.22***	0.15	0.0093***	-0.0123***	0.0030**	-0.25***	0.08	0.0108***	-0.0129***	0.0022*
	(0.05)	(0.11)	(0.0028)	(0.0027)	(0.0014)	(0.05)	(0.10)	(0.0026)	(0.0025)	(0.0012)
Observations	35,640					42,454				
Pseudo R^2	0.4767					0.478				
Panel B: Effect of each information treatment										
Pure Information Treatment	-0.06	0.23	0.0011	-0.0044	0.0033*	-0.02	0.12	0.00004	-0.0016	0.0016
	(0.07)	(0.15)	(0.0038)	(0.0037)	(0.0018)	(0.07)	(0.14)	(0.0035)	(0.0033)	(0.0016)
Milk Treatment	-0.37***	-0.25*	0.0196***	-0.0182***	-0.0013	-0.43***	-0.33**	0.0224***	-0.0204***	-0.0020
	(0.07)	(0.14)	(0.0036)	(0.0034)	(0.0018)	(0.06)	(0.13)	(0.0033)	(0.0031)	(0.0016)
Involvement Treatment	-0.16**	0.48***	0.0040	-0.0110***	0.0070***	-0.21***	0.43***	0.0066**	-0.0129***	0.0063***
	(0.07)	(0.13)	(0.0035)	(0.0033)	(0.0016)	(0.06)	(0.12)	(0.0032)	(0.0031)	(0.0014)
Observations	35,640					42,454				
Pseudo R^2	0.4783					0.4801				
Sample	Dropped missing observations					Replaced missing with 0, and added missing indicators				

Notes: Control Variables (at the household level) are: i) The log of the price of the subsidized product acquired and ii) The log of electricity consumption in October 2019. We controlled for Township fixed effects by including Township dummies. Because 6814 households' electricity consumption in October 2019 were missing, they were excluded from the MNL estimations in column 1-5. In column 6-10, we replaced the missing observations of electricity consumption with 0, and added a missing indicator for each missing observation. Robust standard errors are reported in parentheses.
Significance levels: * p<0.1, ** p<0.05, *** p<0.01.

We summarize these insights next, where we convert the percentage points estimate into percentage values, using the purchase probabilities of Pure Information as base.

Result 2 (Presentation Effects) *The average purchase behavior was significantly different in the Milk and Involvement treatments compared to the Pure Information treatment. The likelihood of purchasing AC1 is about* 17.7 *percent lower in the Milk treatment relative to the AC1 purchases in Pure Information. The likelihood of purchasing AC2 is about* 38.2% *higher in the Involvement treatment, relative to the AC2 purchases in Pure Information.*

Table 4: Milk and Involvement Treatments compared to Pure Information

Variables	(1) AC1	(2) AC2	Average Marginal Effect (3) Heater	(4) AC1	(5) AC2
Milk Treatment	-0.36***	-0.43***	0.0204***	-0.0166***	-0.0039*
	(0.08)	(0.16)	(0.0041)	(0.0039)	(0.0020)
Involvement Treatment	-0.10	0.28**	0.0022	-0.0064*	0.0042**
	(0.07)	(0.14)	(0.0039)	(0.0037)	(0.0018)
Observations	25,249				
Pseudo R^2	0.46				

Notes: For Columns 3-5 the reported coefficients are average marginal effects of the MNL estimations. Robust standard errors are reported in parentheses. Significance levels: * p<0.1, ** p<0.05, *** p<0.01.

5.2 Decision Quality

From the viewpoint of Hypotheses $\mathbf{H_I}$-$\mathbf{H_{III}}$, we would expect that the purchase behavior in the treated villages differs from the one in the respective control group. The statistical evidence, summarized in Results 1 and 2, shows that the purchase behavior indeed was systematically affected by the information treatments. Specifically, the more efficient AC1 is less likely and the less efficient AC2 more likely to be chosen in treated villages. Nevertheless, the mere fact that the behavior changes in this way does not confirm that the decision quality has effectively improved. We address this central issue next.

Assuming that the observed changes indeed reflect an improved decision quality, the treatment effect we found suggests that, among the households seeking to acquire an AC, the purchase mistakes are such that too many households acquire AC1, and too few AC2, absent any information intervention. The data allows us to corroborate this conjecture in three ways.

First, we use the electricity data from the control villages to infer which AC efficiency level actually constitutes the cheaper option on average. Second, we analyze the data from our ex post survey to verify whether the reported daily usage hours are low enough to make AC1 a dominated option. Third, we study a subsample of the data for which we can infer, with high confidence, that AC1 is a dominated option for the respective households.

5.2.1 Average Heating in Control Villages and Survey Data

Our first falsification of the conjecture that AC1 actually constitutes a dominated option for many households builds on the usage hours inferred from the electricity consumption of the households in the control group. By our randomization procedure, these households should be statistically similar to the households in the treatment groups.

In Section 3.1, we estimated that a household needs to use its AC for at least 15.36 hours per day to make AC1 the cheaper option. The most efficient AC1, among all AC1's available in the market, consumes about 1.3kwh. Rounding this number down to 1kwh and using 80 days (see Table 1) as a proxy for the winter season November 2019 - March 2020, a conservative back-of-the-envelope calculation shows that a household needs to use at least 1229kwh ($= 1 \times 15.36 \times 80$) for heating during this time period to make AC1 the cheaper option.[30]

We obtain a corresponding estimate for household electricity consumption due to heating for the period November 2019 - March 2020 in the control villages from our data on total electricity consumption as follows. This data includes the monthly electricity consumption for all households in the villages from October 2019 to March 2020. The average daily temperature of the local area in October 2019 is 15.5°C, which is substantially higher than the base temperature for heating, meaning that villagers most likely do not heat during this month. Thus, we calculate the electricity consumption for heating purpose in each successive winter month as the difference between total electricity consumption in that month and the baseline electricity consumption in October 2019.

Considering only households featuring a positive monthly electric heating consumption during the winter season, this leaves us with 5158 households in the control villages. Among all these households, only 25.6% have an electricity consumption due to heating above the threshold value of 1229 kwh.[31] This simple calculation strongly suggests that AC1 is a dominated option for a majority of households in our sample.

[30] As before, we do not include any discount factor or interest rate in our calculations. Note that adding such elements would actually decrease the usage cost advantage of AC1, making it even less attractive. Ignoring discount factors and interest rates therefore amounts to a conservative testing strategy.

[31] If we also include households featuring a zero monthly electric heating consumption (e.g., because the household was not populated during the period), this leaves us with 10407 households, out of which only 17% have an electricity consumption due to heating above 1229kwh.

Survey Data The data in our ex-post survey also reveals that AC1 seems to be a dominated option for most households. Specifically, we found that only about 20% of the villagers indicated that their daily usage of AC was more than 10 hours during both the heating season and the cooling season, which suggests that at least 80% of them have used AC less than the 15.36 hours that are needed to make acquiring AC1 worthwhile.

Taken together, the above two results indicate that the reduction in AC1 purchases, and the increase in AC2 purchases, likely amount to an improved assessment of the relative cost advantages by the households due to our information interventions, leading to fewer decision mistakes (i.e., not acquiring AC1 anymore).

Result 3 *The heating pattern of the households in the control group and the data from the ex-post survey suggest that AC1 is a dominated option, in terms of total costs, for a clear majority of households. In this respect, Results 1 and 2 support that our information interventions have successfully improved the decision quality, as AC1 is less often and AC2 more often acquired under our information treatments.*

5.2.2 Purchase Mistakes

Result 3 is based on pro rata considerations, rather than on individual choices. We now use the monthly heating data in the winter months for all households to identify a subsample of households for which we can reasonable argue that AC1 constitutes a dominated option.

As mentioned before, an average daily usage of 15.36 hours of activity are required to make AC1 cheaper than AC2 on average. Using 80 as a proxy for the heating days from November 2019 - March 2020 and the most efficient AC1 in the market (1.3kwh electricity consumption per activity hour), this shows that AC1 is a dominated option, in terms of total usage costs, for a household with less than 1597kwh ($\approx 15.36 \times 1.3 \times 80$).

We now conduct another set of regressions based on the subsample of households with a positive monthly electricity consumption pertaining to heating that, in total, was below 1597kwh for the period November 2019 - March 2020. That is, this subsample consists of households across treatment and control groups for which it is highly likely that AC1 is dominated by AC2 in terms of total costs.

Given the construction of this subsample, we operationalize Hypothesis $\mathbf{H_I}$ by testing whether the probability of conducting a decision mistake, i.e., acquiring AC1 while this is a dominated option, is lower in the information treatments than in the control group. Accordingly, we define an indicator variable, which is "1" if a household acquired AC1 (i.e., conducted a decision mistake) and "0" otherwise (in which case the household acquired AC2 or a heater).

Table 5, **Panel A**, contains the corresponding regressions, using a Probit, Logit and OLS specification, respectively, with the same set of controls we used in our previous regressions. Column (1) shows the average marginal treatment effect of a Probit regression where we pool all

Table 5: The informational effect on purchase mistakes

	Probit		Logit		OLS	
	(1)	(2)	(3)	(4)	(5)	(6)
Variables	Mistake	Mistake	Mistake	Mistake	Mistake	Mistake
Panel A: Information Treatments vs control						
Information treatments	-0.008***		-0.009***		-0.007**	
	(0.003)		(0.003)		(0.003)	
Pure Information Treatment		0.001		-0.001		0.002
		(0.004)		(0.004)		(0.004)
Milk Treatment		-0.013***		-0.015***		-0.012***
		(0.003)		(0.004)		(0.004)
Involvement Treatment		-0.007**		-0.009**		-0.009**
		(0.003)		(0.004)		(0.004)
Observations	31027	31027	31027	31027	31027	31027
(Pseudo-)R^2	0.538	0.539	0.531	0.532	0.381	0.381
Panel B: Milk or Involvement Treatment vs Pure Information Treatment						
Milk Treatment		-0.017***		-0.018***		-0.015***
		(0.004)		(0.004)		(0.004)
Involvement Treatment		-0.008**		-0.007*		-0.009**
		(0.004)		(0.004)		(0.004)
Observations		21696		21696		21696
(Pseudo-)R^2		0.527		0.520		0.359

Notes: In columns 1-4, the reported coefficients are the average marginal effects of a Probit or Logit specification. Observations only include cases where the amount of electricity consumption for heating purpose is smaller than 1597 kilo-wat hours for the whole winter heating period. "Mistake" is a dummy variable, which equals 1 if the household had purchased AC1 that was definitely not an optimal choice for that household, and 0 otherwise. In all the specifications, we have the same control variables as used in Table 3 and Table 4. They are the subsidized upfront price of the purchased product, the $Log(E+1)$ transformation of monthly electricity consumption of households in October 2019, and township dummies.
Robust standard errors are reported in parentheses.
Significance levels: * p<0.1, ** p<0.05, *** p<0.01.

information treatments together. We find that the information interventions on average reduce the likelihood of purchase mistakes by 0.8 percentage point, which is significant at the 1% level. As the base probability of acquiring AC1 in the control group of our subsample is 0.114, this amounts to a 7 percent reduction ($-0.008/0.114 \approx -7\%$) of the purchase mistakes made relative to the control villages. This insight is essentially confirmed by the Logit and OLS estimations, respectively (Columns 3 and 5). Further, this insight is robust to replacing the cutoff electricity consumption that defines our subsample by the degree days based on the NHD15 criterion.[32]

Result 4 (Decision Mistakes) *The likelihood of making a decision mistake (purchasing a dominated option) is significantly and substantially reduced in the information treatment compared to the control group, consistent with Hypothesis* $\mathbf{H_I}$.

5.2.3 Presentation Effects

Columns 2,4 and 6 of Table 5 estimate the likelihood of acquiring AC1 for each information treatment separately, relative to the control group. The most striking observation is that only the coefficients on the Milk and Involvement treatments are statistically significant, but not the ones on Pure Information. This suggests that the decision mistakes diminished if the information was presented in a more accessible or more motivating way, as conjectured by Hypotheses $\mathbf{H_{II}}$ and $\mathbf{H_{III}}$.

Panel B of Table 5 compares the Milk and Involvement Treatment to Pure Information, using the same type of regressions as in **Panel A**. In case of the Probit estimation, Table 5 shows that the Milk treatment outperforms Pure Information in thus that it reduces the purchase mistakes by 1.7 percentage points, which is significant at the 1% level, and amounts to a 18.9% reduction of the mistakes made relative to Pure Information. Likewise, we find that the Involvement Treatment reduces the decision mistakes by 0.8 percentage points, which corresponds to a reduction of about 9% of decision mistakes relative to Pure Information.

In sum, the evidence clearly indicates that people are less likely to choose the dominated option (AC1) in the Milk and Involvement Treatment relative to Pure information, consistent with Hypotheses $\mathbf{H_{II}}$ and $\mathbf{H_{III}}$.

Result 5 (Presentation Effects) *The Milk and Involvement Treatments significantly reduce the likelihood of purchase mistakes by* 11.4% *and* 6% *relative to the control group. Moreover, both treatments reduce the decision mistakes significantly more than Pure Information, consistent with Hypotheses* $\mathbf{H_{II}}$ *and* $\mathbf{H_{III}}$.

[32]We repeated all the regression analysis in Table 5 using the NHD15 as another estimation of the annual heating days. In particular, we take the average of NHD15 in 2017 and 2018 (143 days) as the annual heating days, and the average of NHD15+NCD in 2017 and 2018 (208 days) as the annual AC usage. A back-of-the-envelope calculation pinpoints the cutoff point for daily AC usage at 10.7 hours, suggesting that households consuming less than 1991 kilowatt-hours ($10.7 \times 1.3 \times 143 \approx 1991$ kWh) of electric heating should not purchase an AC1.

Finally, we note from the follow-up survey that about half of the households stated that they received and considered the SMS. While this is a reasonable amount, it shows that the above numbers possibly underestimate the impact of our information intervention on those households that actually considered the SMS. That is, if we assume that only about half of the villagers in the treatment groups considered the SMS, we could roughly double the probability estimates in Result 5 to gauge the effect of the information intervention on those who actually considered the SMS.[33]

While our information treatments reduce the demand for the more efficient AC, this type of AC is still chosen more often than its less efficient counterpart, despite that it likely is a dominated option for many households.[34] One reason could be that many villagers may not have paid attention to our information campaign at all, or that the information may not have been accessible, e.g., due to problems of illiteracy.

Another reason could be strong environmental preferences, favoring the more efficient AC1. Nevertheless, the poor educational situation and the sometimes tenuous financial situation of the households shed doubts that environmental concerns really are driving individual decisions. In this respect, our ex post survey also revealed that a majority of households actually think that AC1 constitutes the *cheaper* option, despite stating heating and cooling preferences which are far too low to warrant such a conclusion.

6 Conclusion

We presented a large-scale randomized field experiment designed to study whether the provision of qualified information affects, and possibly improves, the high-stakes purchase decisions made by households in a rural Chinese area. The study exploited a policy intervention by the government, requiring villagers to replace their coal-based stoves by acquiring electric appliances in the market, such as air-conditioners, which can be used for heating and cooling. These air-conditioners were available in two different levels of energy efficiency across brands. Thus, households faced a trade-off between paying higher upfront prices for a more efficient AC while potentially saving on electricity costs due to the higher energy efficiency.

An adequate economic evaluation thus requires careful deliberation about the anticipated

[33]Nevertheless, it is clear that a consistent evaluation of how effective an information intervention is, must include whether the information was considered at all in the first place.

[34]A similar observation is made by Stadelmann (2020) in case of white goods.

usage costs, and cognitive efforts in conducting the relevant calculations. Given the educational situation in the villages of our study – most villagers do not have higher eduction – identifying and comparing the relevant costs most likely imposes a substantial challenge to the villagers, and therefore is prone to evaluation mistakes.

In view of this presumed intricacy, we propose that providing qualified information about the opportunity costs pertaining to the usage of the less efficient AC can improve the quality of the purchase decisions made. Nevertheless, we also conjecture that mere numerical information may be too abstract and intangible for villagers to process. Thus, the provision of nominal cost information may be of limited efficacy for improving decision quality.

To investigate this possibility, we develop two novel treatment variations, based on different considerations. In the first, we make the opportunity costs salient by expressing them in terms of a real good – milk – the villagers know from everyday life. In the second, we pose the solutions to the calculations about the opportunity costs as a quiz, rather than just displaying this information passively, with the goal of enhancing attention and the cognitive involvement of villagers. All treatments provided the same factual information about the opportunity costs.

The data shows a substantial difference in the purchases made between treatment and control villages. Specifically, we observe a reduction in the purchases of the more energy efficient AC's but an increase in purchases of the less efficient AC's. The data of our follow-up survey and a back-of-the-envelope calculation regarding heating costs both indicate that the more efficient AC indeed seems to be a dominated option in terms of total costs for a substantial majority of households.

To further vindicate whether the observed changes are likely to constitute an improvement in individual welfare, we identify a subsample of households to which the more efficient AC most likely constitutes a dominated option, based on each household's usage pattern. The corresponding data corroborates that the likelihood of purchasing a more efficient AC – and thus conducting a decision mistake – is significantly and substantially decreased in the information treatments. Moreover, we find that this effect is driven by the Milk and Involvement treatments. This strongly suggests that, at least in the context of our study, providing information in a more accessible or cognitively enhancing way clearly outperforms the provision of purely factual information.

More generally, the result that the Milk treatment improves the decision quality relative to Pure Information is consistent with the finding that individuals exhibit distinct behaviors when choice are presented in real rather than in nominal terms (Shafir et al., 1997; Fehr and Tyran, 2001). Similarly, the positive impact of the Involvement treatment relative to Pure Information adds to papers demonstrating that enhancing mental involvement and attention helps people taking actions and reaching better decisions (Gollwitzer and Sheeran, 2006; Hettema et al., 2005; Carrera et al., 2018).

The providers of the more efficient AC advertise its higher efficiency, inter alia, with a corresponding efficiency label. Such labels may have the adverse effect of confusing some consumers by inducing an overly optimistic estimation of the tentative cost savings. This may explain why high upfront prices might be part of a successful equilibrium strategy in the market (Hefti et al., 2020). In this respect, our findings suggest that policy makers may want to design, e.g., energy efficiency labels in a way making sure that the real cost savings associated with a certain label are properly understood by the relevant recipients.

References

Allcott, H. and R. L. Sweeney (2017): "The role of sales agents in information disclosure: evidence from a field experiment," *Management Science*, 63, 21–39.

Allcott, H. and D. Taubinsky (2015): "Evaluating behaviorally motivated policy: Experimental evidence from the lightbulb market," *American Economic Review*, 105, 2501–38.

Auffhammer, M. (2014): "Cooling China: The weather dependence of air conditioner adoption," *Frontiers of Economics in China*, 9, 70–84.

Auffhammer, M. and E. T. Mansur (2014): "Measuring climatic impacts on energy consumption: A review of the empirical literature," *Energy Economics*, 46, 522–530.

Barrington-Leigh, C., J. Baumgartner, E. Carteer, B. E. Robinson, S. Tao, and Y. Zhang (2019): "An evaluation of air quality, home heating and well-being under Beijing's programme to eliminate household coal use," *Nature Energy*, 4, 416–423.

Bessec, M. and J. Fouquau (2008): "The non-linear link between electricity consumption and temperature in Europe: A threshold panel approach," *Energy Economics*, 30, 2705–2721.

Bhargava, S., G. Loewenstein, and J. Sydnor (2017): "Choose to lose: Health plan choices from a menu with dominated option," *The Quarterly Journal of Economics*, 132, 1319–1372.

Cai, H., Y. Chen, and H. Fang (2009): "Observational learning: Evidence from a randomized natural field experiment," *American Economic Review*, 99, 864–82.

Caplin, A. and M. Dean (2015): "Revealed preference, rational inattention, and costly information acquisition," *The American Economic Review*, 105, 2183–2203.

Carrera, M., H. Royer, M. Stehr, J. Sydnor, and D. Taubinsky (2018): "The limits of simple implementation intentions: Evidence from a field experiment on making plans to exercise," *Journal of health economics*, 62, 95–104.

Chen, Y., F. Lu, and J. Zhang (2017): "Social comparisons, status and driving behavior," *Journal of Public Economics*, 155, 11–20.

Cheng, D., J. a. G. C. Liu, X. Kuang, and S. Zhang (2018): "Prediction of Electric Loads over Central China Based on Accumulated Temperature Effect (in Chinese with English abstract)," *Meteorological Science and Technology*, 46, 814–821.

Chetty, R., A. Looney, and K. Kroft (2009): "Salience and taxation: Theory and evidence," *American economic review*, 99, 1145–77.

Davis, L. W. and G. E. Metcalf (2016): "Does better information lead to better choices? Evidence from energy-efficiency labels," *Journal of the Association of Environmental and Resource Economists*, 3, 589–625.

Deutsch, M. (2010a): "The effect of life-cycle cost disclosure on consumer behavior: evidence from a field experiment with cooling appliances," *Energy Efficiency*, 3, 303–315.

——— (2010b): "Life cycle cost disclosure, consumer behavior, and business implications: evidence from an online field experiment," *Journal of Industrial Ecology*, 14, 103–120.

Dranove, D. and G. Z. Jin (2010): "Quality disclosure and certification: Theory and practice," *Journal of Economic Literature*, 48, 935–63.

Duan, X., Y. Jiang, B. Wang, X. Zhao, G. Shen, S. Cao, N. Huang, Y. Qian, Y. Chen, and L. Wang (2014): "Household fuel use for cooking and heating in China: results from the first Chinese Environmental Exposure-Related Human Activity Patterns Survey (CEERHAPS)," *Applied Energy*, 136, 692–703.

Duflo, E., R. Glennerster, and M. Kremer (2007): "Using randomization in development economics research: A toolkit," *Handbook of development economics*, 4, 3895–3962.

Fehr, E. and J.-R. Tyran (2001): "Does money illusion matter?" *American Economic Review*, 91, 1239–1262.

Frederick, S., N. Novemsky, J. Wang, R. Dhar, and S. Nowlis (2009): "Opportunity cost neglect," *Journal of Consumer Research*, 36, 553–561.

Gollwitzer, P. M. and P. Sheeran (2006): "Implementation intentions and goal achievement: A meta-analysis of effects and processes," *Advances in experimental social psychology*, 38, 69–119.

Grubb, M. D. (2015): "Failing to choose the best price: Theory, evidence, and policy," *Review of Industrial Organization*, 47, 303–340.

Hansen, J., M. Sato, J. Glascoe, and R. Ruedy (1998): "A common-sense climate index: Is climate changing noticeably?" *Proceedings of the National Academy of Sciences*, 95, 4113–4120.

Hefti, A., S. Liu, and A. Schmutzler (2020): "Preferences, Confusion and Competition," *CEPR Working Paper.*

Heinzle, S. L. (2012): "Disclosure of energy operating cost information: A silver bullet for overcoming the energy-efficiency gap?" *Journal of Consumer Policy*, 35, 43–64.

Hettema, J., J. Steele, and W. R. Miller (2005): "Motivational interviewing," *Annu. Rev. Clin. Psychol.*, 1, 91–111.

Hossain, T. and J. Morgan (2006): "...Plus shipping and handling: Revenue (non) equivalence in field experiments on ebay," *The BE Journal of Economic Analysis & Policy*, 6.

Houde, S. (2018): "How consumers respond to product certification and the value of energy information," *The RAND Journal of Economics*, 49, 453–477.

Jessoe, K. and D. Rapson (2014): "Knowledge is (less) power: Experimental evidence from residential energy use," *American Economic Review*, 104, 1417–38.

Kallbekken, S., H. Sælen, and E. A. Hermansen (2013): "Bridging the energy efficiency gap: A field experiment on lifetime energy costs and household appliances," *Journal of Consumer Policy*, 36, 1–16.

Kaufmann, C., T. Müller, A. Hefti, and S. Boes (2018): "Does personalized information improve health plan choices when individuals are distracted?" *Journal of economic behavior & organization*, 149, 197–214.

Kendon, M., M. McCarthy, S. Jevrejeva, and T. Legg (2017): "State of the UK Climate 2016," *Met Office, Exeter, UK.*

Lacetera, N., D. G. Pope, and J. R. Sydnor (2012): "Heuristic thinking and limited attention in the car market," *American Economic Review*, 102, 2206–36.

Li, J., L. Yang, and H. Long (2018): "Climatic impacts on energy consumption: Intensive and extensive margins," *Energy Economics*, 71, 332–343.

Liu, J., D. L. Mauzerall, Q. Chen, Q. Zhang, Y. Song, W. Peng, Z. Klimont, X. Qiu, S. Zhang, M. Hu, et al. (2016): "Air pollutant emissions from Chinese households: A major and underappreciated ambient pollution source," *Proceedings of the National Academy of Sciences*, 113, 7756–7761.

Luo, C., S. Li, and T. Sicular (2020): "The long-term evolution of national income inequality and rural poverty in China," *China Economic Review*, 101465.

MCPRC (2003): "Code for design of heating ventilation and air conditioning (GB50019-2003)," 1893–1951.

Milkman, K. L., J. Beshears, J. J. Choi, D. Laibson, and B. C. Madrian (2011): "Using implementation intentions prompts to enhance influenza vaccination rates," *Proceedings of the National Academy of Sciences*, 108, 10415–10420.

——— (2013): "Planning prompts as a means of increasing preventive screening rates," *Preventive Medicine*, 56, 92–93.

Newell, R. G. and J. Siikamäki (2014): "Nudging energy efficiency behavior: The role of information labels," *Journal of the Association of Environmental and Resource Economists*, 1, 555–598.

Nickerson, D. W. and T. Rogers (2010): "Do you have a voting plan? Implementation intentions, voter turnout, and organic plan making," *Psychological Science*, 21, 194–199.

Payne, J. W., J. R. Bettman, and E. J. Johnson (1993): *The Adaptive Decision Maker*, Cambridge University Press.

Persson, E. and G. Tinghög (2020): "Opportunity cost neglect in public policy," *Journal of Economic Behavior & Organization*, 170, 301–312.

Read, D., C. Y. Olivola, and D. J. Hardisty (2017): "The value of nothing: Asymmetric attention to opportunity costs drives intertemporal decision making," *Management Science*, 63, 4277–4297.

Rubin, H. and T. Sellke (1986): "On the distributions of sums of symmetric random variables and vectors," *The Annals of Probability*, 14, 247–259.

Shafir, E., P. Diamond, and A. Tversky (1997): "Money illusion," *The Quarterly Journal of Economics*, 112, 341–374.

Shi, Y., X. Gao, Y. Xu, F. Giorgi, and D. Chen (2016): "Effects of climate change on heating and cooling degree days and potential energy demand in the household sector of China," *Climate Research*, 67, 135–149.

Shi, Y., G. Wang, X. Gao, and Y. Xu (2018): "Effects of climate and potential policy changes on heating degree days in current heating areas of China," *Scientific reports*, 8, 1–13.

Sims, C. A. (2003): "The Implications of rational inattention," *Journal of Monetary Economics*, 50, 665–690.

Spiegler, R. (2011): *Bounded rationality and industrial organization*, Oxford University Press.

Spinoni, J., J. Vogt, and P. Barbosa (2015): "European degree-day climatologies and trends for the period 1951–2011," *International Journal of Climatology*, 35, 25–36.

Stadelmann, M. (2020): "How big is the energy gap? An empirical study on online purchases of white goods in Switzerland." *Working paper.*

Stadelmann, M. and R. Schubert (2018): "How do different designs of energy labels influence purchases of household appliances? A field study in Switzerland," *Ecological Economics*, 144, 112–123.

Thaler, R. (1980): "Toward a positive theory of consumer choice," *Journal of economic behavior & organization*, 1, 39–60.

Thom, H. (1952): "Seasonal degree-day statistics for the United States," *Monthly Weather Review*, 80, 143–147.

——— (1954): "The rational relationship between heating degree days and temperature," *Monthly Weather Review*, 82, 1–6.

Zachariadis, T. and N. Pashourtidou (2007): "An empirical analysis of electricity consumption in Cyprus," *Energy Economics*, 29, 183–198.

A Online Appendix: Supplementary Material

A.1 Balanced Data

To test whether our randomization procedure resulted in a balanced partition of the population with respect to the observable data, we conducted the following t-tests based on the data summarized in Table 2. As can be seen from the table, we cannot reject equality of the means in any binary comparison that can be made.

Table 6: p-values for t-tests of equality of means

	Control vs Pure Info	Control vs Milk	Control vs Involvement	Pure Info vs Milk	Pure Info vs Milk	Milk vs Involvement
Number of households	0.79	0.78	0.78	0.53	0.58	0.96
Population size	0.68	0.96	0.93	0.61	0.62	0.96
Inome (RMB)	0.21	0.33	0.33	0.75	0.73	0.98

A.2 Follow-up Survey

In this section, we report on the results of our follow-up survey related to the SMS intervention and the possibility of a demand effect.

Demand Effect We follow Allcott and Taubinsky (2015) to examine if there is a demand effect on the purchases decisions. If the survey participants cannot easily infer the intent of the study, then it is less likely that there is a demand effect. In the post-experiment survey, we asked participants what they thought the intent of the study was. Table 7 shows that the perceived intent in each group was highly dispersed, speaking against the presence of a demand effect.

SMS Reception In order to gauge whether our SMS interventions were registered by the villagers, we asked survey participants in the treatment groups the following questions: 1. whether they had received either SMS or leaflets from researchers from ShanghaiTech University; 2. whether they were aware of the provided information even if they did not receive any information from the researchers (e.g., by means of "word-to-mouth"). The 1st row of Table 8 shows that there were 30% $\sim$ 50% of the respondents received the information, suggesting that our interventions reached a reasonable amount of villagers. In terms of villagers' trust in the information as well as the usefulness of the information, we also asked survey participants how trustworthy the information were on a scale from 1 to 5, and whether the information was

Table 7: Perceived Intent of the Study by survey participants

	(1)	(2)	(3)	(4)
What do you think the intent of the study of the researches from ShanghaiTech was?	Control	Pure information	Milk	Involvement
1. Sales promotion for AC1	0.10	0.14	0.19	0.14
2. Understand why people buy AC1 vs. AC2	0.34	0.26	0.19	0.29
3. Understand the effect of price factor on AC purchases	0.17	0.10	0.07	0.11
4. Test whether the ability to calculate energy costs affects purchase decisions on AC.	0.21	0.13	0.16	0.14
5. Understand what functions of AC's are the most important to people	0.24	0.24	0.25	0.24
6. None of the above	0.28	0.33	0.27	0.27
Number of Respondents	366	230	282	333

Notes: This table presents the share of villagers in each group who responded to the question of the intent of the study.

useful in their purchase decision. Table 8 shows the share of respondents for each question in each treatment group. It clearly shows that villagers highly trust the information. Moreover, more than half of the respondents in each treatment group found the information useful, while many of the remaining respondents were not sure or could not understand the information due to illiteracy.

Table 8: How well information is delivered

	Pure information	Milk	Involvement
Receive information: receive SMS or leaflet or aware of the information	0.48	0.41	0.32
Number of Respondents	228	280	330
Trust information	0.96	0.92	0.95
Number of Respondents	209	224	303
Information is useful	0.50	0.50	0.63
Number of Respondents	109	146	106

Notes: This table presents the share of villagers in each group. "Receive information" is a dummy variable that equals 1 if the survey participant indicated that s/he had received either SMS or leaflet, or were aware of the information from others, 0 otherwise. "Trust information" is a dummy variable that equals 1 if the survey participant revealed that s/he trusted or fully trusted the provided information, 0 if s/he was not sure, or did not trust the information completely . "Information is useful" is a dummy variable that equals 1 if the survey participant found the information useful, 0 if s/he found it not useful, or did not care about the information, or did not know, or could not understand the information.

A.3 Demand for Heaters

While our study squarely focused on AC purchases, mainly because heaters did not feature different energy efficiency levels, we observe in Table 3, **Panel A**, that the probability of acquiring a heater is significantly higher in the pooled information treatments than in the control group.[35] **Panel B** further reveals that this effect is driven by the Milk treatment. While we do not have an ex ante hypothesis on the effects of our information intervention on the demand for heater, we believe that this empirical pattern is not at odds with our findings regarding AC purchases.

In our follow-up survey, we extracted the Willingness-To-Pay (WTP) for AC1 and AC2 using a second-price auction as incentive scheme.[36] Table 9 presents the results, where we regress the WTP for AC1 and AC2 by OLS on the various information treatments. The table shows that the Milk Treatment significantly reduces the WTP for AC1 and AC2 compared to the control group, while no other treatment had such an effect.

Table 9: WTP relative to control group

Variables	(1) WTPAC1	(2) WTPAC2
Pure Information Treatment	-15.624	-4.136
	(83.694)	(76.556)
Milk Treatment	-235.768***	-131.644**
	(65.888)	(61.333)
Involvement Treatment	107.209	147.980
	(82.532)	(76.174)
Observations	872	872
R^2	0.079	0.045

Notes: "WTPAC1" and "WTPAC2" are villagers' stated WTP for AC1 and AC2, respectively. We excluded invalid cases where WTP was either negative or greater than the highest market price. We controlled for township fixed effects. Robust standard errors are reported in parentheses.
Significance levels: ** p<0.05, *** p<0.01.

In terms of interpretation, we believe that this finding can be reconciled with the increased demand for heaters in the Milk Treatment in the following sense. The WTP corresponds to the maximal upfront price somebody wants to pay for an AC. This price, in principle, accounts for preferences as well as the anticipated usage costs. Thus, if the estimated usage costs were

[35] The fact that heaters were the most frequently purchased type of appliance is not surprising as heaters are substantially cheaper in terms of upfront prices than AC's.

[36] We used a second-price sealed-bid auction for two AC's with identical features, except for the energy efficiency level. The participant with the highest willingness to pay for the randomly selected AC will receive the AC and pay the second highest willingness to pay.

to increase in the Milk treatment while preferences are unaffected, this would manifest itself through a lower WTP.

Table 9 shows that the WTP for AC generally is lower than in the control group, which indicates that, indeed, people may have a tendency to underestimate the usage costs of AC's, which the Milk treatment effectively corrects.[37] Such an effect is intuitive because, among all information treatments, the Milk treatment is the only one to make the real value of the costs salient. But if the households' cost estimates increase in general, this tends to shift demand towards the substantially cheaper heaters (upfront prices vary from 190 to 2000 RMB), in particular for households that are close to indifferent between heater and AC in terms of true preferences. This provides a possible explanation for why we observe an increase in the demand for heaters in the Milk treatment, but not so in the other treatments.

A.4 Leaflets

[37] In our formal model in Appendix B, we derive our hypotheses about AC1 and AC2 under the neutral presumption that the perception errors are symmetrically dispersed. We still obtain the same predictions if people tend to underestimate usage costs.

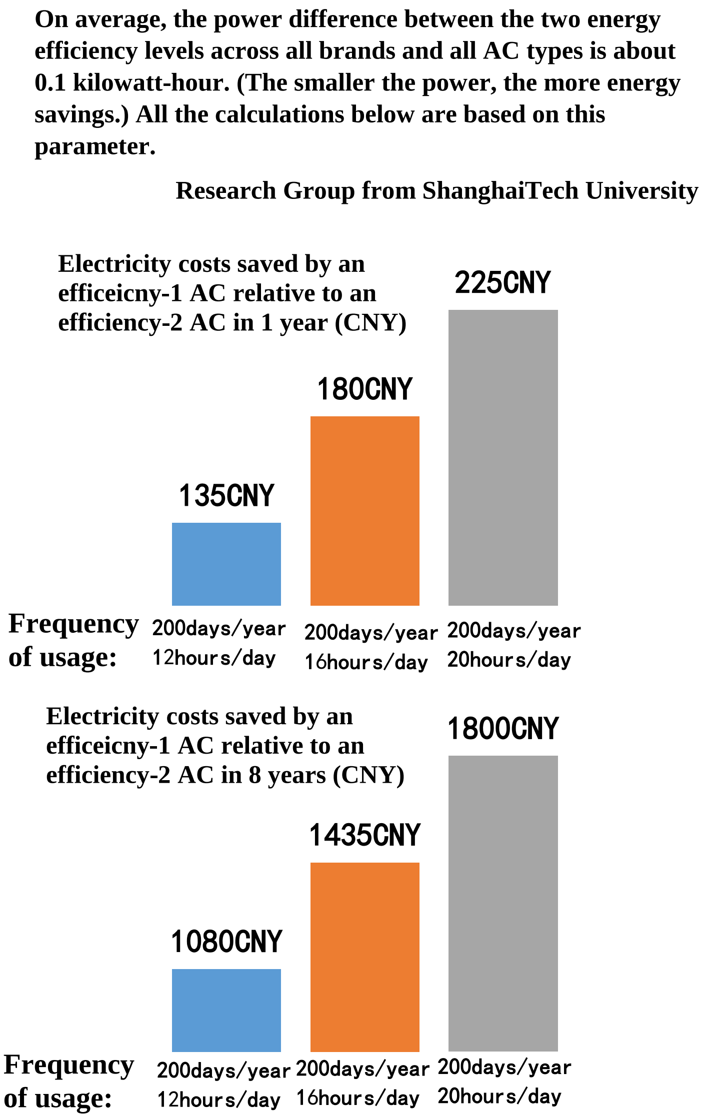

Figure 2: The leaflet for the pure information treatment

A.5 SMS

Table 10 illustrates examples of the messages used in this study for all three information treatments.

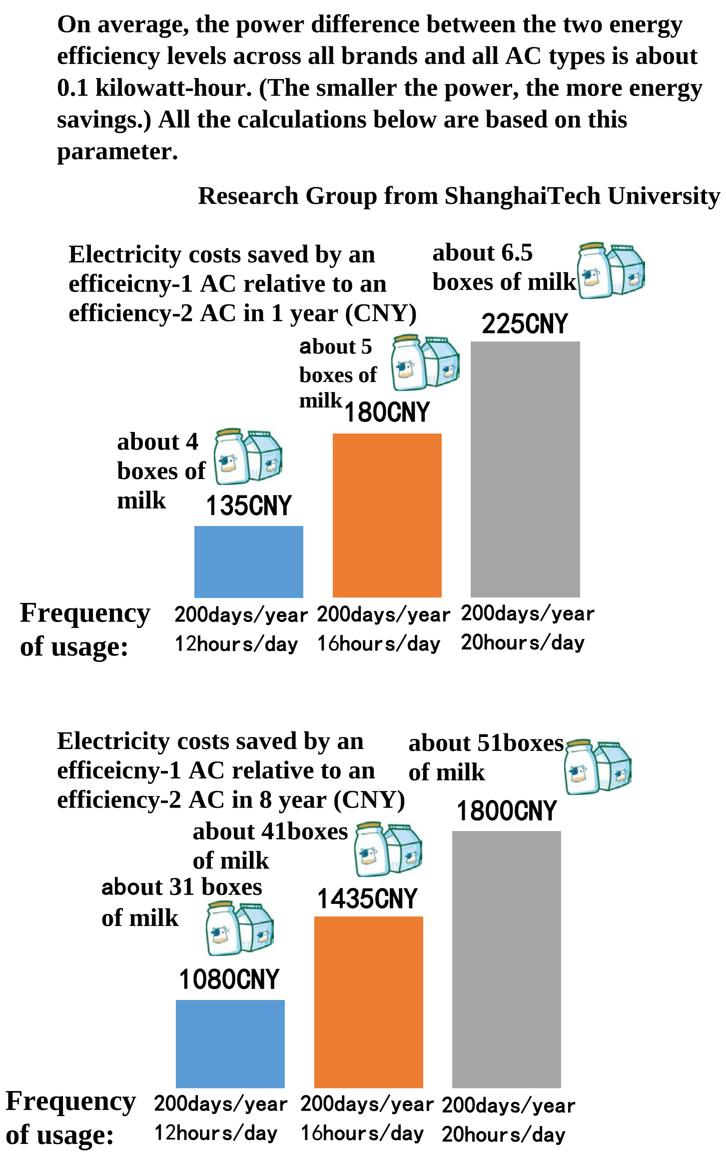

Figure 3: The leaflet for the opportunity cost treatment

(FRONT)

1. If you use an efficiency-1 AC on 200 days per year for 1 hours per day, then you can save 90 CNY over 8 years relative to an efficiency- 2 AC. If you use AC on 200 days per year for 12 hours per day, how much can you save over 8 years if you use an efficiency-1 AC relative to an efficiency-2 AC?

   Please choose your answer: (1) 1080 CNY, (2) 880 CNY, (3) 680 CNY.

2. If you use an efficiency-1 AC on 40 days per year for 16 hours per day, then you can save 287 CNY over 8 years relative to an efficiency- 2 AC. If you use AC on 200 days per year for 16 hours per day, how much can you save over 8 years if you use an efficiency-1 AC relative to an efficiency-2 AC?

   Please choose your answer: (1) 1700 CNY, (2) 1435 CNY, (3) 1000 CNY.

3. If you use an efficiency-1 AC on 200 days per year for 1 hours per day, then you can save 90 CNY over 8 years relative to an efficiency- 2 AC. If you use AC on 200 days per year for 20 hours per day, how much can you save over 8 years if you use an efficiency-1 AC relative to an efficiency-2 AC?

   Please choose your answer: (1) 1800 CNY, (2) 1500 CNY, (3) 1000 CNY.

The answers are on the back.

Figure 4: The leaflet for the involvement treatment (front)

(BACK)

Answer:1. 1080 CNY； 2. 1435 CNY； 3. 1800 CNY

On average, the power difference between the two energy efficiency levels across all brands and all AC types is about 0.1 kilowatt-hour. (The smaller the power, the more energy savings.) All the calculations below are based on this parameter.

Research Group from ShanghaiTech University

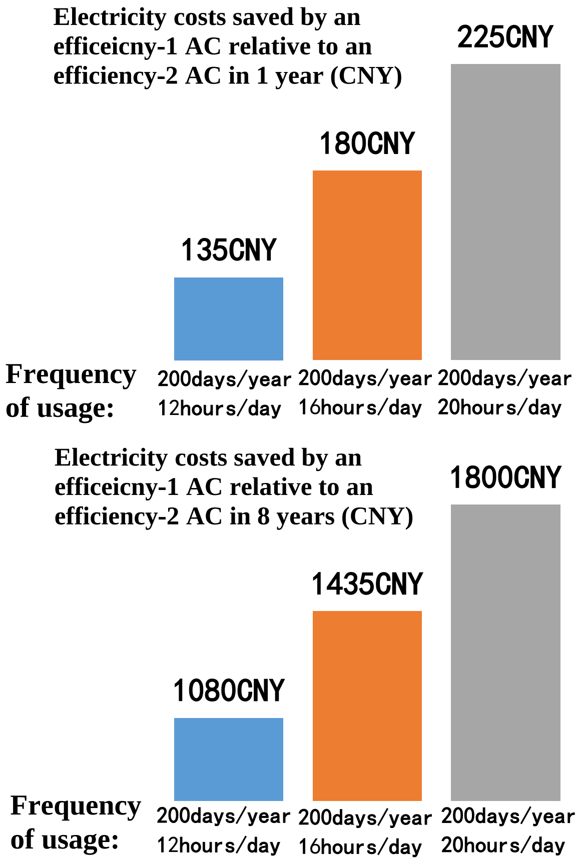

Figure 5: The leaflet for the involvement treatment (Back)

Table 10: SMS Examples

	First: Energy savings (Morning)	Second: Question (Noon)	Third: Answer (Evening)
Pure Information Treatment	An AC with a higher efficiency costs more when you buy it, but you may save money because it is more efficient. The more you use your AC the more you save with a more efficient AC. Example: if you use an efficiency-1 AC on 200 days per year for 20 hours per day, then you can save 225 RMB per year, or 1800 RMB over 8 years relative to an efficiency-2 AC. [ShanghaiTech]	If you use AC on 200 days per year for 20 hours per day, how much can you save over 8 years if you use an efficiency-1 AC relative to an efficiency-2 AC? [ShanghaiTech]	1800 RMB. On average, the power difference between the two energy efficiency levels across all brands and all AC types is about 0.1 kilowatt-hour. All the calculations are based on this parameter. [ShanghaiTech]
Milk Treatment	An AC with a higher efficiency costs more when you buy it, but you may save money because it is more efficient. The more you use your AC the more you save with a more efficient AC. Example: if you use an efficiency-1 AC on 200 days per year for 20 hours per day, then you can save 225 RMB (equal to about 6.5 boxes of milk) per year, or 1800 RMB (about 51 boxes of milk) over 8 years relative to an efficiency-2 AC. [ShanghaiTech]	If you use AC on 200 days per year for 20 hours per day, how much can you save over 8 years if you use an efficiency-1 AC relative to an efficiency-2 AC, and how many boxes of milk does it equal to? [ShanghaiTech]	1800 RMB, 51 boxes of milk. On average, the power difference between the two energy efficiency levels across all brands and all AC types is about 0.1 kilowatt-hour. All the calculations are based on this parameter. [ShanghaiTech]
Involvement Treatment	An AC with a higher efficiency costs more when you buy it, but you may save money because it is more efficient. The more you use your AC the more you save with a more efficient AC. Example: if you use an efficiency-1 AC on 200 days per year for 1 hours per day, then you can save 90 RMB over 8 years relative to an efficiency-2 AC. [ShanghaiTech]	If you use AC on 200 days per year for 20 hours per day, how much can you save over 8 years if you use an efficiency-1 AC relative to an efficiency-2 AC? Please choose your answer: 1800 RMB, 1500 RMB, 1000 RMB. [ShanghaiTech]	If you use AC on 200 days per year for 20 hours per day, you can save 225 RMB from an efficiency-1 AC, and 1800 RMB over 8 years. On average, the power difference between the two energy efficiency levels across all brands and all AC types is about 0.1 kilowatt-hour. All the calculations are based on this parameter. [ShanghaiTech]

B Online Appendix: Model of Misperception

In the following, we present a model of misperception which provides a rigorous basis for the intuitive hypothesis we stated in Section of the main text. This section is structured as following. In Section B.1 we derive a simple model of product comparisons with misperceptions in the context of our study, and show in Section B.2 that interventions which either improve the quality of the information available or the attention devoted to the decision problem can reduce the likelihood of making a decision mistake due to misperception. In Section B.3 we make the connection to our information treatment explicit. Finally, we consider the case where attention is optimally allocated by the household itself given its available information in Section B.4, and show that our main prediction that improved information can diminish the likelihood of making decision mistakes applies in this case as well.

B.1 Product Comparisons and Misperceptions

Let $\hat{F}_j$ denote the overall expenditure that a household associates with AC $j \in \{1, 2\}$. We assume that perceived and effective expenditures may differ according to cognitive difficulties associated with deriving the appropriate costs. Hence we let $\hat{F}_j \neq F_j$ in general, where the latter denotes effective expenditures. Further, we suppose that expenditures (effective and perceived) may be decomposed as $F_j = p_j + Q_j$, where p_j denotes the upfront price of AC j and Q_j is the expected cost of usage.[38]

Compared to the upfront price p_j, obtaining an estimate of the usage cost Q_j involves cognitive operations and information processing, and as such is subject to possible mistakes. Therefore, we assume that perceived and effective expenditures may differ only due to misperceptions in Q_j.[39] Thus we let

$$\hat{F}_j = p_j + \hat{Q}_j, \tag{1}$$

where p_j is the upfront price of AC j, and $\hat{Q}_j$ is the perceived anticipated cost of usage.

Consider a household that intends to purchase an AC $j \in \{1, 2\}$, where the anticipated total costs $\hat{F}$ are determined according to (1). The household acquires the AC which appears to be less expensive. Specifically, $j = 2$ is acquired if $\hat{F}_2 < \hat{F}_1$. Letting $p_1 - p_2 \equiv \Delta p$ and $\Delta\hat{Q} \equiv \hat{Q}_2 - \hat{Q}_1$, the household thus acquires $j = 2$ whenever

$$\Delta p > \Delta\hat{Q}. \tag{2}$$

[38] Thus, Q_j is the present value of the expected discounted future energy costs of heating and cooling, and depends on electricity prices, weather patterns, household preferences and usage.

[39] This is consistent with a leading assumption in the behavioral IO literature: In situations where the overall price of a product has multiple components, decision mistakes are assumed to occur via the price component which is less accessible to consumers (see, e.g., Spiegler, 2011; Grubb, 2015 for overviews).

In the following we suppose that $\Delta p > 0$ and $\Delta Q > 0$, reflecting the fact that while AC $j = 1$ is more expensive regarding the upfront price, its improved energy efficiency leads to a cost advantage in the usage costs for any fixed and given amount of usage. We suppose that the misperception per unit of cost difference is quantified by a random variable $X > 0$ according to

$$\Delta\hat{Q} = X\Delta Q. \tag{3}$$

A household with $X > 1(< 1)$ overvalue (undervalue) the usage cost advantage of $j = 2$. By (3) we assume that the size of the misperception varies with the magnitude of ΔQ_j, meaning that for any given $X \neq 1$, the misperception $\Delta\hat{Q}$ becomes negligible if the actual cost advantage ΔQ is small. That small differences also imply small mistakes seems an intuitive property to impose on the nature of perception errors, In particular, we deem this more reasonable than to assume a constant additive error which is independent of the magnitude of ΔQ.[40]

It shall be formally more convenient to replace X by the random variable defined by $\varepsilon \equiv X - 1$, noting that always $\varepsilon > -1$. By (2) and (3), the household then acquires the less efficient AC $j = 2$ if

$$\varepsilon < \frac{\Delta p}{\Delta Q} - 1 \equiv w. \tag{4}$$

As $\frac{\Delta p - \Delta Q}{\Delta Q}$ measures the relative advantage of the less efficient AC $j = 2$, condition (4) says that a household correctly chooses $j = 2$ whenever its misperception ε is smaller than the relative advantage of $j = 2$.

We refer to the random variable ε as the aggregate cost misperceptions, and think of these as composed of several different sources of misperception. We assume that these sources are not simply invariant characteristics of a household, but that they depend on the information available to the household as well as on the attention devoted to the decision problem by the household.

To make things explicit, we illustrate this notion of perception mistakes considering the simple case of two sources of perception errors.[41] Specifically, let

$$\varepsilon = \alpha_1 Y_1 + \alpha_2 Y_2 \equiv X_1 + X_2, \tag{5}$$

where Y_1, Y_2 are two continuous and independent random variables capturing two different sources of confusion, and $\alpha_1, \alpha_2 > 0$ are weights quantifying the relative impact of the possible

[40] Because $\Delta\hat{Q} = \Delta\hat{Q}_2 - \Delta\hat{Q}_1$ in the above derivation, one could also seek to derive $\Delta\hat{Q}$ by putting a stochastic structure on the seemingly more primitive variables $\Delta\hat{Q}_1, \Delta\hat{Q}_2$. This approach, however, would not add generality to the model as we shall assume a zero-symmetric distribution of the possible perception mistakes $\Delta\hat{Q}$, which implies that $\Delta\hat{Q}$ can always be decomposed into a sum of two zero-symmetric random variables (Rubin and Sellke, 1986). Moreover, we believe that at least a part of the possible perception mistakes comes from the fact that a household needs to compare usage costs besides deriving them.

[41] It should become clear from the subsequent derivations that our results easily generalize to the case of n different sources.

perception errors of the two sources on aggregate misperception.[42] Wlog, we impose all relevant statistical properties on $X_j \equiv \alpha_j Y_j$ (rather than on Y_j).

For example, one conceivable source of misperception in the context of our empirical study is that households may misjudge costs because they have difficulties processing large and largely abstract numbers, as opposed to thinking in opportunity costs expressed, e.g., in units of milk. For illustrative purpose, we shall assume that X_1 capture the errors made due to such misperception, while X_2 collates all other sources of misperceptions.

Let X_1, X_2 be continuous random variables with density functions $f_1(\cdot), f_2(\cdot)$, respectively. We consider the case of unsystematic perception errors, meaning that the possible misperceptions could over- or undervalue the true costs with equal probability. Such a notion of unbiased confusion is supported by a lot of evidence from consumer research, marketing and psychology (Hefti et al., 2020). We therefore assume that for each $i \in \{1, 2\}$, X_i is a symmetric random variable, i.e., its density $f_i(\cdot)$ is symmetric at zero with $(-\bar{s}_i, \bar{s}_i)$, $\bar{s}_i > 0$. It follows that the aggregate misperception ε in (5) then also has a zero-symmetric density $f_\varepsilon(x)$ with support $(-s, s)$, $s = \bar{s}_1 + \bar{s}_2$.

By (4) and (5), the probability that the household chooses AC $j = 2$ is

$$Pr(\varepsilon < w) = F_\varepsilon(w) = \int_{-\infty}^{\infty} F_1(w + e) f_2(e) de, \tag{6}$$

where $F_1(\cdot)$ is the CDF pertaining to X_1. If $\Delta p > \Delta Q$ (hence $w > 0$), the less efficient AC $j = 2$ is the optimal choice for the household, and in the following we take $w > 0$ as given.[43] Because ε is zero-symmetric $F_\varepsilon(w) > 1/2$, and $F_\varepsilon(w) = 1$ if there are no misperceptions at all (i.e., X_1, X_2 both are degenerate at zero).

B.2 Mental States and Information Interventions

We now develop the idea that the different sources of perception errors depend on the information available to a household as well as on the attention devoted to the decision problem. Formally, we assume that each X_j is a function of $(m_j, I_j) \in \mathbb{R}_+^2$, where m_j quantifies the amount of attention devoted to source j and I_j measures the quality of the information available to the household about that source. That is, an element $(m, I) \equiv \{(m_1, I_i), (m_2, I_2)\} \in M \subset \mathbb{R}_+^4$ represents the mental state of a household when evaluating the two AC's, and thus

$$\varepsilon(m, I) = X_1(m_1, I_1) + X_2(m_2, I_2)$$

describes the dispersion of misperceptions given mental state (m, I).

[42] We essentially add the weights α_1, α_2 to add realism, as this captures that not all sources might contribute equally to the aggregate decision mistakes. For the qualitative results derived below, the play no role.

[43] A similar analysis would pertain to the case where $j = 1$ were optimal ($w < 0$).

This setting becomes meaningful by specifying how exactly a change in mental states can affect the dispersion of misperceptions in each source. Acknowledging that an intimate connection between information and attention may exist for various reasons,[44] we only seek to impose the intuitive monotonicity assumption that more attention, i.e., a more careful consideration of the choice options, as well as improved information can diminish the misperceptions resulting from one or multiple sources.[45]

By "diminished" we mean that the magnitude of the strongest perception errors is reduced, while the relative odds of the remaining perception errors remains constant. The motivation for these structural assumptions is that if the brain still makes unsystematic perception mistakes, the errors that may arise should be dispersed by the same statistical principle as before, but the scope for errors has been reduced.[46]

Formally, these assumptions mean that interventions induce symmetric truncations of the perception errors X_j, which we make more precise next. Let $(m, I) = (0, 0)$ denote the (normalized) situation featuring both minimal information and attention. Thus, misperception in each X_j is given by a zero-symmetric density function $f(\cdot)$ with support $\bar{s}_j \equiv s(0, 0)$. That is, the random variable $\bar{X}_j \equiv X_j(0, 0)$ conforms to the situation with maximal confusion in source $j \in \{1, 2\}$.[47]

For any mental state with $(m_j, I_j) \geq (0, 0)$, $X_j(m_j, I_j)$ then is a symmetric truncation of $\bar{X}_j$. Because any symmetric truncation of $\bar{X}_j$ is fully described by its support, we identify $X_j(m_j, I_j)$ by its support $(-s_j, s_j)$, where $s_j = s_j(m_j, I_j)$ and we assume that $\frac{\partial s_j(m_j,I_j)}{\partial m_j}, \frac{\partial s_j(m_j,I_j)}{\partial I_j} < 0$ for any $(m_j, I_j) \neq (0, 0)$. Thus, a mental state with $(m'_j, I'_j) > (m_j, I_j)$ has $s'_j < s_j$ and thus features less confusion from source j than state (m_j, I_j).

The following proposition shows that if (m, I) is the current mental state of a household, then an information intervention leading to $(m', I') \geq (m, i)$ with $(m', I') \neq (m, i)$ reduces the likelihood of making a decision mistake.[48]

Proposition 1 *Let $\Delta p > \Delta Q$ and $\pi(m, i) \equiv Prob(\varepsilon(m, I) < \frac{\Delta p}{\Delta Q} - 1) \in (1/2, 1)$ be the chance of (correctly) choosing AC $j = 2$ given by (6). Then $\pi(m', I') > \pi(m, I)$ whenever $(m', I') \geq (m, I)$ and $(m', I') \neq (m, I)$, i.e., the likelihood of making a decision mistake due to misperception is lowered under mental state (m', I').*

[44]For example, if attention is a fixed capability, better information about a source could imply that a household can reshuffle its attention to other sources, e.g., due to solving an optimization problem as in the rational inattention literature pioneered by Sims (2003), or because of salience effects Kaufmann et al. (2018).

[45]Note that interventions can, in principle, also have confusing effects, in particular if the interventions originate from firms seeking to sell certain products. Such a possibility of "intentional confusion" is analyzed by Hefti et al. (2020) in the context of a strategic game.

[46]That is, we think of the fundamental statistical law determining the distribution of the mistakes $f_j(\cdot)$ as an intrinsic property of the human brain which as such is not affected by information or attention.

[47]Note that it suffices to define a base distribution $\bar{X}_j$ relative to which all truncations of X_j are derived; given $\bar{X}_j$ the collection of symmetric truncations then are totally ordered.

[48]The proof can be found at the end of this section.

B.3 Relation to our Information Treatments

We now explain our main hypotheses regarding the information interventions we conducted in the empirical part of this study through the lens of the above model. In the control group, no additional information was provided to households other than the one by the sellers of the various AC's. Let the mental state in the control group be given by (m, I). By contrast, we provided the households with additional information in all three information treatments about the usage cost difference ΔQ.

In the Pure Information treatment, we provided additional factual information about the nominal cost difference ΔQ. This means that the households do not need to search for similar figures, nor need they come up with similar calculations on their own. In terms of our model, we interpret this as an informational improvement such that $(m', I') \geq (m, I)$ with $I' \neq I$, which predicts that the probability of making a decision mistake should deteriorate.

However, this information effect could be small if providing mere factual information does not have a strong effect on the various sources of perception mistakes X_i. In particular, as mentioned earlier, households still need to understand and work with large numbers, and relate them to their needs, which may be a source of confusion in its own.

For this reason, transforming these numbers in something they know the value of from every-day life, such as quantities of milk, might alleviate such a confusion. We therefore think of the Milk Treatment as inducing an informational improvement $(m', I'') \geq (m', I')$ where $I''_i > I'_i$ and i refers to "confusion from thinking in opportunity costs". In terms of our model, the "Milk" Treatment can outperform the "Pure Information" treatment if this source of confusion is sufficiently relevant (i.e., the weighting factor α_i is large).

Another concern we had is that households may not pay enough attention to the decision problem, e.g., because they think of it as too complicated.[49] One possible solution then is to seek to involve people possibly in a playful manner into the thinking process. Our "Involvement Treatment" asks the households to conduct the relevant calculations (in nominal terms) by themselves, and provides them with an incentive to derive the correct results. The difference to the Pure Information Treatment thus is that they obtain the same factual information in the end, but are involved in the process of acquiring it rather than passively consuming it. In terms of our model, we think of the Involvement Treatment as improving the attention allocated to the decision problem while not altering information relative to the Pure Information treatment, i.e., $(m''', I') \geq (m', I')$ where $(m''' \neq m')$. That is, if the allocation of attention indeed is an

[49]Note that this is at odds with the idea of optimally allocating attention as discussed in Section B.4.

important reason for deficient choices and our "Involvement Treatment" can stimulate attention, then the Involvement Treatment should outperform the Pure Information Treatment.

Finally, we note that as all information treatments in the end provide households with the same additional information about ΔQ, the decision quality in the pooled information treatments should also outperform the one in the control group.

B.4 Optimal Attention

In this section, we apply our model to the case where attention (m_1, m_2) is allocated intentionally by the decision-maker, as this special case has received substantial attention in economics.[50] In this case, (m_1, m_2) is not a direct consequence from an information intervention, but may be indirectly affected via the quality of information provided.We now illustrate that also in the case where attention is allocated by means of optimization, providing better information has the effect of reducing perception errors.

Let $w > 0$ and suppose that attention is a finite resource, such that always $m_1 +, m_2 \leq \bar{m}$, and attention is intentionally allocated by the human brain to maximize $F_{\varepsilon^T}(w)$, i.e., to minimize the chance of a perception error. That is, for any given information state $I = (I_1, I_2)$ the brain chooses its attention (m_1^*, m_2^*) such as to maximize $F_\varepsilon(w)$ given the restriction that $m_1 + m_2 \leq \bar{m}$. An exogenous improvement of the quality of information, at least with respect to one source i, may then induce a reshuffling of attention, e.g., by focusing more on the source for which less information is available.

Maintaining all assumptions previously made on how a given mental state (m, I) can affect $F_\varepsilon(w)$, let $F_{\varepsilon^*}(w) < 1$ denote the optimized chances of choosing correctly given that the current information state is I. Consider a (marginal) increase in information, such that $I' \geq I$ and $I' \neq I$. It then follows by a standard Envelope Theorem argument that any reshuffling of attention triggered by such an informational improvement must reduce the optimal perception error, i.e., $F_{\varepsilon^*}(w)$ strictly increases if $I' \geq I$ and $I' \neq I$.

With respect to our empirical hypotheses, we note that the Involvement Treatment would most likely fail to have an additional effect on the decision quality relative to Pure Information if attention is allocated optimally by the household: As the Involvement Treatment does not provide any additional information relative to Pure Information, the optimal allocation of attention (m_1^*, m_2^*) remains unaffected.

By contrast, the Milk Treatment may still lead to an improved decision quality because the relevant information is directly accessible in opportunity costs, meaning that households do not

[50] See, e.g., Sims (2003); Caplin and Dean (2015).

need mental resources to perform these calculations anymore.

Proof Proposition 1 As in the main text, let $w \equiv \frac{\Delta p}{\Delta Q} - 1$. We prove Proposition 1 by first establishing the following result.

Lemma 1 *Fix $w > 0$ and let $F_\varepsilon(w) \in (1/2, 1)$ be given by (6). Consider the aggregate perception error $\varepsilon^T = X_1^T + X_2$, where for any given $s_1^T \in (0, s_1)$, X_1^T is the symmetric truncation of X_1 to the support $[-s_1^T, s_1^T]$. Then $\frac{\partial F_{\varepsilon^T}(w)}{\partial s_1^T} < 0$ on $\forall s_1^T \in (0, s_1)$, and thus $F_{\varepsilon^T}(w) > F_\varepsilon(w)$ for any given $\forall s_1^T \in (0, s_1)$.*

Proof Lemma 1: Note that the CDF pertaining to X_1^T is

$$F_1^T(x) = \frac{F_1(x) + F_1(s_1^T) - 1}{2F_1(s_1^T) - 1}. \tag{7}$$

Let $s_1^T \in (0, s_1)$. Then, by (6),

$$F_{\varepsilon^T}(w) = \int_{-\infty}^{\infty} F_1^T(w + e) f_2(e) de = \int_{-\infty}^{\infty} \frac{F_1(w + e) + F_1(s_1^T) - 1}{2F_1(s_1^T) - 1} f_2(e) de \tag{8}$$

We shall now show that at any given $s_1^T \in (0, s_1)$ we obtain that $\frac{\partial F_{\varepsilon^T}(w)}{\partial s_1^T} < 0$, implying that $F_{\varepsilon^T}(w)$ is strictly decreasing in s_1^T on $(0, s_1)$. It then follows immediately that $F_{\varepsilon^T}(w) > F_\varepsilon(w)$ as claimed by the Lemma.[51]

Let $s_1^T \in (0, s_1)$. Differentiation of (8) with respect to s_1^T shows that

$$\frac{\partial F_{\varepsilon^T}(w)}{\partial s_1^T} < 0 \quad \Leftrightarrow \quad \int_{-\infty}^{\infty} (1 - 2F_1(w + e)) f_2(e) de < 0.$$

Evaluation of this integral gives

$$\int_{-\infty}^{\infty} (1 - 2F_1(w + e)) f_2(e) de = 1 - 2 \int_{-\infty}^{\infty} F_1(w + e) f_2(e) de = 1 - 2F_\varepsilon(w) < 0,$$

because $F_\varepsilon(w) > 1/2$ by presumption, and hence $\frac{\partial F_{\varepsilon^T}(w)}{\partial s_1^T} < 0$. □

Note that Lemma 1 equally applies if X_2 is truncated to X_2^T instead, or if both X_1, X_2 are simultaneously truncated to X_1^T, X_2^T. We now prove Proposition 1. Because $(m', I') \geq (m, I)$ and $(m', I') \neq (m, I)$ it must be the case that both attention and information have not been reduced in any source, and attention or information have strictly increased at least in one source. Thus, at least one X_j^T is a truncation of X_j, such that $s_j(m_j', I_j') < s_j(m_j, I_j)$ while $s_{-j}(m_{-j}', I_{-j}') \leq s_{-j}(m_{-j}, I_{-j})$.

Let $\varepsilon^T \equiv \varepsilon(m', I')$ and $\varepsilon \equiv \varepsilon(m, I)$. By Lemma 1 and the argument just given, $F_{\varepsilon^T}(w) < F_\varepsilon(w)$ for any $(s_1', s_2') \leq (s_1, s_2)$ with $(s_1', s_2') \neq (s_1, s_2)$. Therefore, we may conclude that $F_{\varepsilon(m',I')}(w) > F_{\varepsilon(m,I)}(w)$, or $\pi(m', I') > \pi(m, I)$ as claimed. ■

[51] By continuity, we have that $Pr(\varepsilon < w) = Pr(\varepsilon \leq w) = F_\varepsilon(w)$.