Cognitive Dissonance, Confirmatory Bias and Inadequate Information Processing: Evidence from Experimental Auctions

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Abstract

Using psychological terms such as cognitive dissonance and confirmation bias, this study reveals how individual consumers inadequately process (food safety) information, pay limited attention to signals, and make purchase decisions that are bias towards their initial choices. While it is expected that reading extra information about potential risk associated with the food decreases consumers' willingness to pay (WTP), the magnitude of the impact varies across individuals. In general, consumer's judgment and information processing depend a lot on their initial beliefs or consumption status. They tend to use higher bidding prices to justify previous behaviors and selectively pay attention to information in favor of their initial choices. Using an incentive compatible auction mechanism, this study elicited consumers' WTP under different informational settings. Results showed that consumers bid much higher when they chose to commit to food items (treatment) than when they were randomly assigned (control), suggesting cognitive dissonance. On average, the bidding premium was about 13 cents (roughly 30%) higher for low-risk food item and 30 cents (almost 60%) higher for high-risk item. The bidding premiums were further enlarged as food safety information was revealed to consumers. Confirmatory bias hypothesis was supported by the finding that those who made commitment earlier were more reluctant to change the bids despite of increased risk perceptions. In terms of market responses, due to psychological biases among consumers, demand curves were less possible to shift down under food safety risk. Results in this study implied that consumers were less responsive to public information due to their existing habits. Extra strategies would be needed to increase the efficiency of public communication to promote health.

Key Words: Cognitive Dissonance, Confirmatory Bias, Risk Perception, Self-Justification

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1 Introduction

Food safety issues have been a major concern for both public health and food industry. However, a significant amount of control over these health risks lies in the hands of the consumers, who are the final decision makers of consumption. In this sense, it is of great importance to better understand consumers' risk perception and reaction to related information. Previous studies suggested food safety information is relatively ineffective in changing consumers' behavior (Downs, Loewenstein and Wisdom, 2009). A survey in response to 2006 spinach recall even showed that of 154 respondents who had fresh spinach at hand, 19.2% still ate it with knowledge of the recall (Turvey et al., 2010). Among those studies, however, very few offered a reason. This study used experimental evidence to investigate consumers' risk attitude and response to information in a food safety context. The results of the experiment provided some explanations for why typical consumers are less responsive to food safety scares.

The objective of this study is to explore the following research questions: First, how does individual consumer react to information regarding food safety issue in general? Second, what are the psychological factors that may affect consumers' responses to the information? Third, if the psychological factors exist, to what extent do they affect the decision-making? And fourth, how to mediate the factors that impact consumers' rational decision making so as to make the public communication more effective?

Theories of cognitive dissonance and confirmatory bias were adopted to guide through the experimental design. Cognitive dissonance is a state of discomfort caused by individual holding two contradictory beliefs (Leon Festinger, 1957). By cognitive dissonance theory, past behavior and experience may induce consumers to adjust their beliefs to rationalize their behavior and reduce the dissonance (Akerlof and Dickens, 1982). When an individual selectively seeks confirming evidence and neglects disconfirming evidence according to his previous behaviors, he is subject to confirmatory bias (Frey, 1986).

Psychological biases such as cognitive dissonance and confirmatory bias have been extensively applied to consumer behavior. Empirical research generally falls into two categories: (1) effects of dissonance on attitude change and tendency to repurchase (For example, Wessells, Kline and Anderson, 1996), and (2) effects of dissonance on selective information seeking by consumers (For

example, Lin, Lee and Yen, 2004).

In this study, a two-group between-subject experiment was conducted. Participants were instructed to bid for chocolate candy bars with 3 different flavors through BDM (Becker-Degroot-Marschak) auction. The auction lasted for 3 rounds. Ambiguous qualitative information and salient quantitative information about Aflatoxin food-borne risk was provided to the participants at the beginning of the second and the third round respectively. Of all the 3 flavors, peanut flavor was framed highly related to the food-borne illness, followed by almond flavor, and plain flavor did not get involved in the food safety issue in the study. For all the 3 rounds, risk perceptions and bids were collected. The only difference between control and treatment group was that participants bid for all 3 flavors and randomly got one flavor to be binding in the control group, whereas participants in the treatment group freely chose one out of the 3 flavor to bid at the very beginning.

There are two major features of the experimental design. First, consumers in the treatment group made commitment to one single item. This irrevocable behavior was used to generate dissonance feelings once the food-borne risk attaching to each single item was introduced. This feature reflects the real life situation when consumers made purchase before they noticed the potential safety risk or food recalls. Second, information with both ambiguous qualitative signals and salient quantitative signals was provided to the participants sequentially. As predicted by the theory, those who committed to a food item with higher safety risk feel more dissonance, and hence, bear more psychological biases when digesting and processing information.

Three groups of interesting results were found. First, as soon as participants made their free choices (i.e. commitment), they bid higher prices for the food item they chose than their counterparts (in the control group). The result was robust when the factors such as initial risk perception and preference were controlled. This result suggested consumers experienced cognitive dissonance after committing to one product and the higher bids was used as self-compliance device to justify their previous choices.

Second, when participants were exposed to safety information regarding the products they chose, though risk perceptions increased, the changing magnitude in the treatment group was much lower than that of control group. As a natural tendency to reduce dissonance feelings, consumers selectively ignored conflicting (risk) information and behaved with confirmatory bias.

Third, in terms of market responses, the demand curves for those "committed" consumers were

less likely to shift downwards after the risk information shock. While loyal customers were more tolerant to negative news regarding their favorite products, they were also less sensible in picking up crucial information when health or food safety issues were involved.

This study showed the direct evidence that consumers may have a hard time to resist the food that is already in hand. Past behaviors and long-term habits make individuals less responsive to conflicting information, even though it would be to their benefits to do so. Due to psychological biases, extra strategies would be needed to increase the efficiency of social media and public communication to promote health or to warn of danger.

The remaining paper is organized as follows: Section 2 provides a review of relevant literature. Section 3 describes the experimental design used to test consumer behaviors. In the meantime, testing hypotheses are linked to the measures in the experiment. Section 4 presents the tests of hypotheses and results of the study. Section 5 explores the causal effects on psychological biases and makes market predictions. Section 6 concludes the paper.

2 Literature Review

Consumer food choices with food safety risk concerns generally involve two primary factors, risk perceptions and behavioral responses to risk information. On the one hand, consumers systematically overestimate events with relatively small actual risks (such as technological related food contamination), whereas underestimate factors which potentially represent a substantial threat to human health (such as diet or lifestyle related behaviors, and food-borne illnesses, etc.) (Miles and Frewer, 2001; and Verbeke et al., 2007)[1]. On the other hand, in cases where signals and information about food safety uncertainty are available, many consumers do not attend to the signals or process the information (Grunert, 2005; Kornelis et al., 2007; and Verbeke et al., 2002).

Many studies have been devoted to explore factors that contribute to the above two trends. Among those representative ones are social interpretations of risk (a.k.a. risk characteristics, Slovic, 1987), optimistic bias (Frewer et al., 1994) and rationally ignorant consumer hypothesis (McCluskey and Swinnen, 2004), etc. Slovic (1987) suggested a set of (objective) risk characteristics to explain public reaction to risk (including the area of food safety), such as severity of consequences, con-

[1]This is consistent with the common observations that individuals overestimate the probability of rare events and underestimate moderate to high probabilities (Kahneman and Tversky, 1979)

trol over risk, immediacy of effect, voluntariness of risk, knowledge about risk, newness, chronic-catastrophic, common-dread[2]. Besides the social qualities of risk, people frequently believe that they are less at risk from a hazard than other people (Miles et al, 1999). Within the area of food safety risks, this optimistic biases are much larger for lifestyle hazard, such as food poisoning contracted at home or inappropriate dietary choices. Furthermore, people perceive that they know more about the risks and are in greater control of their personal exposure than others (Frewer et al., 1994), even when the comparison is made with someone with similar demographic characteristics (Miles and Scaife, 2003). Another argument suggested that when the price of information and/or the opportunity cost of processing are too high compared to the marginal expected benefit, consumer may rationally choose to remain imperfectly informed about food safety issues (McCluskey and Swinnen, 2004)[3].

This study contributes to the existing literature on food safety by incorporating consumer initial food choice behaviors and prior beliefs into the analytical framework. Results in the study will show the effects of consumer subjective behavioral status (such as food choices or lifestyle habits) on risk perception and judgment, which will be a matching counterpart to Slovic's objective risk characteristics paradigm. This study will also provide additional explanations of consumer's insensitivity to health information. The psychological mechanisms in this study could even be used to rationalize the presence of optimistic bias and over-estimation of negative information costs. The theories that are used to guide the design of this study are cognitive dissonance and confirmatory bias.

Cognitive dissonance theory was originally formulated by Leon Festinger (1957). It refers to the uncomfortable feeling aroused from holding two contradicting attitudes, beliefs or behaviors. Motivated by the unpleasant state of dissonance, people will further engage in some "psychological work" to reduce the inconsistency, and typically this work will support the cognition which is most resistant to change[4]. In the context of food safety, since it is usually hard to change long-term habits, and even impossible to undo the past (food choice) behaviors, consumers in general would tend to update their attitudes or perceptions to be consistent with their recent/long-term behaviors.

[2]Also see Slovic, 1993; Slovic et al., 1980; Fischhoff et al., 1978; and Kasperson et al., 1988.

[3]In general, the impact of information about an issue with potential negative welfare effects (e.g. risks) is larger than that with positive welfare effects (e.g. benefits). As a result, consumers evaluate the information about health risks at higher prices than risk neutral or health benefit information. This perspective is in line with prospect theory (Kahneman and Tversky, 1979) and endowment effect (Kahneman et al., 1991).

[4]See Harmon-Jones and Harmon-Jones, 2007 as a good review of the origin, development, challenge and revision of the theory.

Another motivational process that was found in line with cognitive dissonance is called confirmatory bias (Frey, 1986). Rabin and Schrag (1999) summarized three different information-processing problems that will lead to confirmatory bias. First, confirmatory bias arises when people misread ambiguous evidence as additional support for initial beliefs[5]. Second, confirmatory bias occurs with illusionary correlation. People either underestimate the true correlation when they do not perceive it or overestimate some imaginary correlation when they think it is true. Third, confirmatory bias can result from people selectively collecting confirming evidence or scrutinizing disproving ones[6]. A more severe bias could happen when people digest information according to their prior hypotheses and further use the consequent "filtered" evidence as additional support for these hypotheses.

Cognitive dissonance and confirmatory bias have been extensively applied to consumer behavior. Empirical research generally falls into two categories: (1) effects of dissonance on attitude change and tendency to repurchase, and (2) effects of dissonance on selective information seeking by consumers[7]. In general, studies which have examined the effects of dissonance on attitude change and tendency to repurchase have supported the predictions from the theory. By the foot-in-the-door technique, consumers who care about consistency can make big commitment following a small one (Freedman and Fraser, 1966). Wessells, Kline and Anderson (1996) showed consumers' perceptions of seafood safety are influenced by their past experiences. Further, the perceptions influence the anticipated changes in consumption under different hypothetical information concerning seafood. However, empirical findings about information seeking/avoidance tendency by high dissonance subjects are mixed. Lin, Lee and Yen (2004) found that search for fat and cholesterol information on food labels is less likely among individuals who consume more of these nutrients and thus supports the selective information avoidance tendency. Veeman et al. (2006) found those with more negative attitudes toward genetically modified (GM) food are most likely to access information, which is opposite to the prediction of selective information search. A more recent study by McFadden and Lusk (2014) examined the effect of prior beliefs on assimilation of scientific information (about GM food and global warming) and showed that selective scrutinizing information, misinterpretation and illusionary correlation all result in belief updating failures.

[5]See Lord, Ross and Lepper (1979) as one popular example of belief polarization, i.e. people with different initial beliefs move their beliefs even farther apart after reading the same ambiguous information.

[6]See Wason's card experiment (1968) as one representative study of information selection bias.

[7]See Kassarjian and Cohen, 1965; and Cummings and Venkatesan, 1976 for good review.

This study complements existing research in the following aspects: First, this study links the dissonance feelings caused by past behaviors with both attitude change and subsequent information processing, and further treats behavioral decision-making, belief updating and information processing in a sequential and cyclical manner. Second, the study focuses on the application of dissonance theory to food safety and health related issues, which would differentiate this study from other consumer behavior research in general. Third, within food safety concern, this study addresses personal / lifestyle related risks, rather than technological related risks, which may generally result in different consumer responses[8]. Last, this study adopted a forced compliance paradigm for experimental design. This option is not generally feasible for marketing research in the field[9], but is potentially powerful in manipulating dissonance feelings and informational impacts, and hence, establishing reliable causal inferences.

3 Experimental Design

3.1 Treatments and Experimental Procedure

This study used a between-subject experiment design. Grocery shoppers were recruited through existing mailing list of staff members at University and were guaranteed with $10 for participation. Upon arrival, subjects were randomly assigned to 1 of 2 groups. In the control group, the subjects were invited to bid for 3 food items with different flavors but otherwise identical for 3 rounds consecutively, and were told 1 out of the 9 bids would be randomly chosen to be implemented at the end. In the treatment group, the subjects were invited to freely choose 1 flavor out of the 3 otherwise identical food items to bid for 3 consecutive rounds and were told 1 out of the 3 bids would be randomly chosen to be binding at the end. Table 1 provided a brief list of the experimental procedure for both control and treatment groups.

For the control group, as subjects walked into the room, they were told that it was a study about consumer's food preference and evaluation. Subjects were each guaranteed $10 for completing the study. Subjects were also told that the study involved non-hypothetical auctions for food items and based upon their bids and lottery results, they would have a chance to win one food items and

[8]See Miles and Frewer (2001) and Miles et al. (2004) as examples distinguishing between two broad categories of potential hazard: technology and its application, and diet / lifestyle-related choices.

[9]One can never force consumers to buy sub-optimal products in the real life.

Table 1: Experimental Procedure

Control	Treatment
Instruction and Hypothetical Practice Bid	Instruction and Hypothetical Practice Bid
	Participant Chooses 1 Food Item to Bid
Non-Hypothetical Bid for **3** Food Items - Round 1	Non-Hypothetical Bid for **1** Food Items - Round 1
Relaease **Qualitative** Information	Relaease **Qualitative** Information
Non-Hypothetical Bid for **3** Food Items - Round 2	Non-Hypothetical Bid for **1** Food Items - Round 2
Relaease **Quantitative** Information	Relaease **Quantitative** Information
Non-Hypothetical Bid for **3** Food Items - Round 3	Non-Hypothetical Bid for **1** Food Items - Round 3
Random Draw to Implement 1 bid out of **9**	Random Draw to Implement 1 bid out of **3**
Survey ans Settlement	Survey ans Settlement

pay the corresponding price. The procedure of the auction was then explained to subjects and a hypothetical practice round using a small piece of stationary (a small pack of BIC sticky notes) was conducted to make sure subjects understand the auction procedure. Subjects were also instructed that they could ask the experimenter if there were any questions or concerns, but they were not allowed to talk to each other or share results or bids.

After going through a hypothetical practice auction using a non-food item and making sure subjects were clear about how the auction worked, the experimenter brought subjects to the real auction. 3 food items were presented and subjects were told that the whole auction involved making bids for the 3 food items in 3 rounds. In order to encourage subjects to be serious in making all 9 bids, a friendly reminder was given before they made any bid. The reminder said the auction for each item in each round worked in the same way as in the practice session and all of the 9 auctions were equally likely to be chosen and implemented. It was to the participant's benefit to treat each auction seriously as if it was the one that would determine final payoffs.

In each bidding round, subjects were asked 3 pairs of questions, one pair for each food item. The first question asked about food safety risk perception for the particular food item ("What do you think is the risk that people getting sick from eating XXX – the food item, where 1 means no risk at all and 10 means absolute risk?"). The second question is willingness to pay for the food item. The Becker-Degroot-Marschak (BDM) mechanism was adopted[10]. Subjects were instructed to choose "Yes" (willing to) or "No" (not willing to) to purchase the food item at each of 10 listed prices, ranging from \$0.10 to \$1.00 with increment of \$0.10. The order of bidding items were randomized

[10]BDM is the only mechanism that could be performed on an individual basis that does not require a group of subjects. It has been proved to be useful for eliciting values in field setting such as grocery stores (Lusk et al, 2001).

in order to control for order effects on bidding behaviors. Round 2 and 3 were conducted the same way as in round 1, except that before these two rounds, qualitative and quantitative information sessions regarding food safety risk and some food-borne pathogen were given to subjects. The content and details of the information were discussed in the next subsection.

Subjects were asked to finish a survey after the auction. The survey included questions such as preference of the food items, eating habits, current sense of hunger, previous knowledge and awareness of food safety issues, risk perceptions and demographics such as age, gender, income and household composition, etc. Upon completion, lotteries were run to determine the monetary payoffs. The subjects then got their settlements and the experiment ended.

For treatment group, the procedure was the same as the control group except for the auction rounds. Instead of bidding for all 3 listed food items, subjects in the treatment group were told to freely choose 1 food item out of the 3 to bid for 3 rounds. An extra reminder was given to subjects that once they made their choice, they would bid only for the item they chose and would only have a chance to win the chosen item. But same as in the control group, whenever the 3 listed food items came together in the instruction or choice options, the order of the 3 was randomized to control for order effects.

3.2 Food Commitment, Dissonance Inducing and Relevant Information Exposure

The essential part in this study was to induce dissonance feelings and investigate consumers' behavioral responses. In addition to "choice to commit" (Treatment) to bidding items (as oppose to random assignment in the control group), other critical conditions to induce dissonance are 1) similarity among choice options and 2) exposure to conflicting information.

Chocolate candy bars, which were different only in flavors but otherwise identical, were used as bidding items in the study. The three different flavors were plain/original, peanuts and almonds. There were three major features of the bidding food items. First, the items were highly identical to one another with only one trivially different attribute (i.e. different flavors). The trivial attribution made it possible for external intervention to induce dissonance feelings, while at the same time excluding other potential compound impacts. Subjects in the treatment group picked their bidding items by preference or by some temporary and unconscious decisions. Exogenously offering food

safety information regarding some of the flavors/food items afterward induced dissonance feelings among those who chose the corresponding items.

Second, the selected food items were common and tempting in general. On the one hand, using food items commonly seen in the real life would yield results that were generalizable to most food purchase and consumption situations. On the other hand, choosing food items that were tempting enough would induce the subjects to bid for it, especially at the snack time in the middle or late afternoon. The changes in bidding behaviors and reactions to information driven by temptation and dissonance feelings would provide implication for public health and food safety regulation.

Third, big gap between wholesale price and retail price was another merit. Large auction price ranges enabled subjects to bid freely to capture behavioral changes. At the same time, since the large price ranges also exist in the real life, the subjects would not feel it too unrealistic to bid so differently across products and section rounds.

In addition to the selection of food items, providing conflicting information was another crucial part of the design. In this study, aflatoxin food-borne pathogen was selected. First of all, it was not so widely familiar to the public as other pathogens such as semolina or E. coli, etc. Subjects would be tested for their reactions after control over their self-reported individual awareness or knowledge of the pathogen. Second, food items were involved with different levels of Aflatoxin risk. Among the selected food items in the study, peanut flavor candy bars were the ones with highest risk of Aflatoxin, followed by almond flavor, while plain/original flavor was generally believed to be free from this particular risk. Last, Aflatoxin was highly associated with corn and nut products, which took a substantial proportion of common foods in the real life. Testing public responses to pathogen of this type could generate rich policy implications.

During the experiment, food safety information was provided to subjects twice, once before bidding in the second round and once before bidding in the third round. The first information sheet included some general qualitative introduction about Aflatoxin, how it was related to common food items and how it was related to human health and potential sickness, etc. In addition, peanut and almond were pointed out to be highly relevant to this food-borne pathogen. In the second information sheet, quantitative information about Aflatoxin concentrations detected in different types of products was provided. Comparisons were also made between peanut products and almond products. It was also made clear that whenever a product was detected with Aflatoxin, concentrations in

peanut products were roughly 1000 times more than that in almond products. All information were collected from public available scientific websites. The information sheet was designed to be general and vague in the first session and to be more clear and standardized in the second session. These two information sheets were provided to induce dissonance feelings for those subjects who chose peanut or almond candy bars in the treatment group. Impact of dissonance feelings, effectiveness of information processing and subsequent behavioral changes can then be tested for both immediately related food items (peanut and almond candy bars) and the indirectly involved item (plain flavor bars).

3.3 Testing Hypotheses

With the design of the study, the following hypotheses are going to be tested:

Hypothesis 1 : ***(Cognitive Dissonance):*** *Pre-committing to a certain item leads to more favorable evaluations, i.e. estimating a lower risk and/or bidding for a higher price (WTP).*

In the treatment group, subjects were instructed to choose 1 out of 3 chocolate candy bars to bid and would have a chance to win only the chosen flavor; whereas in the control group, subjects did not make any choice, bidding for all 3 items and having a chance to win a randomly chosen flavor. Comparing the two groups, subjects in the treatment group actually pre-committed themselves to 1 food item. Putting such restrictions before bidding made subjects at least being no better off, since they could always choose to bid the same for the item without pre-committing to it, while still keep the chance of winning other items at desired prices. According to cognitive dissonance theory, subjects would in this case rate more favorably for the chosen item and less favorably for the rejected ones. Equation 1 and 2 were constructed to test these experimental responses.

$$Bid_{ij} = \alpha_0 + \alpha_1 Treatment_i + \alpha_2 Prefer_i + \alpha_3 Risk_{ij} + X_i\beta + \sum_{k=2}^{3} \mu_k + \epsilon_{ij} \tag{1}$$

$$Risk_{ij} = \delta_0 + \delta_1 Treatment_i + \delta_2 Prefer_i + X_i\beta + \sum_{k=2}^{3} \mu_k + \epsilon_{ij} \tag{2}$$

In the model, Bid_{ij} is the bid made by subject i in informational round j, where $j = 1$, 2 and 3. Similarly, $Risk_{ij}$ is the risk perception reported by subject i in information round j. $Treatment_i$ and

$Prefer_i$ are dummy variables, where $Treatment_i$ equals 1 for treatment, and 0 otherwise; $Prefer_i$ equals 1 if the subject indicated he/she preferred the corresponding food item, and 0 otherwise. μ_k represents the information round fixed effect, round 2 or round 3, as oppose to the first round of no information. X_i is a set of control variables. Note that Equation 1 and 2 apply to all 3 flavors, with postfixes *_pl* (*Plain*), *_pe* (*Peanut*) and *_al* (*Almond*) respectively.

Testing of $H1$ focused on the estimated parameters of α_1 and δ_1 for each flavor. Positive estimates of α_1 and negative estimates of δ_1 would support $H1$. In addition, preference of the food item was controlled in the model to get an exclusive estimation of the treatment effect. In general, preference yielded higher bids, indicating consumers being willing to pay a positive premium for the food they like. Only after controlling for preference could one say the additional gap in bids between treatment and control group was due to psychological temptations. The effect of preference on risk perception could be more controversial. In normal cases with common food, the effect should be non-positive. Zero (or insignificant) estimates of δ_2 imply that the consumers could rationally and objectively perceive the risk regardless of their preference, whereas negative estimates indicate a self-justification/self-compliance tendency to reduce dissonance feelings[11].

Hypothesis 2 : ***(Risk Aversion):*** *When being exposed to relevant risky information about common item, people in general increase the risk perception and decrease the WTP.*

Following from the above discussion about risk perception and preference, $H2$ was to test that, in general, consumers perceived risk as a bad attribute and tried to stay away from it when dealing with common food items. In the study, participants were instructed to bid for candy bars (common food items) in three rounds. Before round 2 and round 3, information regarding potential food-borne risk involved with food items was revealed to them. According to Equation 1 and 2, $H2$ would be supported if the fixed effects μ_k, $k = 2, 3$, were negative in Equation 1 and positive in Equation 2. In addition, in Equation 1 the effect of risk perception on bids, i.e. α_3, being negative would further support this hypothesis.

$H2$ could also be tested by checking the average changes of bid and risk perception across rounds, shown in Equation 3 and 4.

[11]Note that this may not be true for innovative and/or more exotic food, since consumers might prefer the food just because they could enjoy the fun of risk. An endogenous problem would potentially bias the result in this case. Fortunately, this concern was less relevant to this study, since the tested food items were commonly seen almost every day and everywhere.

$$dBid_i^{jk} = \gamma_0 + \gamma_1 Treatment_i + \gamma_2 Prefer_i + \gamma_3 Risk_{ij} + \gamma_4 dRisk_i^{jk} + X_i\beta + \epsilon_i \quad (3)$$

$$dRisk_i^{jk} = \theta_0 + \theta_1 Treatment_i + \theta_2 Prefer_i + \theta_3 Risk_{ij} + X_i\beta + \epsilon_i \quad (4)$$

In Equation 3 and 4, $Treatment_i$, $Prefer_i$ and X_i are the same as in Equation 1 and 2. $Risk_{ij}$ is the risk perception of individual i in round j, where $j = 1$, 2 and 3. $dBid_i^{jk}$ is the change of bid for individual i from round j to round k, where j, $k = 1$, 2 and 3, and $k > j$. Similarly, $dRisk_i^{jk}$ is the change of risk perception for individual i from round k to round j, where j, $k = 1$, 2 and 3, and $k > j$. Same as the previous two equations , Equation 3 and 4 apply to all 3 flavors , with postfixes $\_pl$ (*Plain*), $\_pe$ (*Peanut*) and $\_al$ (*Almond*) respectively.

Testing of $H2$ is now equivalent to testing the intercept terms γ_0 being significantly negative and θ_0 being significantly positive. More specifically, these expected effects would apply to the most relevant food items, i.e. peanut and almond flavored candy bars, while leaving the less relevant food item, i.e. the plain flavored candy bar unchanged. Further, the model controls preference and the absolute level of risk perception from the previous round.

Hypothesis 3 : ***(Confirmatory Bias):*** *The tendency to reduce dissonance feelings will (i) mitigate (or attenuate) the impact of negative information and (ii) amplify (or exaggerate) the impact of positive information.*

When people experience cognitive dissonance, a natural tendency to reduce dissonance feeling is to selectively pay attention to information/evidence that is in line with previous behaviors and to intentionally overlook the information that generates the confliction (i.e. confirmatory bias, Frey, 1986). In the study, food-borne risk information about Aflatoxin was provided to participants before the second and third round of auction. Taking the control group as a benchmark, participants' reactions to information based on the food items they chose earlier in the treatment group can be used to test $H3$.

First, according to $H3-(i)$, subjects who chose peanut or almond flavor in the treatment group would be less willing to increase their risk perceptions. In Equation4 one would expect negative θ_1 for both peanut ($\_pl$) and almond ($\_al$) equations between either information round (round

2 or 3) and the initial round (round 1). Second, according to $H3-(ii)$, those in the treatment group would react to the same piece of information differently from those in the control group. In the quantitative information sheet it mentioned that once detected, the concentration of Aflatoxin from peanut products was about1000 times higher than that from almond products. While subjects in the control group would still pick up the evidence that almond products were typically high in Aflatoxin risk, those who pre-committed to the almond candy bars in the treatment group would focus more on the fact that almond was much less risky than peanut. $H3-(ii)$ could be tested by checking the estimated coefficients in Equation 4 for the almond flavor between Round 1 & 2 (i.e. $jk=12$) and Round 2 & 3 (i.e. $jk=23$). Less positive θ_0 and/or less negative θ_1 are expected in the latter (i.e. $jk=23$) than the former (i.e. $jk=12$).

Hypothesis 4 : ***(Sticky Behavior):*** *The taste of consistency makes people less likely to change their consumption behaviors, even though it is to their benefits to do so.*

According to $H4$, even though subjects increased their risk perceptions, those in the treatment group would be more reluctant to decrease their bids than those in the control group,due to their early commitment to the certain items. This taste of consistency would be supported by positive estimates of γ_1 in Equation 3[12]. In real life, this sticky behavior caused by cognitive dissonance and confirmatory bias made consumers less responsive to food-safety information and keep consuming certain products even when facing high risk.

4 Results

4.1 Summary Statistics

Ten sessions of experiments were conducted in mid-late afternoons within two days. A total of 116 subjects participated in the study, 42 of whom were randomly selected to the control group and 74 to the treatment group. Among those in the treatment group, 18 subjects chose to bid for a plain flavor candy bar, 20 chose peanut flavor and the remaining 36 chose almond flavor. Three general groups of responses were collected for all the participants: 1) risk perceptions and biddings in the auctions; 2) objective demographics and household background; and 3) subjective beliefs, including

[12]so that the change in bids $dBid$ can be less negative.

Table 2: Summary Statistics of Demographics

	Control					Treatment				
Variable	Obs	Mean	Std. Dev.	Min	Max	Obs	Mean	Std. Dev.	Min	Max
Age	40	41.13	2.57	18	52	73	42.16	6.08	18	50
Gender	40	0.48	0.51	0	1	73	0.33	0.47	0	1
Height	40	66.93	4.83	57	79	73	65.88	3.59	56	76
BMI	39	22.75	3.21	17.92	32.61	73	22.95	3.62	17.64	34.54
HrsBfrEat	40	2.84	2.28	0.2	14	73	3.51	2.86	0	17
Diet	40	0.43	0.68	0	2	73	0.45	0.60	0	2
Marriage	40	1.13	0.46	1	3	73	1.08	0.36	1	3
Race	40	2.05	0.96	1	4	73	2.00	1.20	1	6
Edu	40	3.23	1.03	1	6	73	3.47	1.03	2	6
Employ	40	4.95	1.71	1	6	73	4.41	2.07	1	6
Income	40	3.98	2.41	1	7	73	4.21	2.38	1	7
Families	40	3.65	2.18	0	11	73	3.04	1.15	1	6
Children	40	0.55	0.90	0	4	73	0.42	0.66	0	3
Shopper	40	0.68	0.38	0	1	73	0.70	0.46	0	1

past eating habits, knowledge, awareness and judgment of food-safety issues, etc.

Table 2 listed the demographics and household background for both treatment and control groups. In general, the two groups were well balanced for the characters such as basic body measures, social demographics, household composition and dietary habits, etc. The age of participants in both groups ranged between 18 and 52, with an average of about 41 years old. The mean level of height and BMI were about 66 inches and 23 respectively. 45.69% were White/Caucasian. The majority of the subject pool had at least 2-year college education and was currently employed either part-time or full-time, with an average annual household income of $50,000 to $75,000. On average, the participants came from families of 3-4 people with 1 kid under 18 years old. Roughly 70% of the participants claimed themselves as primary grocery shoppers for their families. In terms of eating habit, 7% said they were currently on diet and 29% had a past experience to be on diet. At the time of study, it was about 3.27 hours before the participants ate any food.

The main responses in the study were risk perceptions and bids reported by participants during the auction. Table 3 presented summary statistics with F-test between treatment and control groups.

The top panel reported results of risk perceptions for 3 flavors in 3 rounds. First of all, control and treatment groups were not different from each other in estimating risk in the initial round for the 3 flavors. This was the risk perception when no information regarding food-borne illness

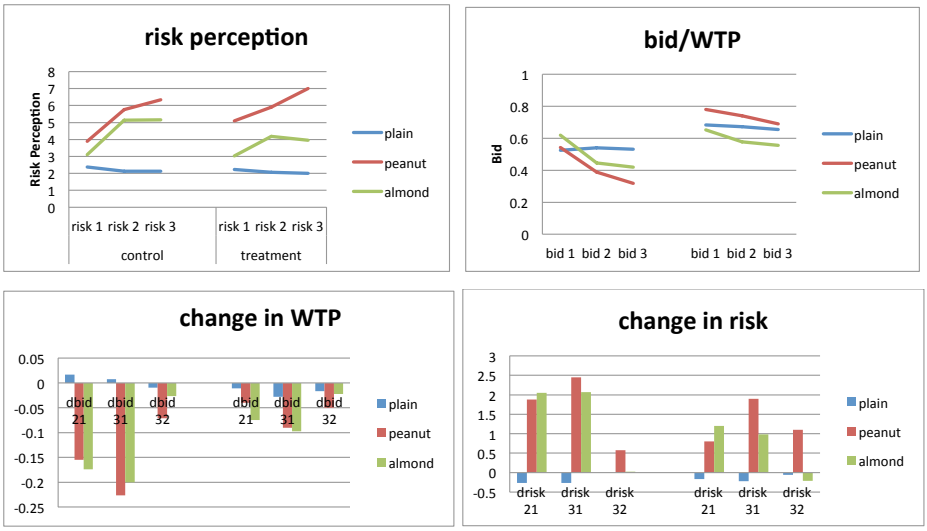
Table 3: Summary Statistics of Risk Perception and WTP by Round

	Control					Treatment						
Variable	Obs	Mean	Std. Dev.	Min	Max	Obs	Mean	Std. Dev.	Min	Max	F-test	P(>F)
Risk_plain1	42	2.38	1.71	1	8	18	2.22	1.44	1	7	0.119	0.732
Risk_plain2	42	2.12	1.40	1	6	18	2.06	0.87	1	4	0.032	0.860
Risk_plain3	42	2.12	1.35	1	6	18	2.00	0.84	1	4	0.120	0.730
Risk_peanut1	42	3.88	2.10	1	10	20	5.10	2.65	2	10	2.427	0.126
Risk_peanut2	42	5.76	2.28	2	10	20	5.90	1.97	3	9	0.031	0.862
Risk_peanut3	42	6.33	2.46	2	10	20	7.00	1.78	4	9	0.647	0.425
Risk_almond1	42	3.10	1.53	1	7	36	3.03	2.34	1	10	0.023	0.879
Risk_almond2	42	5.14	1.97	2	9	35	4.17	2.53	1	10	3.592	0.062
Risk_almond3	42	5.17	2.08	2	10	35	3.96	2.58	1	10	5.172	0.026
Bid_plain1	42	0.52	0.31	0	1	18	0.68	0.24	0.1	1	3.826	0.055
Bid_plain2	42	0.54	0.30	0	1	18	0.67	0.24	0.1	1	2.747	0.103
Bid_plain3	42	0.53	0.30	0	1	18	0.66	0.24	0.1	1	2.481	0.121
Bid_peanut1	42	0.54	0.27	0	1	20	0.78	0.14	0.6	1	7.012	0.011
Bid_peanut2	42	0.39	0.27	0	0.9	20	0.74	0.13	0.5	1	15.490	0.000
Bid_peanut3	42	0.32	0.27	0	0.9	20	0.69	0.20	0.2	1	16.620	0.000
Bid_almond1	42	0.62	0.27	0	1	36	0.65	0.27	0.1	1	0.297	0.587
Bid_almond2	42	0.45	0.27	0	0.9	36	0.58	0.28	0.1	1	4.473	0.038
Bid_almond3	42	0.42	0.28	0	1	36	0.56	0.28	0.1	1	4.596	0.035

was shown to participants. On average, they estimated 2 out of 10-point-scale for risk with plain flavor, 3/10 with almonds, and 4.5/10 with peanuts. The treatment began to play a role in affecting risk perception when food safety information was provided in the 2nd and 3rd round. Since the Aflatoxin food-borne risk was highly related to peanut and almond products, but was almost not relevant to plain flavor candy bar, one would expect risk perception for peanut and almond flavored candy bars increased and risk perception for plain flavor remained unchanged. While this was the case, changings in risk perception were not the same between control and treatment groups. For almond flavor, the control group estimated much higher risk after reading information than treatment groups (5.14/10 for control vs. 4.17/10 for treatment, F=3.59, P>F=0.06 in round 2; and 5.17/10 for control vs. 3.96/10 for treatment, F=5.17, P>F=0.03 in round 3). For peanut flavor, though participants in the treatment estimated a slightly higher risk in the first round, their changes in the 2nd and 3rd rounds were much lower than those of the control group. For example, on average, the increase in risk perception was 1.9/10 in control and only 0.8 in treatment (F=3.06, P>F=0.00) from round 1 to round 2. These differences between treatment and control group were evidence supporting cognitive dissonance and confirmatory bias.

The bottom panel of Table 3 listed descriptive information about biddings. Based on the auction mechanism, the bids revealed participants' willingness to pay (WTP) for each food item in each informational round. Table 3 showed that participants in the treatment group bid higher prices for

Figure 1: Risk Perception and Bid by Information Round & Treatment



their pre-selected food items in almost all rounds, i.e. for plain flavor in round 1, 52 cents in control vs. 68 cents in treatment, F=3.83, P>F=0.06; for peanut flavor in round 2, 39 cents in control vs. 79 cents in treatment, P>F=0.00. Further, bids in treatment group roughly remained the same across all 3 rounds, while in the control group bids for peanut and almond flavor bars were clearly decreased in the 2nd and 3rd round.

Figure 1 provided a straightforward description of these behavioral responses.

4.2 Cognitive Dissonance

Cognitive dissonance hypothesis ($H1$) was supported if participants in the treatment group made higher bids in absolute value than those in the control group. The top panel of Table 4 listed the results of regressing 9 bids (3 flavors in 3 rounds) on the treatment dummy. Initially, participants in the treatment group bid higher prices for all the 3 flavors. 16 cents higher for plain (t=1.96, P=0.06), 24 cents higher for peanut (t=3.96, P=0.00) and about 3 cents higher for almond, though not statistically significant. In the 2nd and 3rd round, risk information was provided to participants. If the risk information involving peanut and almond can further intensify the dissonance feelings, one would expect the treatment effect on bid to be enlarged for peanut and almond flavors in these two rounds. The results were in line with this hypothesis. Peanut flavor candy bars were bid 35 cents and 37 cents higher in the 2nd round and the 3rd respectively. Almond flavor was bid 13 cents and 14 cents higher and the significant level was 5%. For plain flavor, since it was not involved in

Table 4: Average Treatment Effects on Bid - All & Preferred Only

All	1	2	3	4	5	6	7	8	9
VARIABLES	Bid_pl1	Bid_pl2	Bid_pl3	Bid_pe1	Bid_pe2	Bid_pet3	Bid_al1	Bid_al2	Bid_al3
Treatment	0.160*	0.132	0.125	0.237***	0.352***	0.373***	0.034	0.133**	0.137**
	(1.956)	(1.657)	(1.575)	(3.659)	(5.448)	(5.477)	(0.545)	(2.115)	(2.144)
Constant	0.524***	0.540***	0.531***	0.543***	0.388***	0.317***	0.619***	0.445***	0.419***
	(11.730)	(12.410)	(12.250)	(14.750)	(10.580)	(8.180)	(14.730)	(10.460)	(9.687)
Obs	60	60	60	62	62	62	78	78	78
preferred only	1	2	3	4	5	6	7	8	9
VARIABLES	Bid_pl1	Bid_pl2	Bid_pl3	Bid_pe1	Bid_pe2	Bid_pet3	Bid_al1	Bid_al2	Bid_al3
Treatment	0.057	0.006	0.036	0.347***	0.407***	0.457***	-0.097	0.015	0.031
	(0.630)	(0.069)	(0.419)	(4.699)	(6.257)	(5.591)	(-1.310)	(0.189)	(0.368)
Constant	0.627***	0.667***	0.620***	0.433***	0.333***	0.233***	0.750***	0.562***	0.525***
	(9.428)	(11.260)	(9.887)	(7.073)	(6.175)	(3.440)	(12.150)	(8.362)	(7.599)
Obs	33	33	33	29	29	29	52	52	52

t-statistics in parentheses
*** p<0.01, ** p<0.05, * p<0.1

the risk information, the difference in bid between control and treatment disappeared in the last two rounds, which also supported the dissonance hypothesis on the flip side. That is, initial dissonance due to previous choice (/pre-commitment) could be reduced by any (ambiguous) information that seemed to support the earlier choice behavior.

To further verify treatment effects, regressions for each flavor were run using only those who claimed they prefer the corresponding flavor. For each flavor, the subsample included all participants in the treatment group, and those participants in the control group who reported in the survey that they prefer the certain flavor to the other two alternatives. Based on self-reported preferences, final subsets had 33 observations for plain flavor, 29 for peanut and 52 for almond. This partition of data could help to exclude the effect of preference on bidding premiums between two groups, and get a much cleaner estimation of the dissonance effect.

The bottom panel of Table 4 presented the results using these sub-samples. The bidding premium was decreased to only 6 cents for plain flavor in the initial round, and 2 to 3cents for almond flavor in the two informational rounds. This implied preference did perform a role in making participants bid higher. However, after excluding preference effects, bidding premiums for peanut candy bars remained to be 30-40 cents at 1% significant level. Existence of cognitive dissonance was established even after controlling for preference effects.

Table 5 listed the estimated average treatment effects (ATE) on bidding premiums with different combinations of the control variables. As shown in the table, treatment effects were stable while

Table 5: ATE on Bid - Robustness Check

	1	2	3	4	5	6	7	8	9
VARIABLES	Bid_pl1	Bid_pl2	Bid_pl3	Bid_pe1	Bid_pe2	Bid_pet3	Bid_al1	Bid_al2	Bid_al3
ATE no control	0.160*	0.132	0.125	0.237**	0.352***	0.373***	0.034	0.133**	0.137**
	(1.956)	(1.657)	(1.575)	(2.648)	(3.936)	(4.076)	(0.545)	(2.115)	(2.144)
ATE ctrl for risk	0.159*	0.131	0.123	0.227***	0.356***	0.403***	0.034	0.131**	0.117*
	(1.929)	(1.634)	(1.546)	(3.381)	(5.673)	(6.359)	(0.551)	(2.061)	(1.823)
ATE ctrl for risk & pref.	0.052	0.005	0.03	0.307***	0.405***	0.506***	−0.054	0.066	0.064
	(0.551)	(0.061)	(0.326)	(3.670)	(5.026)	(6.218)	(−0.787)	(0.930)	(0.880)
Obs.	60	60	60	62	62	62	78	78	78
ATE w/ preferred only	0.057	0.006	0.036	0.347***	0.407***	0.457***	−0.097	0.015	0.031
	(0.630)	(0.069)	(0.419)	(4.699)	(6.257)	(5.591)	(−1.310)	(0.189)	(0.368)
ATE ctrl for risk	0.053	0.003	0.033	0.329***	0.417***	0.491***	−0.097	0.029	0.022
	(0.576)	(0.041)	(0.375)	(4.218)	(6.340)	(5.830)	(−1.300)	(0.359)	(0.264)
Obs.	33	33	33	29	29	29	52	52	52
Diff due to preference	0.163*	0.199**	0.14	−0.16	−0.092	−0.125	0.212***	0.196**	0.179**
	(1.731)	(2.254)	(1.545)	(−1.624)	(−0.906)	(−1.228)	(2.714)	(2.539)	(2.160)
Obs.	40	40	40	40	40	40	40	40	40

controlling for risk perceptions and preferences. Further, effects of preference on bidding for all 9 scenarios within control group were listed on the bottom. Subtracting these numbers from the treatment effects using all observations (top panel of Table 5) could also yield exclusive estimations of dissonance effects on bidding behaviors[13].

4.3 Risk Aversion and Manipulation Check

Manipulation in the study was the information regarding Aflatoxin food-borne risk provided to participants before the 2nd and the 3rd round of auction. Peanut products were highly involved with this risk, followed by almond products. Those plain flavored chocolate candy bars were believed to be unrelated. Validity of this manipulation could be verified by checking reported risk perceptions across 3 rounds for all 3 flavors.

On average, participants reported 2.08 out of 10 points of risk associated with plain flavored candy bars, 5.3 out of 10 with peanut flavor and 4.67 out of 10 for almond flavor. Tests of equality between any pair of means was rejected, suggesting almond flavor was perceived higher in risk than plain flavor (t=3.58, P=0.00) and risk perception of peanut flavor was the highest among the three (peanut vs. almond, t=4.86, P=0.00). The manipulation of different risk perceptions across product was established successfully.

[13]This argument implicitly assumed that treatment was assigned randomly, which was guaranteed by the design of the study.

Table 6: Independence of Risk Perception on Treatment & Preference

	1	2	3	4	5	6	7	8	9
VARIABLES	Risk_pl1	Risk_pl2	Risk_pl3	Risk_pe1	Risk_pet2	Risk_pe3	Risk_al1	Risk_al2	Risk_al3
Treatment	−0.397	−0.122	−0.292	1.323	0.385	1.292	0.074	−0.831	−1.174*
	(−0.701)	(−0.290)	(−0.706)	(1.603)	(0.483)	(1.587)	(0.142)	(−1.370)	(−1.883)
Prefer	0.411	0.187	0.339	−0.293	−0.311	−0.877	−0.402	−0.252	−0.142
	(0.789)	(0.485)	(0.893)	(−0.375)	(−0.411)	(−1.138)	(−0.742)	(−0.403)	(−0.221)
Constant	2.246***	2.005***	1.973***	4.041***	5.795***	6.497***	3.311***	5.226***	5.257***
	(6.836)	(8.209)	(8.225)	(9.943)	(14.780)	(16.210)	(8.739)	(11.950)	(11.700)
Obs	57	57	57	60	60	60	76	75	75
R-squared	0.013	0.004	0.016	0.054	0.004	0.043	0.008	0.046	0.069

t-statistics in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Further, Table 6 showed the average levels of participants' self-reported risk perceptions in 9 cases. As shown in the constant row, on average risk perceptions for peanut increased from 4.04 in the 1st round to 5.80 in the 2nd and 6.50 in the 3rd; risk perception for almond also increased from 3.31 in the initial round to about 5.23 in the later rounds, while for plain flavor, risk perception remained constantly at around 2. The changes in risk perceptions across rounds were also tested using Equation 4. The average changes of risk perception corresponded to the intercept term θ_0 in Equation 4. As shown in Table 7, for example, the average increase in risk perception for peanut candy bar was 1.88 (t= 9.37, P=0.00) in round 2 as opposed to round 1, and the increase for almond candy was 2.07 (t=8.41, P=0.00) in round 3 compared to round 1. Hence, the manipulation of different risk perceptions across informational rounds was also proved to be effective. $H2$ is supported.

In addition, risk perceptions were shown to be unrelated with preferences (Table 6). This implied that participants were to some extent rational enough to objectively estimate risk and were not impacted by their own preferences. This finding validated Equation 1 through 4, which used risk perception and preference as two independent control variables to estimate treatment effects.

During the study, wherever a list of the 3 food items was mentioned to the participants, the order of the 3 was randomized to make sure there was no confounded order effect. Further, regressions were run to double check. For the control group, participants' bids were not significantly related to the order of the food being mentioned. For the treatment group, order of the food items did not predict participants' choices, either.

Table 7: ATE on Changes in Risk Perception - All & Preferred Only

All	1	2	3	4	5	6	7	8	9
VARIABLES	dRisk_pl21	dRisk_pl31	dRisk_pl32	dRisk_pe21	dRisk_pe31	dRisk_pe32	dRisk_al21	dRisk_al31	dRisk_al32
Treatment	0.095	0.04	-0.056	-1.081***	-0.552	0.529*	-0.848***	-1.086***	-0.238
	(0.283)	(0.127)	(-0.454)	(-3.058)	(-1.102)	(1.775)	(-2.696)	(-2.972)	(-1.010)
Constant	-0.262	-0.262	0	1.881***	2.452***	0.571***	2.048***	2.071***	0.024
	(-1.422)	(-1.532)	(-0)	(9.367)	(8.615)	(3.379)	(9.661)	(8.412)	(0.150)
Obs	60	60	60	62	62	62	77	77	77
Preferred only	1	2	3	4	5	6	7	8	9
VARIABLES	dRisk_pl21	dRisk_pl31	dRisk_pl32	dRisk_pe21	dRisk_pe31	dRisk_pe32	dRisk_al21	dRisk_al31	dRisk_al32
Treatment	0.3	0.111	-0.189	-0.978*	-0.322	0.656	-0.800*	-1.077**	-0.277
	(0.596)	(0.244)	(-1.164)	(-2.033)	(-0.392)	(1.177)	(-1.841)	(-2.087)	(-0.781)
Constant	-0.467	-0.333	0.133	1.778***	2.222***	0.444	2.000***	2.063***	0.063
	(-1.256)	(-0.993)	(1.113)	(4.452)	(3.254)	(0.961)	(5.556)	(4.826)	(0.213)
Obs	33	33	33	29	29	29	51	51	51

t-statistics in parentheses
*** p<0.01, ** p<0.05, * p<0.1

4.4 Confirmation Bias

Though participants did respond to the information provided to them, the magnitude of reaction was not the same between treatment and control groups. These findings brought us to the investigation of $H3$, confirmatory bias. Confirmatory bias was defined as a natural tendency to selectively pay attention to relevant information so as to reduce the dissonance feelings. To be more detailed, when participants tried to overlook the available information that was conflicting to their previous choices and/or became less sensitive to it, they were experiencing confirmatory bias. On the flip side, being sensitive to some irrelevant signals or interpreting information as supporting evidence to the previous behaviors were also considered as confirmatory bias.

Changes in risk perceptions across rounds in Table 7 supported the above hypothesis ($H3$). Columns 4-6 reported regression results of changes in risk perception for peanut flavor between the 2nd and the 1st round (i.e. $dRisk\_pe^{21}$), the 3rd and the 1st round (i.e. $dRisk\_pe^{31}$), and the 3nd and the 2rd round (i.e. $dRisk\_pe^{32}$) respectively. Similarly, columns 7-9 were the results for almond flavor.

Take the peanut flavor candy bar as an example, the control group people on average increased their risk perception by 1.881 points after reading the qualitative information in the 2nd round auction (Column 4 in Table 7). However, those in the treatment only increased their perception by 0.8 points (=1.881-1.081), implying that they were reluctant to respond to the risk information

regarding the food item they just pre-committed to. Same thing happened to the almond flavor, too. The control group increased risk perception by 2.048 (Column 7), whereas the increase in the treatment group was only about 1.2 (=2.048-0.848).

Proportion of perception updating in Round 2[14] (out of total perception updating until the last round) can also be used to demonstrate the difference in sensitivity (to risk information) between two groups. Take peanut flavor as an example, in the control group, risk perception increased 2.452 in total from Round 1 to Round 3 (i.e. the constant term of Column 5 in Table 7), and increased 1.881 immediately in Round 2 (Column 4). In this sense, participants made 76.71% (=1.881/2.452) of updating in Round 2. In contrast, in the treatment group, the increase in risk perception was about 1.9 (=2.452-0.552) in total, and about 0.8 (=1.881-1.081) in Round 2. The immediate updating proportion was only 42.11% (=0.8/1.9). This result implied that participants in the treatment group were much less responsive to information about negative attributes (i.e. risks) of the food they chose earlier. Not only did they respond less, but also reponded slower.

For almond flavor candy bars, participants in the treatment group increased their risk perceptions by only 0.985 (=2.071-1.086) in total, compared with 2.071 in the control group (Column 8 of Table 7). But interestingly, as early as in the 2nd round, the increase in risk perception was 1.20 (=2.048-0.848) in the treatment group. This implied that participants in the treatment group even decreased their risk perceptions by roughly 0.215 (=1.2-0.985) points in the 3rd round. Recall the information provided in the 3rd round, while people in the control group still picked up the main idea that almond products were high in Aflatoxin food-borne risk, those in the treatment were more attracted by the signal that almond products had much lower concentration of Aflatoxin than peanut products once detected, and thus, interpreted it as a favorable evidence to update their beliefs. These findings supported $H3$, i.e. people selectively pay attention to information so as to reduce dissonance feelings. The bottom part of Table 7 controlled for preference by using the subset of those who preferred the food for regression, just as in Table 4 (Section 4.2). Major results about confirmatory bias remained.

[14]This was the first chance participants updated their perceptions.

4.5 Sticky Behavior

While participants updated their beliefs differently after reading pieces of information, it is interesting to see if their purchase tendency was impacted in the same way. By $H4$, consumers would have a taste of consistency and hence, be less willing to change their purchase behaviors. In the study, the participants in the treatment group made their food choices explicitly in the first place, but people in the control group did not. If one could find the participants in the treatment group were less willing to change their bids after reading risk information, then $H4$ would be supported.

Table 8 showed the results of treatment effects on changes in bid. Similar as in Table 7, the top panel used the full sample and the bottom panel used only those who claimed that they preferred the food to control the effect of preference. As shown in the table, for peanut flavor, participants in the control group decreased their bids by 15.5 cents in the 2nd round (Column 4) and additional 7.1 cents in the 3rd round (Column 4). However, subjects in the treatment group decreased their bids by only 4 cents in the 2nd round (0.155-0.115= \$0.04) and 5 cents in the 3rd round (0.071-0.021= \$0.05). The differences between treatment and control were significant at 1% level. In terms of proportion, the control group made 68.58% (=15.5 / (15.5+7.1)) of the total changes immediately after reading the first piece of information, whereas the treatment group made only 44.44% (=4 / (4+5)) of the changes. Taking absolute values of initial bids into account, the same information regarding food-borne illness of the same food item yielded about 40.74% (=(0.54-0.32)/0.54, as shown in Table 1) decrease in willingness to pay (WTP) for those who did not pre-committed to the food, but only about 11.54% (=(0.78-0.69)/0.78, as shown in Table 1) decrease in WTP for those who made their pre-commitments. While loyal customers were less likely to be affected by negative news of their beloved products, they were also less sensible and less responsive in picking up crucial information when health or food safety risks were involved. Same patterns applied to almond flavor as well.

Table 9 listed absolute numbers and percentages of participants who changed their preferences after the study. In the control group, roughly 9.52% (=26.19%-16.67%) of participants' switched away from peanut products after the study, and 7.15% (=40.48%-33.33%) for almond products. In comparison, the switching percentages in the treatment group were only 5.41% (=28.37%-22.97%) and 4.95% (=43.24%-39.19%) respectively. Evidence suggested that after pre-committing to certain

Table 8: ATE on Changes in Bid - All & Preferred Only

All	1	2	3	4	5	6	7	8	9
VARIABLES	dBid_p121	dBid_p131	dBid_p132	dBid_pe21	dBid_pe31	dBid_pe32	dBid_a121	dBid_a131	dBid_a132
Treatment	-0.028	-0.035	-0.007	0.115***	0.136***	0.021	0.099***	0.103**	0.004
	(-0.913)	(-0.853)	(-0.305)	(3.252)	(2.833)	(0.646)	(2.663)	(2.423)	(0.164)
Constant	0.017	0.007	-0.01	-0.155***	-0.226***	-0.071***	-0.174***	-0.200***	-0.026
	(1.000)	(0.319)	(-0.742)	(-7.723)	(-8.283)	(-3.789)	(-6.894)	(-6.942)	(-1.592)
Obs	60	60	60	62	62	62	78	78	78

Preferred only	1	2	3	4	5	6	7	8	9
VARIABLES	dBid_p121	dBid_p131	dBid_p132	dBid_pe21	dBid_pe31	dBid_pe32	dBid_a121	dBid_a131	dBid_a132
Treatment	-0.051	-0.021	0.03	0.06	0.11	0.05	0.113**	0.128**	0.015
	(-1.022)	(-0.326)	(0.971)	(1.216)	(1.574)	(1.036)	(2.116)	(2.116)	(0.542)
Constant	0.04	-0.007	-0.047**	-0.100**	-0.200***	-0.100**	-0.188***	-0.225***	-0.037
	(1.083)	(-0.139)	(-2.044)	(-2.440)	(-3.447)	(-2.496)	(-4.239)	(-4.478)	(-1.600)
Obs	33	33	33	29	29	29	52	52	52

t-statistics in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 9: Preference Changes Before & After Study by Flavor

		Prefer Plain	Prefer Peanut	Prefer Almond	Total
Control	Before #	14	11	17	42
	%	33.33	26.19	40.48	100
	After #	21	7	14	42
	%	50	16.67	33.33	100
Treatment	Before #	21	21	32	74
	%	28.38	28.38	43.24	100
	After #	28	17	29	74
	%	37.84	22.97	39.19	100

Table 10: ATE on Bid - Causal Inference

	1	2	3	4	5	6	7	8	9
VARIABLES	Bid_pl1	Bid_pl2	Bid_pl3	Bid_pe1	Bid_pe2	Bid_pet3	Bid_al1	Bid_al2	Bid_al3
Treatment	0.052	0.005	0.03	0.307***	0.405***	0.506***	-0.054	0.066	0.064
	(0.551)	(0.061)	(0.326)	(3.670)	(5.026)	(6.218)	(-0.787)	(0.930)	(0.880)
Risk	-0.002	0.001	0.003	0.003	-0.028**	-0.048***	0.011	-0.011	-0.021
	(-0.0922)	(0.025)	(0.089)	(0.263)	(-2.128)	(-3.712)	(0.696)	(-0.795)	(-1.577)
Prefer	0.155*	0.186**	0.13	-0.131*	-0.096	-0.166**	0.175**	0.145**	0.126*
	(1.799)	(2.268)	(1.551)	(-1.686)	(-1.259)	(-2.181)	(2.454)	(2.021)	(1.726)
Constant	0.472***	0.471***	0.478***	0.573***	0.589***	0.670***	0.519***	0.442***	0.477***
	(6.392)	(6.100)	(6.079)	(8.605)	(6.777)	(7.220)	(7.283)	(5.096)	(5.493)
Obs	57	57	57	60	60	60	76	75	75
R-squared	0.107	0.121	0.074	0.217	0.386	0.477	0.083	0.132	0.142

t-statistics in parentheses
*** p<0.01, ** p<0.05, * p<0.1

food items (in the treatment group), dissonance feelings made subjects less willing to change their behaviors and/or more inclined to stick to their previous food choices.

5 Discussion

5.1 Habits, Risk Perceptions and Causal Effects (Identification and Validation)

After talking about how participants in the treatment group behaved differently from those in the control group in making and changing their bids (WTP: willingness to pay), this section starts to explore the main reasons that caused these differences. Two major reasons were investigated. One was (long-term) self-stated preference and the other was risk perception manipulated by the experimental design. The following two sub-sections discussed how these two factors interacted with psychological biases and finally impacted food choice behaviors.

5.1.1 Determinants of Absolute WTP

Table 10 listed partitioned regressions of bid for all 9 scenarios (3 flavors in 3 rounds). Risk perceptions and preference were controlled in these regressions.

First of all, preferences did have significant impacts on bids. For plain and almond flavor, preference yielded about 15 cents more in WTP. This preference premium reduced the treatment effects to 5.2 cents for plain flavor in the initial round and about 6.6 cents for almond flavor in

the two informational rounds. Previously, as shown in Table 5, these treatment effects were about 16 cents for the former and 13 cents for the latter. However, one could not merely say these preference interpretations disprove the dissonance argument. Observing preference premiums across (information) rounds within each flavor, one could find that for plain flavor, the premium increased from the first round to the second round and for almond flavor, the premium decreased. One interpretation of these findings was that the manipulation of risk perception triggered the interaction between preference and dissonance feelings. For plain flavor, since the risk information was not relevant to it, the premium was reinforced and people who claimed that they preferred the flavor were willing to pay 3 (=\$0.186-\$0.155) cents more. In contrast, since almond flavor was involved in food safety risks, the preference premium decreased (from \$0.175 to \$0.145 , then to \$0.126).

Interestingly, the effect of preference on WTP was negative for the peanut flavor candy bars. This strange relationship could be caused by the trade-off with the treatment effect. The treatment effect (i.e. adding premiums to bids due to pre-commitment) was so strong that the preference effect compromised to be negative when fitting the data. Another explanation could be a cross-product effect with plain and almond flavors. As peanut flavor being a more common option in the daily life than the other two alternatives, those who liked it bid for a lower price.

Compared to the significant impact of preference, risk perception seemed to be less influential in affecting WTPs. It almost had no impact on the WTP for plain flavor. For almond, although it was pretty close to be significant in the third round, the magnitude of effect was only as low as 2.1 cents. Risk perception played a significant role only for peanut flavor in the two informational rounds, yielding 2.8-cent and 4.8-cent decrease in WTP for every one-point increase in risk perception. Considering the fact that peanut products were highly involved in the provided food safety information, these significant estimates could be seen as signal for successful manipulation[15].

5.1.2 Determinants of Changes in WTP

Table 11 showed how changes in WTP were explained by driving factors, i.e. treatment (previous food choices), preference, risk perception and the changes, etc. While preference was more important in explaining pure WTP, risk perceptions had more explanatory power in interpreting the changes in

[15]Participants did view food safety risks as bad attributes. However, risk concerns were triggered only after the information had been revealed. Though people in general decreased their bids as risk perceptions increased, the changes were not large enough to overweight the bidding premiums caused by the psychological biases.

Table 11: ATE on Changes in Bid - Causal Inference, All

	1	2	3	4	5	6	7	8	9
VARIABLES	dBid_pl21	dBid_pl31	dBid_pl32	dBid_pe21	dBid_pe31	dBid_pe32	dBid_al21	dBid_al31	dBid_al32
Treatment	-0.045	-0.027	0.01	0.081*	0.166***	0.101**	0.059	0.067	0.004
	(-1.177)	(-0.527)	(0.381)	(1.823)	(2.797)	(2.410)	(1.506)	(1.384)	(0.144)
dRisk_21	-0.013			-0.01			-0.046***		
	(-1.018)			(-0.734)			(-3.209)		
dRisk_31		0.009			-0.016			-0.031*	
		(0.513)			(-1.257)			(-1.966)	
dRisk_32			-0.074***			-0.046***			-0.022*
			(-2.920)			(-3.284)			(-1.722)
Risk_2	-0.009			-0.020***			-0.019**		
	(-0.729)			(-2.737)			(-2.214)		
Risk_3		-0.009	-0.003		-0.027**	-0.007		-0.020*	-0.002
		(-0.544)	(-0.312)		(-2.629)	(-1.049)		(-1.945)	(-0.306)
Prefer	0.03	-0.02	-0.043*	0.038	-0.025	-0.069*	-0.025	-0.042	-0.017
	(0.871)	(-0.412)	(-1.741)	(0.955)	(-0.454)	(-1.797)	(-0.642)	(-0.869)	(-0.568)
Constant	0.02	0.037	0.014	-0.031	-0.015	0.012	0.02	-0.02	-0.01
	(0.616)	(0.821)	(0.591)	(-0.654)	(-0.226)	(0.252)	(0.417)	(-0.353)	(-0.276)
Obs	57	57	57	60	60	60	75	75	75
R-squared	0.06	0.028	0.215	0.29	0.289	0.233	0.365	0.263	0.055

t-statistics in parentheses
*** p<0.01, ** p<0.05, * p<0.1

WTP. Note first that dependent variables in Table 11 were changes in WTP from an earlier round to a later round (i.e. $dBid\_pe^{21} = Bid\_pe^{2} - Bid\_pe^{1}$), and hence, were all negative in value. In the table, for peanut and almond flavor, the absolute values of risk perceptions significantly negatively impacted changes in WTP between the last two rounds and the initial round (Column 4, 5 and 7, 8); and changes in risk perception significantly negatively impacted changes in WTP within the last two rounds (Column 6 and 9). On average, 1 point increase in absolute value of risk perception in a certain round (round 2 or 3) yielded about 2-cent decrease in WTP compared to the first round. 1 point increase in risk perceptions yielded about 4.6-cent decrease in WTP for peanut between the second and the third round and about 2.2-cent decrease for almond. Preference, however, was only marginally significant.

In addition to the impact of preference and risk perceptions, treatment (i.e. pre-commitments to food items) still played a role in mitigating changes in WTPs, significant and large (in magnitude) for peanut flavor, and close to significant and relatively smaller (in magnitude) for almond flavor. These positive estimates of the treatment effect were evidence of sticky behaviors due to a taste of consistency.

Table 12 showed the robustness check for the above findings by using the subsample of those who preferred the certain flavors. Comparing Table 12 with Table 11, main results are consistent.

Table 12: ATE on Changes in Bid - Causal Inference, Preferred Only

	1	2	3	4	5	6	7	8	9
VARIABLES	dBid_pl21	dBid_pl31	dBid_pl32	dBid_pe21	dBid_pe31	dBid_pe32	dBid_al21	dBid_al31	dBid_al32
Treatment	-0.047	-0.023	0.011	0.124**	0.179***	0.052	0.067	0.045	-0.033
	(-0.915)	(-0.347)	(0.407)	(2.726)	(3.327)	(1.502)	(1.348)	(0.837)	(-1.242)
dRisk_21	-0.02			-0.015			-0.045**		
	(-1.096)			(-0.763)			(-2.446)		
dRisk_31		0.014			-0.013			-0.023	
		(0.548)			(-0.877)			(-1.387)	
dRisk_32			-0.110***			-0.037**			-0.015
			(-3.755)			(-2.677)			(-1.398)
Risk_2	-0.01			-0.022**			-0.022**		
	(-0.402)			(-2.325)			(-2.104)		
Risk_3		-0.002	0.005		-0.040***	-0.013		-0.025**	0
		(-0.0673)	(0.422)		(-3.083)	(-1.555)		(-2.216)	(-0.0453)
Constant	0.052	0.003	-0.045	-0.022	0.038	0.031	0.002	-0.022	0.008
	(0.785)	(0.035)	(-1.265)	(-0.286)	(0.414)	(0.519)	(0.035)	(-0.317)	(0.224)
Observation	33	33	33	35	35	35	50	50	50
R-squared	0.081	0.014	0.347	0.391	0.448	0.331	0.387	0.295	0.071

t-statistics in parentheses
*** p<0.01, ** p<0.05, * p<0.1

5.2 Market Demand and Price Elasticity

In this section, the focus is the aggregated results derived from each group. Results in this section provide insights about market responses to food safety information.

In order to investigate market responses, aggregate demands for each flavor were derived from the following subgroups: 1) control group, 2) treatment group, 3) control group with only subjects who preferred the flavor, 4) control group with only subjects who did not prefer the flavor and 5) all subjects in both control and treatment groups. The aggregate demands were then converted to demand shares (in percentages) for each subgroup so as to make all 5 sub-groups comparable.

Table 13 listed the regression results of the fitted inverse demand functions for each flavor-subgroup combination. Equation 5 is the inverse demand functional form used in fitting regressions in Table 13.

$$Price_{(flavor,group)} = a + bDemand_{(flavor,group)} + \sum_{k=2}^{3} \mu_k + \epsilon_{(flavor,group)} \tag{5}$$

In Equation 5, the inverse demand function was specific to "flavor, group" combination. There were 3 flavors and 5 subgroups of subjects, each representing a customer pool in the real market. Price was exogenously given by the design of the study. 11 price values ranged from \$0 to \$1, with increment of 10 cents. Demand was calculated as the inverse cumulative percentage in accordance to

Table 13: Inverse Demand Curve by Group

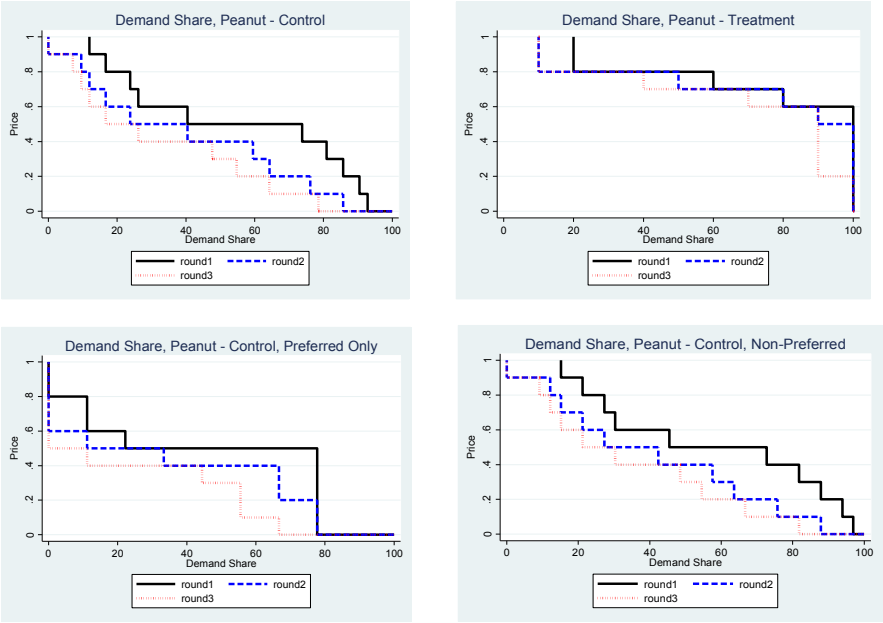
	Plain			Peanut					Almond				
	Control	Treat	ctrl prefer	Control	Treat	ctrl prefer	ctrl no-pref	all	Control	Treat	ctrl prefer	ctrl no-pref	all
VARIABLES	price	price	price	price	price	price	price	price	price	price	price	price	price
Demand	-0.010***	-0.009***	-0.009***	-0.009***	-0.008***	-0.008***	-0.010***	-0.010***	-0.010***	-0.010***	-0.009***	-0.010***	-0.010***
	(-25.16)	(-12.94)	(-16.00)	(-22.93)	(-8.665)	(-14.34)	(-26.29)	(-30.66)	(-27.18)	(-26.87)	(-16.29)	(-25.13)	(-29.47)
Round2	0.015	-0.009	0.034	-0.133***	-0.03	-0.075	-0.151***	-0.120***	-0.153***	-0.070**	-0.155***	-0.144***	-0.124***
	(0.511)	(-0.170)	(0.748)	(-3.991)	(-0.390)	(-1.469)	(-5.126)	(-4.754)	(-5.354)	(-2.478)	(-3.367)	(-4.683)	(-4.725)
Round3	0.007	-0.024	-0.006	-0.195***	-0.067	-0.149***	-0.207***	-0.180***	-0.176***	-0.091***	-0.187***	-0.160***	-0.140***
	(0.217)	(-0.427)	(-0.126)	(-5.736)	(-0.874)	(-2.892)	(-6.931)	(-7.054)	(-6.122)	(-3.213)	(-4.003)	(-5.202)	(-5.333)
Constant	1.076***	1.168***	1.125***	1.054***	1.152***	0.898***	1.098***	1.121***	1.131***	1.208***	1.205***	1.054***	1.175***
	(34.420)	(18.040)	(22.150)	(31.430)	(12.460)	(19.840)	(35.930)	(41.780)	(37.090)	(36.520)	(22.400)	(34.370)	(40.100)
Obs	33	33	33	33	33	33	33	33	33	33	33	33	33
R-squared	0.956	0.852	0.898	0.948	0.721	0.876	0.96	0.97	0.962	0.961	0.901	0.956	0.968

t-statistics in parentheses
*** p<0.01, ** p<0.05, * p<0.1

each price value (i.e. the demand D at a certain price P is the percentage of the number of biddings that are higher than or equal to P). The constant a represented the intercept of the inverse demand for the first round (default, no information). b was the slope effect. By the construction of the model, price elasticity can be calculated by $e = \frac{dDemand/Demand}{dPrice/Price}$. μ_k represented the shift of the inverse demand curve caused by the information in either round 2 or round 3. Focus was given to the comparison of these estimates across subgroups to capture different market responses to risk information.

According to the results in Table 13, the slopes of the demand curves were roughly 0.10 for all cases. In response to risk information, demand for peanut and almond flavor both shifted downward, while demand for plain flavor did not, which once again suggested the successful manipulation of risk information. However, for both peanut and almond flavor, the shift of demand curve was not the same across different subgroups. Take peanut flavor for example, the demand curve shifted 13.3 cents downwards in the control group (Middel Panel, Column 1), which meant at any given demand level (in terms of market demand share), the price was 13.3 cents less in round 2 than in round 1. In contrast, the treatment group did not show any significant downward shift after the same risk information being revealed to participants (Middel Panel, Column 2). Similarly, in the third round, the downward shift was 19.5 cents for control group, significant at 1% level; and only 6.7 cents for the treatment group, but statistically insignificant. Differences remained when comparison was made between treatment and control with only those who preferred peanut flavor (Middel Panel, Column 3). Same for almond flavor, even though the demand curve significantly

Figure 2: Demand Curves in Percentage Share - Peanut



shifted down for both treatment (Right Panel, Column 2) and control group (Right Panel, Column 1), the magnitude of shift was always larger in control group than in treatment (15.3 cents vs. 7.0 in round 2 and 17.6 cents vs. 9.1 in round 3).

Figure 2 to 4 showed the shift of demand curves across rounds for each flavor and subgroup. Differences in the shift of demand curve suggested that customers with long-last preference or pre-commitment were less responsive to food safety information regarding the product they chose earlier. Psychological biases were crucial in influencing the efficacy of public health communication with consumers.

6 Conclusion

This study investigated how individual consumers react to food safety information and make purchase decision according to their past food choices. Using an incentive compatible auction mechanism, this study elicited consumers' WTP under different informational settings. Consistent to the findings in psychology, consumer's judgment and information processing depend a lot on their initial beliefs or consumption status.

Results showed that consumers bid much higher when they chose to commit to food items

Figure 3: Demand Curves in Percentage Share - Almond

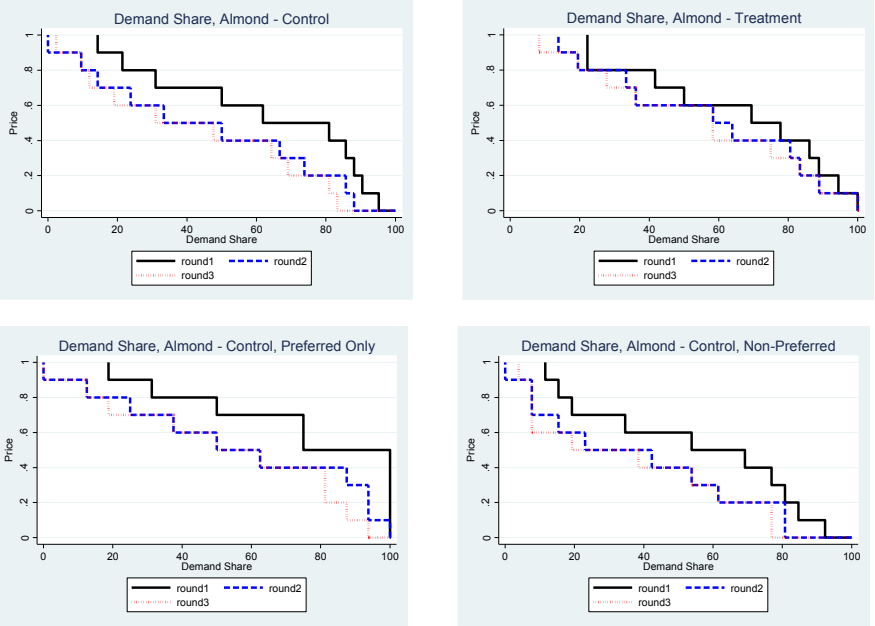
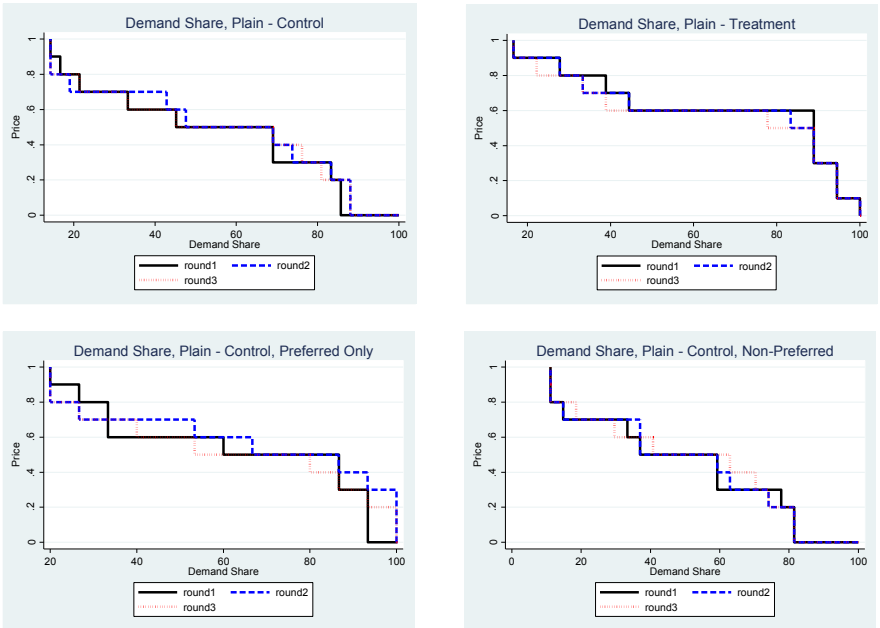


Figure 4: Demand Curves in Percentage Share - Plain



(treatment) than when they were randomly assigned (control), suggesting cognitive dissonance. On average, the bidding premium was about 13 cents (roughly 30%) higher for low-risk food item and 30 cents (almost 60%) higher for high-risk item. The bidding premiums were further enlarged as food safety information was revealed to consumers. Confirmatory bias hypothesis was supported by the findings that subjects in the treatment group were more reluctant to change the bids despite of increased risk perceptions. In terms of market responses, due to psychological biases among consumers, demand curves were less possible to shift down under food safety risk.

Results in this study suggested that consumers were less responsive to public information due to their existing habits. Extra strategies would be needed to increase the efficiency of public communication to promote health.

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