Consumer Willingness to Pay for Nano-packaged Food Products: Evidence from Experimental Auctions and Visual Processing Data

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Dedication

Abstract

Using eye-tracking technology and experimental auctions, this paper evaluates the impact of information from various sources on consumers' willingness to pay (WTP) for nano-packaged food products with varying shelf-lives. Information about the risks and benefits of nanotechnology in food processing from various sources was presented to consumers and consumers' eyes were tracked and the time they spent on viewing the information was recorded. Double hurdle models estimation results show that the specific information about nanotechnology from various sources has a negative effect on the probability of consumer submitting positive bids for the nano-packaged products. Conditional on participants' willingness to submit positive bids, general and specific information about nanotechnology had a positive effect on participants' WTP for nano-packaged salads and apple sauce which are products with a relatively shorter shelf-life. The eye-tracking data in the analysis showed the proportion of the normalized time viewing the information from private industry significantly increased the WTP conditional on participants submitting a positive bid for apple sauce as compared with the proportion of normalized time viewing the information from environmental protection groups.

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1. Introduction

Given to the huge amount of research and development, new technologies are always being applied in food production, storage, processing and packaging. Adequate and perfect information about these technologies is not always available and not all the technologies are embraced with the same level of trust. One such technology, nanotechnology, has been claimed to have the potential for developing radically new food products (Sanguansri and Augustin, 2006), and the market for it has shown an increasing trend in recent years. There are more than 180 nanofood applications in developing stage and more than 300 available in the market and globally, with 1200 companies involved in the research and development, mainly in the USA. The nanofood market is expected to grow from 7.0 billion USD in 2015 to 20.4 billion USD in 2020 (Helmut Kaiser Consultancy, 2011). According to the Project of Emerging Technologies (http://www.nanotechproject.org/) an online inventory of products produced using nanotechnology, there are 98 consumer based nano-food and nano-packaged products, which range from Nanotea to a chocolate slim shake with nanoceuticals (Maynard & Michelson, 2006, Dudo et. al. 2010)..

National Nanotechnology Initiative defines nanotechnology as understanding and control of matter at nanoscale, at dimensions approximately between 1 and 100 nanometers, where unique phenomena enables novel applications. The nanoscale particles are only visible through an optical microscope. To understand the minuteness of these particles, consider a single strand of human hair, it is about 80,000 to 100,000

nanometers wide. Nanotechnology has equipped scientists to de-constitute or decompose nature into its constituent components of atoms, molecules and super-molecular structures and reconstitute and recombine these components into new forms (Scrinis, 2006a). This phenomenon can be implemented in changing the nature of various food ingredients and nutrients to improve control and diminish desired and undesired characteristics of the food products.

Various food companies are invested in the research of implementing this technology in their processed food and beverages and have marketed nanotechnology in a positive light (Kuzma and VerHage, 2006). As food ingredients, nano-capsules can be used to increase availability of nutraceuticals, enhance flavor and bind selectively to remove unwanted chemicals (Joseph and Morrison, 2006). Nano-packaging can control the flow of gases resulting in improved shelf-life for products such as vegetables and fruits (Nanobio-RAISE project, 2011). Nano-sensors can change color to warn consumers of food spoilage or contamination by pathogens (ETC Group, 2004) or warn farmers of pests, nutrient deficiencies, or drought stress for improved management (Gruère, 2011). In case of food processing, nanotechnology can be applied to generate nutrient delivery systems in functional foods so that food ingredients are delivered to their specific sites of action (Weiss et al., 2006).

However, environmental groups such as ETC and Friends of Earth have countered industry claims asserting the hazards associated with nanotechnology. These groups claim that with the absence of laws regarding the labeling of nanofoods, nano-modified foods would enter the food chain without any public awareness. They also claim that

there are environmental as well as physiological risks associated with nanotechnology. Many of the nano-processed foods are contaminated by inorganic nano-particles that have no nutritional value and can be toxic pathogens (Friends of earth, 2008). Workers who handle, manufacture, package or transport foods and agricultural inputs that contain manufactured nano-materials are likely to face higher levels of nano-material exposure (Friends of Earth, 2008). Nano-particle and nano-encapsulated food ingredients may have unanticipated effects, far greater absorption than intended or altered uptake of other nutrients (Parry, 2006).

Governmental food safety organizations such as European Food Safety Authority and United States Food and Drug Administration (FDA) have concerns due to the lack of knowledge about the potential effects and impacts of the nano-sized particles on human health and environment (European Food Safety Authority, 2009; FDA, 2009). The 2007 FDA Task Force Report accepts that almost any food category regulated by FDA might currently or in the future involve the uses of nanotechnology somewhere in the manufacturing process. However, it mentions that only a smaller set of products can be expected to retain nano-scale structures in the finished product, such as nano-scale particles or structures in solid objects may release nano-scale materials through use. It also stated that due to unavailability of long-term evaluation data, the long-term effects and toxicity levels remain unknown.

As with any new technology, there is a plethora of information available on nanotechnology and various sources arguing for or against it. But studies have found that the consumers who are one of the main stakeholders are unaware or uninformed about the

seepage of this new technology into their lives. The Consumer Perception and Food Technology survey conducted by Institute of Food Technologist in 2010 showed that two-thirds of the survey participants had no knowledge about nanotechnology (Food Safety News, 2010). In 2010, the Eurobarometer survey conducted in European countries showed that 40 percent of respondents did not have any knowledge about nanotechnology, while almost 20 percent of respondents had a negative or indifferent attitude (European Commission, 2010). In the United States, with limited knowledge about nanotechnology, the majority of consumers are convinced that nanotechnology is more beneficial than risky (Cobb and Macoubrie, 2004), while in Europe, consumers are less supportive of nanotechnology (Gaskell et al., 2005), but nano-packaging is perceived as more beneficial than nano-foods (Siegrista et al., 2007).

A study about the risk and perception about nanotechnology in United States, found that people made decisions about the risks and benefits of nanotechnology based on their previously developed culture and social stance (Kahan et. al., 2007). The perception of consumers about the benefits and the natural origin of nano-foods have a big influence on their willingness to buy, and consumers portray a negative attitude towards nano-foods even if they derive higher health benefits from them (Siegrist et al., 2009). There is a difference in the risk perception between the public who are the end consumers and the scientists who are implementing new technologies for the public (Siegrist et. al, 2007). Diffusing the disconnect between the end users and the innovators could lead to an optimized usage of the emerging technologies which might be actually beneficial to the public.

The purpose of the study was to examine how the major function of nano-packaging, i.e. enhancing the shelf-life of perishable products, and information about nanotechnology affect the consumers' WTP for these perishable products. Specifically, we explore how consumers' WTP for nano-packages differ across three different types of perishable products with varying shelf-lives, i.e. the products with short, medium and long shelf-lives (for example, salads, apple sauce and dried peanuts). We also explore how the information about nanotechnology from various sources, namely, private industry, environmental group, and government agencies (FDA) affect consumers' WTP. In this study focus is on the impact of secondary information (information other than that available on the labels) affects the participants WTP for nanopackaged products. Previous research has shown that the secondary information has an impact on the WTP for various food products (Liaukonyte et. al. 2013).

This current paper is different from the previous studies on consumers' attitudes toward nanotechnology in three ways. First, we use experimental auction with real nano-packaged products instead of hypothetical surveys or hypothetical auctions to elicit consumers' WTP for nano-packaged food products. The experimental auction is incentive-compatible, gives consumers an option of purchasing the nano-packaged products and helps eliminate the hypothetical bias (Harrison and Rutström, 2008). Second, it tests how the information about risks and benefits of nanotechnology from various sources affect consumer WTP for nano- packaged products. Third, eye-tracking is used to develop a more comprehensive understanding of how consumers respond to different types of information.

The motivation for using eye-tracking in this experiment was two-fold. The main reason is that eye-tracking technology provides quantitative and objective evidence of the user's visual and attention processes (Duchowski, 2002). Eye-tracking has been extensively used in studying how users read and perceive information provided on a webpage (Cutrell and Guan, 2007). High infrared eye-tracking cameras are used to track participants' eye movement. These cameras are attached to computer screens on which the subjects are shown visuals such as texts, images or webpages. The second reason is that eye-tracker collects data on the movement of the subject's pupil in the form of fixations (when the pupil was fixated on a particular object) and saccades (eye movement between fixations). One of the major concerns about using eye-tracker might be that the subjects are conscious of their eyes being tracked and would lead to inaccurate results. However, evidence shows that participants forget about their eyes being tracked thus leading to accurate measurements (Maughan et al., 2007). Using eye-tracking technology in the present study makes it possible to quantify the amount of time consumers spent on viewing the information about the nanotechnology. This data can help understand the impact of information from various sources on consumer WTP for nano-packaged products.

Eye movements include fixations (when the eye stops and fixates on the stimuli) and saccades (when the eye is moving between fixations). Research shows that during fixations information acquisition and processing is performed (Pieters et al., 2002; Reutskaja et al. 2011) but not during the saccades (Rayner, 1998). Previous research shows that consumers fixate more frequently and for a greater amount of time on

complex information that is difficult to understand (Ares et al., 2013; Loftus and Mackworth, 1978). Various studies have shown that greater fixation counts occur when consumers are processing information (Jacob and Karn, 2003, Velichkovsky et al, 2002) and/or if the information is more important to them (Pieters and Warlop, 1999; Wedel and Pieters, 2000; Wedel et al., 2008). Consequently, fixation data is often used in eye-tracking research to indicate visual attention.

The current experiment was approved by the University of Minnesota Institutional Review Board.

2. Materials and Methods

This section details the experimental methods, experimental set-up, auction participants, products and information from three different sources made available to participants.

I. Experimental Method.

Experimental auctions place the consumers in a setting, which uses both real money and real products to provide incentives to consumers to reveal their true preferences. In cases where the consumer WTP is elicited through hypothetical auctions or surveys, consumers are found not to reveal their true preferences, thus leading to hypothetical bias (Harrison and Rutström, 2008). Experimental evidence confirms that experimental auctions are a valuable tool for estimating the true value of consumer WTP (Umberger and Feuz, 2004). In the literature investigating consumer WTP for nano-packaged food, the consumers are not presented with the real nano-packaged products.

The consumers were aware of the hypothetical existence of the nano-packaged products and hence these experiments elicited hypothetical instead of actual WTP from the consumers (Bieberstein et al., 2012). The current study goes a step further by making the actual nano-packaged products available to consumers so they have the option of purchasing it if they win the auction. This experiment also builds on the literature that explores the effect of negative, positive and neutral information on consumers' WTP (Rousu et al., 2007) by using eye-tracking technology to quantify the amount of attention consumers give to different types of information.

Eye-tracking Equipment

A Tobii X1 Light Eye Tracker was rented from Tobii Technology (www.tobii.com). The X1 Light Eye Tracker was selected because it could be inconspicuously mounted on a computer monitor and provided the same level of accuracy as other eye tracker options. The eye tracker was then calibrated using a 5 point calibration system of Tobii Studio Professional version 2.2.8 (Ares et al., 2013). The eye-movement data for the information text displayed on the computer screen was recorded by the eye tracker in the form of total visit duration (TVD) and fixation count (FC). The FC indicates the number of eye fixations and the TVD indicates the amount of time each participant spent on the information text displayed in the computer screen. Previous research (Ares et al., 2013) has indicated that fixation data is often used in eye-tracking research to indicate visual processing. Hence the paper has used the fixation counts data in the data analysis.

Auction Mechanism

The auction mechanism used in the experiment was the demand revealing Becker-DeGroot-Marschak (BDM) mechanism (Noussair et al., 2004). Each participant submits the price he or she is willing to pay to purchase the product. At the end of the auction, the market price is drawn randomly. If the bid for auctioned good is equal to or higher than the market price, the participant is required to buy the product. Thus the auction mechanism is incentive compatible because bidders have no strategic incentive to bid above or below their true WTP.

The BDM mechanism was used instead of other popular mechanisms like a 2nd or random nth-price auction to accommodate eye-tracking. With the eye-tracking, subjects participated in the experiment individually rather than in groups. The BDM mechanism can work with individual subjects, while the 2nd and random nth-price auctions require groups of participants.

The participants took 30 -45 min to complete the experiment and almost 15 to 20 min to complete the post-experiment survey.

II. The sample

The experiment was conducted in St. Paul, Minnesota in April 2012 over a period of two weeks. In total, 109 participants were recruited through an advertisement in 13 local newspapers having wide readership in all the socio-economic classes in the Minneapolis and St. Paul metropolitan area. The advertisement specified the requirement

that only the grocery shopper in a household can participate in the experiment. To avoid bias, nanotechnology was not mentioned in the advertisement. Out of the 109 participants 3 participants were dropped because of their unusable eye-tracking data. In total 106 participants were considered during the data analysis for this paper.

III. Products

The experiment focused on the WTP for apple sauce (12 oz.), spring mixed salads (5 oz.) and peanuts (12 oz.), packaged in nano-containers. These food products were chosen because of their varying shelf-lives, allowing us to investigate how consumers react to the main function of nano-container — keeping products fresh for a longer time. The three products were available in organic and conventional versions. Thus there were six products presented to the participants in each round of bidding.

Nanotechnology has been excluded from the organic food production in Canada, European Union, the United Kingdom and Australia (The Organic and Non-GMO Report, 2010). Currently there is there is no regulation for prohibiting the use of nanomaterial in organic products in the United States. There is an ongoing opposition from the organic industry to application of nanotechnology in the food industry (Scrinis et al. 2012). In the United States, the National Organics Standards Board voted on banning nanotechnology from organic food production (Kessler 2011, Center of food Safety, 2009). The consumers are unaware of the use of nanotechnology in the organic food production (Paull and Lyons, 2008). In our study we try to elicit the consumers' WTP for nano-packaged organic food products so that we can understand consumer's

willingness to accept or reject the application of nanotechnology in organic food production.

The experiment comprised of three rounds of bidding, each with six products (3 products in conventional and 3 products in organic form). In the first round, the products were with "plain-labels," that is, we did not have any label indicating the packages of the products were nano-packages. In the second and third rounds, the products were with "nano-labels." Both the "plain-labels" and "nano-labels" displayed contents and weight of the products, and whether or not the products were organic. The nano-label displaying 'Nano-Silver Technology', implied nanotechnology used in the packaging and a logo with the words 'Stays Fresh Longer' which are typically found on nano-containers in the market. Figure 2 and 3 show an example of plain and nano labels which were displayed on the products. We followed the experimental procedure widely followed by the existing literature, where the items were presented to the participants sequentially (Huffman et. al. 2003, Kanter et. al. 2009, Liaukonyte et. al. 2013).

To avoid income and substitution effects, we randomly drew which of the real auction rounds was to be binding and then drew the individual binding product. If a participant won the binding product in the binding round, she/he was required to purchase the product and pay the market price.

IV. Information about Nanotechnology

During the experiment, participants were shown two sets of information in two different steps, and participants were asked to submit their bids for the products after

viewing each set of information. The first set of information was general about nanotechnology and its application in the food industry, which is the same as the information used by Roosen et al. (2011). The second set of information was the view of nanotechnology from different sources, that is, the food-industry's view of nanotechnology, the FDA's view of nanotechnology and an environmental groups' view of nanotechnology.

The industry perspective was mainly about the positive applications of nanotechnology in food packaging and its ability to keep food fresh longer and prevent food-borne illness. The FDA's information was neutral in terms of confirming the usefulness of nanotechnology for increasing shelf-life and preventing food-borne illness, but also in terms of warning about the unknown nature of the emerging technology and its untested level of risk in the long-term. The environmental group's perspective was mainly negative about nanotechnology, mainly presenting the harmful side-effects of nanotechnology. It informed the participants about the migration of harmful nanomaterials such as zinc oxide and titanium oxide from the nano-packaging into the food products. It also mentioned the presence of silver nano-particles in consumer products and its adverse effects such as the destruction of useful bacteria and development of antibacterial resistance bacteria. This information was from a well-known environmental protection group, Friends of Earth. The text of the information displayed to the participants is shown in Table 7.

V. The Experiment

The experiment was set up on a computer with eye-tracking equipment. The product images, information about nanotechnology and the instructions for the experiment were made available on computer screens. This allowed for little to no interaction between the participants and the proctor of the experiment, thus reducing any errors caused due to miscommunication.

The diagrammatic representation of the experimental flow is shown in Figure 1. On arrival participants were asked to sign a consent form. They were then instructed about the eye-tracking mechanism, how to use the computer and mouse to traverse from one computer screen to another, and entering the bids on the provided bidding sheet. Each participant's eyes were calibrated to the eye-tracking equipment and the auction mechanism was explained. To make the experimental auction procedure smoother and eye-tracking process easier, participants viewed the information about nanotechnology and the images of the auctioned products on a computer screen. Participants were informed that the exact same real products shown in the image were being auctioned and if a participant won the auction, he/she would receive the item and pay the market price.

When the application was launched, there was a practice round for a candy bar. Following the practice round, participants were asked to bid on six plain-labeled products. The following screen displayed general information about nanotechnology and its application in food production and packaging. This was followed by the six products with nano-labels and instructions for participants to write down their WTP for each product. Then the following three consecutive screens displayed three different

information sets from three different sources. The sequence of the three information set was randomized to form six sequences of the information sets. Table 6 shows the randomized sequences and the number of participants it was presented to during the experiment. Six products with nano-labels (3 products, each in conventional and organic version) were displayed with instructions for participants to write down the price they were willing to pay for each product. This ended of the bidding. After the auction, participants completed a survey asking their opinions about the risks and benefits of nanotechnology and nano-packages along with typical socio-demographic questions. It should be noted that the products in the different rounds were displayed in the packages with the same appearance but with different labels. The products were displayed with plain-label in the first round of bidding and then with nano-label in the second and the third round of bidding.

3. Results

The study sample consisted of seventy-three percent women (Table 1). The average age was 55 years and the average income was $63,000, which is consistent with the findings in the literature that most grocery shoppers are women and tend to be older (Bawa and Ghosh, 1999 and Goodman, 2008). The average household size was 2.47 and about 56 percent of participants were married or in a relationship. Over half had a college degree.

Fixation counts (FC) indicate the level of visual information processing (Jacob and Karn, 2003; Velichkovsky et al., 2002). Research also shows that while comparing

texts with varying length and varying level of difficulty average fixation count per word is the measure of visual perception processing (Poole et al. 2004). As the length of the text of information from various sources has varying length we calculated the average of the fixation count per word. Table 2 reports the average fixation counts per word i.e. the average level of visual information processing of the participants while viewing information from various sources. From the table it can be seen that the participants had highest visual processing for viewing information from the environmental groups followed by information from governmental agency and then information from the private industry[1].

The first three rows of Table 3 report the average bids across the three rounds of auction. The numbers in the parentheses in the first three rows of table 3 display the percentage of zero bids for each round of bidding. A participant registered a zero bid for an item when he or she was not willing to buy that particular item. As the participant submitted zero bids even if his WTP was negative, the participants' bids were left censored to zero. The percentage of zero bids in the second round is higher than that in the first round, and the percentage of zero bids is the highest in the third round. The WTP for individual products increased from auction round 1 to round 2 except for peanuts. The WTP decreased or remained constant for all the products from auction round 2 to round 3. This implies that more participants were less inclined towards buying nano-packaged products when they gained more information about nano-technology (since the percentages of zero bids increased when they gained more information). However, on

[1] *Average Fixation Counts per word* = $\frac{Average\ Fixation\ Count}{Number\ of\ Words}$

average, the participants who submitted non-zero bids have increased or did not decrease their bids to a large extent when they get the general information about nano-technology (since the average bids increased from round 1 to round 2). This implies that, on average, there is a positive impact of general information about nanotechnology on participants' WTP, whereas more information from various sources has a negative or no impact on the participants' WTP. The reduction the WTP from auction round 1 to round 2 for peanuts can be interpreted as participants' unwillingness to pay for a nano-packaged product with a longer shelf-life.

The last two rows of Table 3 denote the percentage change in the WTP for products in consecutive auction rounds. The percentage change in WTP from round 1 to round 2 shows that the participants paid a premium of almost 17 percent to purchase nano-packaged apple sauce. On the contrary, they paid a premium of only 6.4 percent to purchase nano-packaged salads and a premium of 2.3 percent for nano-packaged peanuts.

Participant bids were left censored at zero. There are a significant percentage of zero bids in the second and third round of auction, in which the participants were submitting their WTP for nano-packaged food products. With a significant percentage of the bids being limited to zero, the appropriate model to use for estimating the WTP is a Tobit model (Lusk et. al. 2000). The Tobit model assumes that the probability of a zero WTP and the probability of a non-zero WTP are both affected by the same factors and to the same degree. The participants' risk perception and attitudes towards nanotechnology influences the probability of the participants submitting a positive bid. Once the participants' cross the first hurdle of submitting a positive bid, the second hurdle is the

decision about how much to pay for the product. These two hurdles might be affected by the different factors or affected by the same factors but in different ways. Hence in order to decompose these two effects from the data a Cragg's double hurdle model was used to estimate the WTP. The Cragg's double hurdle model is less restrictive as it allows for different determinants for zero bids and non-zero bids. Following the Cragg's model the first hurdle is the probability of participants' submitting a positive bid for the nano-packaged products. If the participant decides not to pay for the nano-packaged products by submitting a zero bid, then the probability of submitting a zero bid is denoted by the following equation (1).

$$\text{Prob}\left(\text{WTP}_j^i = 0\right) = \Phi(-X_j^i \beta_j^i) \quad (1)$$

where

WTP_j^i is the bid for a product by participant j in round i;

β_j^i is the vector of regression coefficients;

X_j^i is the vector of exogenous variables, which include the participant characteristics; and

Φ is the standard normal cumulative distribution function.

Similarly the second hurdle measures the participants' WTP conditional on participants' willingness to submit positive bids and can be formulated as denoted by equation (2)

$$f\left(WTP_j^i \,|WTP_j^i > 0\right) = \frac{\left\{\frac{1}{\sigma}\Phi\left(\frac{\left[WTP_j^i - X_j^i \beta_{2j}^i\right]}{\sigma}\right)\right\}}{\Phi\left(\frac{X_j^i \beta_{2j}^i}{\sigma}\right)}$$

(2)

where

β_{2j}^i is the vector of regression coefficients;

Φ is the standard normal probability density function; and

σ is the standard deviation of the distribution function Φ.

Given equation (1) and (2), the estimated likelihood function for the random sample is denoted by

$$L = \prod_{j=1}^{n} \Phi\left(-X_j^i \beta_j^i\right)^{1-p_i} \left\{\Phi\left(X_i \beta_{1j}^i\right) \frac{\left[\left(\frac{1}{\sigma}\right)\Phi\left(\frac{\left[WTP_j^i - X_j^i \beta_{2j}^i\right]}{\sigma}\right)\right]}{\Phi\left(\frac{X_j^i \beta_{2j}^i}{\sigma}\right)}\right\}^{p_i} \quad (3)$$

where

$p_i = 1$ if $WTP_j^i > 0$ and zero otherwise.

There were three information sets (i = 0, 1, 2) for each participant, j. The dummy variables information 1 (general information about nanotechnology) and information 2 (information about nanotechnology from various sources) are created to account for the

revelation of information after bidding rounds 1 and 2, respectively. To understand the effect of previous knowledge of nanotechnology on participants' WTP, a variable about participants' prior knowledge about nanotechnology was included in the regression. Almost 50 percent of the participants indicated that they had previous knowledge about nanotechnology.

The demand for a product in nano-packaging can be a function of the product's shelf-life. Therefore, three food products with various shelf-lives (salads, apple sauce, and peanuts) were used in this experiment. The double hurdle model was estimated for each product separately. Table 4 reports the results from the first hurdle and second hurdle estimation.

There are two columns showing the results for each food product. The first column for each food product shows the effect of participants' demographic variables and information variables on the probability of bidding positively for the nano-packaged good. The estimated coefficient on the dummy variable for information 1 (general information) was not statistically significant for any of the products. Thus general information displayed to the participants in the second round of bidding did not have any significant effect on the participants' probability of bidding positively for the nano-packaged products. The estimated coefficient on the dummy variable for information 2 (specific information from various sources) was negative and statistically significant for all the food products. This indicates that the specific information from various sources displayed to the participants in the third round of bidding, decreased the participants' probability of biding positively for nano-packaged products. It also can be interpreted,

that as the participants gained more specific information about nanotechnology from various sources their probability of submitting positive bids for nano-packaged products decreased. The coefficient for the variable denoting the participant's prior knowledge about nanotechnology was positive for apple sauce, showing that participants who had prior knowledge about nanotechnology were more likely to bid positively for apple sauce. Results also show that women were less likely to submit a positive bid for salads and apple sauce. Similarly participants with bigger households were less likely to submit a positive bid for peanuts.

The estimates from the second hurdle model indicate that consumers were willing to pay more for the organic nano-packaged products. There are various studies which have shown similar results in which consumers or participants were ready to pay a premium for organic food products (Batte et al., 2007; Akaichi et al., 2012). The results also indicate that both the general information and specific information had a positive effect on participants' WTP for salads and apple sauce conditional on their willingness to submit positive bids. The effect was higher for apple sauce than that for salads, for both the information variables[2]. The interaction term for organic and information 1 is significant for apple sauce, but not for salads and peanuts, implying that general information had a positive effect on the participants' WTP for nano-packaged organic apple sauce Female participants were willing to pay more for nano-packaged products as compared to that of male participants.

[2] The coefficients for the effect of information (both general information and specific information) on conditional WTP for salads and apple sauce were statistically different from each other with a significance level of $p < 0.001$.

The age of the participants had a negative effect on the conditional WTP for salads. This finding is consistent with the literature that older people were less accepting of nanotechnology (Bieberstein et al., 2012). Education had a positive effect on the conditional WTP for salads and income had a positive effect on the conditional WTP for peanuts. This result is consistent with the previous studies which have found that consumers with higher education and income seek innovative products while grocery shopping (Ailawadi and Neslin, 2001). Results also show that participants who had prior knowledge about nanotechnology showed a positive attitude towards nano-packaged products. Existing literature suggests that prior beliefs about an emerging technology have impact on the acceptance of technology such as GMO (Huffman et al., 2007). The findings in the current paper are consistent with the earlier findings that prior knowledge about nanotechnology has positive impact on consumer acceptance of nano-packaging (Bieberstein et al., 2012).

There is a difference in the effect of general information and specific information about nanotechnology on the probability of submitting positive bids and conditional WTP for nano-packaged products. While general information about nanotechnology did not have any effect on participants' probability of submitting positive bids, the specific information about nanotechnology reduced the participants' probability of submitting positive bids. The conditional WTP for nano-packaged products was influenced positively by both the general information and specific information about nanotechnology.

To understand how the visual processing of the specific information about risks and benefits of nanotechnology from various sources affected participants' bidding behavior, a double hurdle model was estimated for bids submitted by the participants in the third round of bidding for each product.

Table 5 reports double hurdle model estimation results for the bids in the third round of bidding. The explanatory variables in these estimations included the visual processing data (average fixation counts per word) of the participants in viewing the information from various sources. These variables were derived from the eye-tracking software. Average fixation counts (FC) indicate the level of visual information processing (Poole et. al. 2004). This was helpful in evaluating the effect of visual processing of the presented information from various sources on the WTP for the nano-packaged products. The explanatory variables also included the interaction effects between the average fixation per word and the socio-demographic variables. This is to investigate how the differences in participants' socio-demographic backgrounds affect the visual processing of information's impacts on participants' WTP for nano-packaged products.

The first hurdle model shows that the information from governmental agency had a negative effect on participants' probability of bidding positively for the nano-packaged products. Results also show that information from environmental agency had a negative effect on the probability of older participants bidding positively for the nano-packaged products and the information from governmental agency had a negative effect on the probability of older participants bidding positively for the nano-packaged products. Participants with higher income had a negative probability for submitting positive bids if

they had spent more time visually processing the information from governmental agency. Participants with prior information about nanotechnology had a positive probability for submitting positive bids for all the nano-packaged products. This implies that someone with a prior knowledge of nanotechnology might have positive impression about it. Compared to participants who had no prior knowledge of nanotechnology, the environmental information had a relatively smaller negative impact on the probability of submitting a positive bid than those who had heard of nanotechnology before. Results also show that participants with higher income had a positive probability of submitting positive bids while married people had a negative probability for submitting positive bids for nano-packaged products.

The estimates from the second hurdle model indicate that consumers with prior knowledge of nanotechnology were willing to pay a premium for nano-packed apple sauce and peanuts. The premium is higher for apple sauce than peanuts. This might be due to the consumption preferences of the participants. It is possible that the participants' consume higher amount of apple sauce and peanuts as compared to salads. Also, the participants might prefer to consume salads immediately instead of storing them for a longer time.

Results also show that women in general were not willing to pay for nano-packaged salads and that private information had a negative effect on women's WTP for nano-packaged salads. Research has shown that on average women consume more salads than men (Blanck et. al. 2008). This might be the reason for women not wanting to store their salads for a longer time as they consume their salads immediately. Private information

had a negative effect whereas information from governmental agency had a positive effect on the married participants' WTP for nano-packaged salads and apple sauce compared to unmarried participants. Additionally, if participants had prior knowledge of nanotechnology, the information from governmental agency had a negative impact on their WTP for all the nano-packaged products. Results also show that for participants with higher income, the environmental and private industry information had a positive effect on the WTP for apple sauce. The governmental information had a positive effect on the older participants' WTP for apple sauce. Participants with larger household size were willing to pay a higher premium for the nano-packaged products compared to those participants with smaller household size.

4. Conclusion

This paper has explored the influence of information on consumers' WTP for nano-packaged food products with varying shelf-lives. The experiment conducted in April 2012, consisted of a sample of 106 non-student grocery shoppers from Minneapolis and St Paul in Minnesota, USA. Consumers are important stakeholders in the food industry and hence it is important to understand consumer attitude towards application of nano-packaging in food industry before introducing nano-packaged food products into the market.

The results show that participants' probability of submitting positive bids and participants' conditional WTP for nano-packaged products were influenced by the general and specific information from different sources about nanotechnology in different

ways. While general information had no effect on the participants' probability for submitting a positive bid, specific information from various sources had a negative influence on the participants' probability for submitting positive bids. The participants, who were probable of submitting a positive bid for the nano-packaged apple sauce and salads, were also willing to pay a premium for nano-packaged apple sauce and salads after viewing both the general information and specific information from various sources. The participants who had prior knowledge of nanotechnology were willing to pay a premium for all the nano-packaged products.

The analysis using the participants' visual perception data (average fixation counts per word) collected from the eye tracker, shows interesting behavioral patterns across participants from different segments. Information from governmental agency had a negative effect on the participants. But older participants had a positive perception of the governmental information than the environmental agency information. Governmental information had neutral perspective whereas environmental information had a negative perspective about nanotechnology and so this is an expected behavior. Environmental information had a positive effect on the participants with prior knowledge about nanotechnology, as compared to other participants. It is possible that their prior knowledge had a lower negative effect on their willingness to submit a positive bid as compared to that of the participants with no knowledge. Similarly, the governmental agency information had a negative effect on the WTP of participants with prior knowledge of nanotechnology. We can conclude that for participants who had prior knowledge of nanotechnology and chose to submit a positive bid for nano-packaged

products, the governmental information had a negative effect on their bids. The results show how information from various sources had a different effect on participants with different characteristics.

The participants, who submitted a positive bid for the nano-packaged products, were willing to pay a premium for the nano-packaged apple sauce and salads, but they were not willing to pay a premium for peanuts. Salads, a fresh produce, have a shorter shelf-life and apple sauce, a processed food has a medium shelf life, as compared to that of peanuts, a dried food which have a comparatively longer shelf life. One of the main characteristics of nano-packaging is its ability to keep food fresh for a longer period of time. From the table 2, it can be seen that apple sauce has the highest percent of zero bids as compared to salads and peanuts. Hence it can be concluded that participants were interested in storing fresh produce like salads and processed food like apple sauce with a lower shelf life for a longer period of time by using nanotechnology, given that the participants consume these products at the same level. However, participants were not interested in using nano-packaging for dried food products like peanuts, which intrinsically have a longer shelf-life. The results also suggest that participants were willing to pay a higher premium for apple sauce than for the salads. Apple sauce is a processed food product with a medium shelf-life and gets spoiled if not refrigerated or stored in an air-tight container. Salads are green vegetables which are intended to consume immediately and hence participants were willing to pay a lower premium for nano-packaged salads. .The participants were also willing to pay a premium for organic nano-packaged food products. This might be the case because these participants preferred

consuming organic food. The results contribute to understanding consumers' attitude towards nano-packaged food as a function of product shelf-life, which have important food marketing implications. The food processing industry can use the knowledge about consumer attitude to evaluate which products they can package using nanotechnology. There is also a potential for further research in this area. Consumer WTP for nano-packaged fresh produce and processed food products like fresh vegetables, fresh juices and herbs, bread, jams, jellies, sauces and milk products such as cheese and milk, can be further explored to understand the intricacies of consumer attitude towards application of nano-packaging in food products whose moderate shelf-life largely depends upon the way they are stored The National Organic Standard Board can investigate this further to understand the consumers' attitude towards nano-packaged organic food products and apply the findings in their policy decisions.

In closing, it is worth reflecting on some of the limitations of this study, so the results can be interpreted with suitable caution. Subjects were recruited from in and around the Minneapolis and St. Paul, a metropolitan area in the Midwest so our results may not be representative of consumers in other regions of the U.S. or consumers in other countries. The sample size was relatively small compared with hypothetical surveys. While these limitations suggests our results should be interpreted with some caution, they also point to directions for future research that could provide additional information for policy makers and the food industry for the challenging problem — the use of new technologies in food products.

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Table 1

Summary statistics of participants' socio-demographic background variables (n=106)

Variable	**Description**	**Mean**	**Standard Deviation**
Gender	Gender of participants, 1 if Female, 0 if male	0.73	0.44
Age	Age of participants in years	54.09	15.47
Annual Income	Annual Income of participants in USD	61432.09	27978.15
Education	Participants' education level, 1 if college graduate or higher, 0 otherwise	0.57	0.49
Marital Status	1 if Single, 0 otherwise	0.56	0.49
Size of Household	Number of people in the household	2.47	1.53
Prior knowledge of Nanotechnology	Self-Reported Knowledgeable about Nanotechnology, 1 if they had some knowledge about nanotechnology, 0 otherwise.	0.49	0.50

Table 2

Average Fixation Counts per word for the information from various sources.

	Average Number of Fixations per word	Standard Deviation
Government agency	0.909	0.524
Environmental Group	1.106	0.658
Private industry	0.851	0.446

Average Number of Fixation Counts per word = $\frac{Average\ Fixation\ Count}{Number\ of\ Words}$

Table 3

Average WTP, differences in WTP and percentage of zero bids for the three rounds of auctions.

	Salad	**Apple Sauce**	**Peanuts**	**All Products**
Round 1 of Auction	1.88 [z] (0.95%) [y]	1.62 (2.38%)	2.21 (0.95%)	1.90 (1.47%)
Round 2 of Auction	2.00 (5.23%)	1.89 (5.23%)	2.27 (4.25%)	2.06 (4.92%)
Round 3 of Auction	1.82 (11.42%)	1.72 (13.33%)	2.07 (11.90%)	1.87 (12.22%)
% change in WTP Round 2 - Round 1	6.38%	16.66%	2.71%	8.4%
% change in WTP Round 3 - Round 2	(-) 9%	(-) 8.99%	(-) 8.81%	(-) 9.22%

[z] The mean of the bids;

[y] Percentage of zero bids.

Table 4

Effect of Information on WTP (Double hurdle model parameter estimation)

Variable	**Salads**		**Apple Sauce**		**Peanuts**	
	First Hurdle	Second Hurdle	First Hurdle	Second Hurdle	First Hurdle	Second Hurdle
Organic	0.006 (0.551)	0.536*** (0.129)	0.197 (0.411)	0.539*** (0.145)	0.000 (0.539)	0.543*** (0.1462)
Information 1	-0.632 (0.453)	0.302*** (0.132)	-0.285 (0.346)	0.404*** (0.147)	-0.598 (0.447)	0.208 (0.149)
Information 2	-1.258*** (0.423)	0.247** (0.135)	-0.875*** (0.314)	0.427*** (0.151)	-1.185*** (0.418)	0.190 (0.153)
Information 1 * Organic	-0.269 (0.629)	-0.122 (0.183)	-0.204 (0.514)	0.368** (0.201)	-0.190 (0.621)	-0.544 (0.209)
Information 2 * Organic	-0.079 (0.601)	-0.118 (0.188)	-0.194 (0.471)	-0.125 (0.207)	-0.049 (0.587)	-0.138 (0.213)
Prior knowledge about nanotechnology	0.143 (0.254)	0.171*** (0.081)	0.347** (0.178)	0.221** (0.089)	0.143 (0.186)	0.350*** (0.092)
Gender	-0.495*** (0.254)	0.410*** (0.093)	-0.620*** (0.255)	0.208*** (0.097)	-0.249 (0.230)	0.331*** (0.103)
Age	-0.009 (0.008)	-0.007*** (0.003)	-0.010 (0.008)	-0.001 (0.003)	-0.010 (0.008)	0.002 (0.003)
Income/1000000	-0.538 (3.650)	2.183 (1.460)	-2.484 (3.476)	2.523 (1.596)	-2.991 (3.600)	5.180*** (1.660)
Education	0.003 (0.086)	0.116*** (0.034)	0.114 (0.082)	0.058 (0.037)	0.020 (0.084)	0.025 (0.039)
Marital Status	-0.097 (0.204)	0.047 (0.089)	0.205 (0.190)	-0.002 (0.097)	0.163 (0.198)	0.083 (0.101)
Size of Household	-0.066 (0.080)	0.072*** (0.033)	-0.120 (0.077)	0.062** (0.036)	-0.134** (0.078)	0.053 (0.038)
Constant	3.886 (0.967)	0.167 (0.036)	2.786 (0.837)	0.149 (0.336)	3.332*** (0.888)	0.026 (0.351)

***, **, * represent significance level at p <0.01, 0.05, 0.1 respectively. Standard errors are reported in parentheses.

Table 5

Effect of average fixation per word (visual processing) for the information on WTP (Double hurdle model parameter estimation)

Variable	**Salads**		**Apple Sauce**		**Peanuts**	
	First Hurdle	Second Hurdle	First Hurdle	Second Hurdle	First Hurdle	Second Hurdle
Prior knowledge about nanotechnology	-1.104 (1.367)	0.564 (0.454)	-1.053 (1.360)	1.180** (0.502)	-4.221** (2.145)	1.093 ** (0.476)
FC_Environment	2.304 (10.836)	0.591 (1.948)	1.685 (10.973)	2.927 (2.045)	20.711 (1.732)	0.762 (1.923)
FC_Government	-18.325** (8.848)	0.886 (1.975)	-16.795** (8.652)	-2.491 (0.490)	-57.198** (23.489)	0.196 (1.944)
FC_Private	-0.666 (11.624)	-1.729 (2.096)	-0.830 (12.220)	0.394 (0.665)	-26.471 (54.851)	0.813 (2.070)
FC_Environment * Age	-0.352*** (0.135)	-0.019 (0.022)	-0.350** (0.135)	-0.000 (0.024)	-1.070** (0.339)	-0.013 (0.023)
FC_Government *Age	0.267** (0.135)	-0.001 (0.018)	0.259** (0.127)	0.037* (0.020)	0.883*** (0.329)	-0.000 (0.019)
FC_Private * Age	0.017 (0.152)	-0.010 (0.030)	0.023 (0.149)	-0.041 (0.033)	0.233 (0.327)	-0.007 (0.031)
FC_Environment *Income	0.222 (0.324)	-0.100 (0.096)	0.231 (0.302)	0.217** (0.073)	0.211** (0.084)	-0.862 (0.098)
FC_Government *Income	-1.111** (0.432)	-0.091 (0.011)	-1.131** (0.498)	-0.156 (0.121)	-0.571** (0.198)	-0.468 (0.023)
FC_Private * Income	-4.349 (0.494)	0.161 (0.103)	-0.418 (0.498)	0.217** (0.105)	0.801 (0.959)	0.136 (0.010)
FC_Environment *Gender	3.706 (3.480)	0.299 (0.462)	4.028 (3.377)	-0.536 (0.506)	11.655* (6.535)	-0.565 (0.472)
FC_Government *Gender	3.389 (2.926)	0.033 (0.493)	2.796 (2.796)	0.081 (0.527)	0.918 (6.479)	-0.146 (0.494)

FC_Private * Gender	-1.241 (4.275)	1.365** (0.650)	-1.315 (4.375)	-0.060 (0.708)	-10.053 (22.403)	0.353 (0.669)
FC_Environment *MaritalStatus	-0.275 (2.816)	-0.296 (0.598)	-0.379 (2.828)	-0.352 (0.656)	-4.636 (5.646)	-0.141 (0.618)
FC_Government *MaritalStatus	3.734 (3.077)	1.209** (0.605)	3.954 (3.040)	1.205* (0.676)	23.814** (9.631)	0.844 (0.627)
FC_Private * MaritalStatus	5.682 (3.677)	-1.665*** (0.651)	5.596 (3.523)	-1.384* (0.715)	13.615* (7.327)	-1.042 (0.657)
FC_Environment *Education	0.587 (1.059)	0.104 (0.249)	0.629 (1.033)	-0.191 (0.270)	-0.085 (2.145)	0.049 (0.252)
FC_Government *Education	0.493 (0.947)	-0.237 (0.228)	0.449 (0.924)	0.240 (0.252)	3.873** (1.872)	0.177 (0.234)
FC_Private * Education	-0.868 (1.186)	0.227 (0.249)	-0.868 (1.141)	0.121 (0.275)	-2.582 (1.781)	0.117 (0.257)
FC_Environment *Prior knowledge of nanotechnology	5.798** (2.729)	0.217 (0.571)	5.685** (2.709)	0.174 (0.636)	4.893** (2.174)	-0.951 (0.584)
FC_Government *Prior knowledge of nanotechnology	-3.024 (2.057)	-0.819* (0.447)	-3.018 (2.017)	-1.298** (0.490)	-7.409** (3.057)	-1.348** (0.457)
FC_Private * Prior knowledge of nanotechnology	-1.310 (1.852)	0.287 (0.593)	-1.315 (4.375)	0.394 (0.665)	7.357 (4.588)	-0.239 (0.607)
Gender	-8.792 (5.744)	-1.238* (0.772)	-8.337 (5.681)	0.913 (0.850)	-6.651 (14.721)	0.723 (0.803)
Age	0. 100 (0.094)	0.0177 (0.025)	0.101 (0.094)	-0.005 (0.028)	0.132 (0.161)	0.022 (0.026)
Income/1,000,000	1.071** (5.150)	1.070 (1.070)	1.064** (0.534)	1.301 (1.180)	1.623* (0.962)	8.232 (1.011)
Education	0.084 (0.909)	0.031 (0.195)	0.077 (0.876)	-0.184 (0.216)	-0.446 (1.699)	-0.382* (0.206)
Marital Status	-8.051**	0.629	-8.146***	0.257	-3.685***	0.255

	(2.751)	(0.559)	(2.786)	(0.613)	(1.248)	(0.583)
Size of Household	0.036	0.176***	0.042	0.177**	0.795	0.133*
	(0.260)	(0.067)	(0.269)	(0.076)	(0.492)	(0.070)
Constant	20.206	0.572	19.414	-1.787	72.781	-1.326
	(11.291)	(1.872)	(11.263)	(2.070)	(38.638)	(1.956)

***, **, * represent significance level at p <0.01, 0.05, 0.1 respectively. Standard errors are reported in parentheses.

$$Average\ Fixation\ Counts\ per\ word = \frac{Average\ Fixation\ Count}{Number\ of\ words\ in\ the\ information}$$

Table 6

Six different sequences of the information presented to the participants

Sequence	First Information	Second Information	Third Information	No. of participants.
1	Private Industry	Environmental Group	Government	17
2.	Private Industry	Government	Environmental Group	21
3.	Government	Private Industry	Environmental Group	16
4.	Government	Environmental Group	Private Industry	17
5.	Environmental Group	Government	Private Industry	17
6.	Environmental Group	Private Industry	Government	17

Table 7

Information from various sources displayed to the participants.

Source	Information presented
Information 1	
General Information	Nanotechnology refers to materials, systems and processes which exist or operate at the scale of atoms and molecules. This is a scale between 1 and 100 nanometres (nm). One nanometre is one millionth of a millimetre (mm). Materials at the nano-scale show novel properties that lead to novel applications in diverse fields like medicine, cosmetics, biotechnology, energy production and environmental science. There is uncertainty regarding how nano-materials may interact with human health and the environment. Nanotechnology offers new opportunities for food industry application. Manufactured nano-materials are already used in some food products, nutritional supplements and food-packaging applications(Bieberstein et. al.2013, Roosen et al., 2011).
Information 2	
Private Industry	Nano-packaging has created a modified atmosphere in packaging in order to control the flow of gases resulting in improving the shelf-life of products like vegetables and fruits. One of the most promising innovations in smart packaging is the use of nanotechnology to develop antimicrobial packaging. Scientists at big name companies including Kraft, Bayer and Kodak, as well as numerous smaller companies, are developing a range of smart packaging materials that will absorb oxygen, detect food pathogens, and alert consumers to spoiled food. These smart packages, which will be able to detect public health pathogens such as *Salmonella* and *E. coli*. (Nanobio-RAISE project, 2011)
Environmental Agency	Anti-bacterial nanofood packaging and nano-sensor technologies have been promoted as

	delivering greater food safety by detecting or eliminating bacterial and toxin contamination of food. However it is possible that nanomaterials (such as silver, zinc oxide and titanium dioxide) will migrate from antibacterial food packaging into foods, presenting new health risks. This appears inevitable where nano-films or packaging are designed to release antibacterial onto the food surface in response to detected growth of bacteria, fungi or mould. Silver nanoparticles are found in an increasing number of consumer products such as food packaging, odour resistant textiles, household appliances and medical devices. The potential for nanosilver to adversely affect beneficial bacteria in the environment, especially in soil and water, is of particular concern. Conversely, there is also a risk that use of silver nanoparticles ("nanosilver") will lead to the development of antibiotic resistance among harmful bacteria. (Friends of Earth, 2008).
Governmental Agency	Nano-packaging has the potential to help improve the safety, shelf-life, and convenience of food. At present there is insufficient data publicly available to reach meaningful conclusions on the potential toxicity of food or color additives incorporating nano-materials, although the available information does not give us cause for concern. (Food and Dietary Association, 2007)

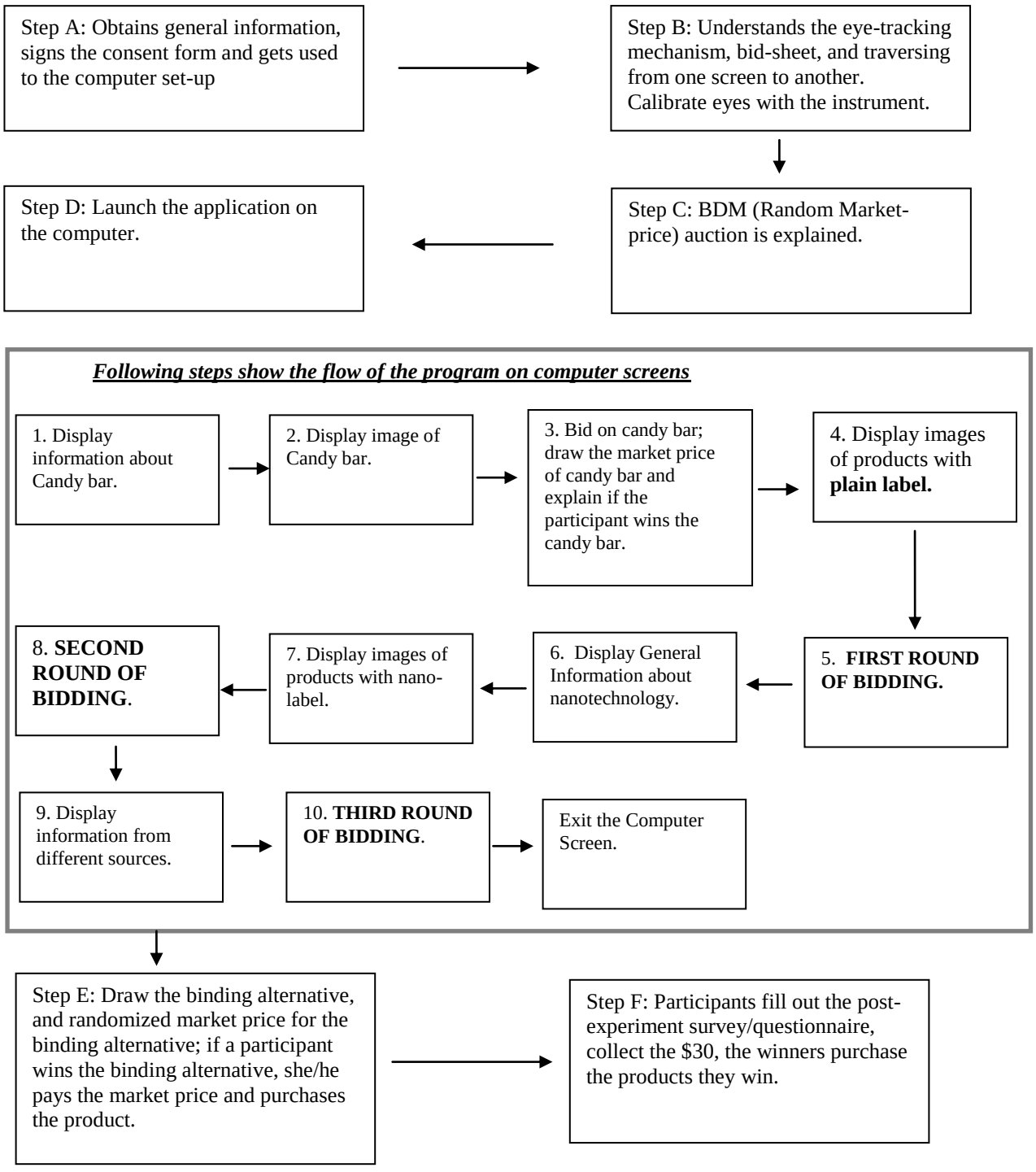

Figure 1. Diagrammatic Representation of the Flow of the Experimental Auction

Figure 2. Nano-labeled product displaying the ‘Stays Fresh Longer’ nanotechnology label

Figure 3. Plain-labeled product