Consumer Response to Controversial Food Technologies and Price: A Neuroeconomic Analysis

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1. Introduction

Historically, the challenge for humans has been to secure a sufficient supply of food to stave off hunger and starvation. As a result, significant efforts have been devoted to improving agricultural productivity and farm profitability. Agricultural research and technological development have drastically increased food availability. For example, whereas corn yields were only 24 bushels/acre in the 1940s, today average corn yields are more than 150 bushes/acre (Paarlberg, 2010). While the problem of food availability has not been completely eradicated, people living in today's developed countries are more likely to suffer from problems of over-consumption as they are from hunger. Today's food consumers not only have access to more food than ever before, they can also choose between a much wider variety and quality of foods than ever in the past.

In part because of these changes and the reduction in food prices that have resulted, consumer and environmental groups are demanding more from the food production system – including sustainability, naturalness, reduced environmental impacts, and decreased use of genetic modification, growth hormones, and pesticides. In fact, technologies such as animal growth promotants and genetically modified crops, which have the potential to further increase productivity and lower food prices, are being spurned by many consumers and governments. Some have argued that the general public is increasingly distrustful and skeptical of science in general (Maddox, 1995) and new food technologies specifically (Gaskell et al., 1999; Ronteltap et al., 2007). For example, Loisel and Couvreur (2001) show that a majority of French consumers (52%) trust independent consumer action groups on the issue of the safety of emerging food technologies more than the French public agency for consumer protection (36%), though consumers trust advertising (5%) and other government agencies much less (4%). Several studies show the U.S. public is more trusting of food regulatory agencies such as the U.S. Department of Agriculture and the Food and Drug Administration than are Europeans; however, 92% of U.S. consumers want to know whether their food has been produced with such technologies and roughly 45% state they are undecided as to whether the foods produced from these technologies are safe and only 26% respond that they would have no concerns consuming these foods (Wimberley et al., 2003). As a result, achieving further increases in agricultural productivity is not simply a question of what is scientifically possible, but also a question of what consumers will support and the kind of society in which they want to live (Gaskell et al., 2005). It is clear that more research is needed to understand *why* consumers are averse to some new food technologies.

The emerging field of neuroeconomics, which integrates the findings of economics, psychology, and neuroscience, can provide unique insights into consumer preferences. With new food technologies such as cloning or added artificial growth hormones, consumers face complex and conflicting information related to the quality, safety, nutrition, and ethical outcomes associated with food choices. Economics has partially addressed this challenge by using experimental methods to predict people's choices and willingness-to-pay for products using the technologies, but thus far has offered little to explain why choices are made. There is a renewed need to open the "black box" to better characterize the decision-making process and the determinants of food choice.

Neuroeconomics approaches the economic question of choice by considering the brain as an adaptive organ that evolved over time to solve important problems facing the biological organism. Food gathering and food safety were important challenges that needed to be addressed in order to ensure the survival of the human organism and, hence, the species. The human brain evolved in ways that helped solve these problems. While hunting and gathering may not be important to the survival of the human species in 21st century United States, nonetheless, the human brain is still "wired" to respond to pleasures and perceived threats from food, in part, because of evolutionary processes that determined the brain's structure. How the brain responds is a function not only of conscious deliberations but automatic and emotional responses to new stimuli (Glimcher, 2002; Camerer et al. 2005; Weber and Johnson 2009).

The purpose of this research is to enhance understanding of consumers' preferences for new food technologies by capitalizing on recent developments in economics and neuroscience. Specifically, this research seeks to determine how the human brain responds to the controversial newer food technologies as compared to standard, "rational" food attributes such as product price. By determining which regions of the brain activate in response to stimuli on new food technologies, the research will provide insight into whether aversion to new food technology are driven by emotions such as fear or by more logical "calculating" regions of the brain. Specifically, the objectives of this paper are to: i) identify how consumers' brains respond to the controversial food technologies of animal cloning, and ii) determine whether and how brain activations predict consumer choice.

The ability of the scientific enterprise to increase the quality and availability of food hinges critically on consumers' willingness to accept new technologies. Consumer rejection of new technologies can either lead to regulations which prohibit broad application of the technologies (e.g., European ban on growth hormones in beef; U.S. bans on certain pesticides) or can lead to businesses eschewing certain technologies (e.g., grocery stores selling only rBST-free milk). Although such reactions may be based on legitimate risks and uncertainties associated with the technologies, it is clear that the public is often poorly informed about such technologies and are readily persuaded by information. Accordingly, there is a need to better understand the underlying mechanics behind consumer reactions to new food technologies, and the proposed research seeks to provide such information. Results will enable developers of new food technologies and products to better understand consumer preferences and predict profitable developments, and will provide information on the merits of regulations or consumer information targeted toward new food technologies.

2. Research Approach

2.1 Overview

A diverse sample of food consumers were (and, at the time of this writing, continue to be) recruited to undergo functional magnetic resonance imaging (fMRI) scanning while engaged in the evaluation and choice of a gallon milk product. A multi-phase research design was used to: i) identify how consumers' brains respond to the controversial food technologies of animal cloning and added artificial growth hormones, and ii) determine whether and how brain activations predict consumer choice. The ultimate goal of the project is to collect fMRI data

from approximately 100 subjects. This particular paper relies on data from the first 29 participants, and as such, and results reported herein should be regarded as preliminary.

2.2 Sample Participants

A sample of 29 healthy adult participants (16 females) were recruited from the Kansas City metropolitan area using internet advertisements and University of Kansas Medical Center broadcast emails. Interested participants underwent a brief phone screen to determine eligibility for the study. Based on the participant's responses to these questions and their agreement or lack of agreement with the inclusion/exclusion criteria, potential participants were scheduled to meet with project personnel at which time the study was fully explained, questions were answered, and informed consent was obtained. Exclusion criteria included current psychotropic medication use, current substance dependence, participant report of diagnosis of severe psychopathology (e.g. depression, schizophrenia), current vegan diet, and self-reported lactose intolerance. Scanning occurred at the Hoglund Brain Imaging Center at the University of Kansas Medical Center.

All participants were right-handed, English-speaking adults between the ages of 18-55 (M = 31.6 years; SD = 10.5). Most participants reported having annual household incomes of less than $20,000 ($n$ = 10, 34.5%) or between $40,000 and $59,999 ($n$ = 10, 34.5%), while fewer reported having incomes of between $20,000 and $39,999 ($n$ = 3, 10.3%) or greater than $59,999 ($n$ = 6, 20.7%). Over half of participants reported having earned a bachelor's degree (n = 16, 55.2%), while the remainder reported having earned a high school degree or equivalent (n = 3, 10.3%), an associate's degree or equivalent (n = 8, 27.6%), or a graduate degree (n = 2, 6.9%).

2.3 Methods

Each subject participated in a multiple-phase research design. This paper focuses on some of the data collected in the first two phases, each of which is described in more detail in the sub-sections below. Technical information on fMRI scanning can be found in the Appendix.

2.3.1 Phase I – fMRI Cognitive Activation Paradigm – Visual Appraisal Task

The initial research phase was designed to answer the question: *How does the brain respond to seeing a food item labeled with controversial new food technologies as compared to traditional food attributes such as price?*

To address this issue, participants underwent fMRI scanning using an experimental paradigm similar to Bruce et al. (2010) and Martin et al. (2010). A block design was used to display the product (a gallon jug of milk) labeled with (1) price, (2) a controversial food technology, or (3) a combination of price and technology attributes (see figure 1). Blurred baseline images were displayed in between each block. The controversial food technologies were "from cloned cow," "from non-cloned cow" and "artificial growth hormones added" and "no artificial growth hormones." Prices ranged from $3.00 to $7.00 in $.50 increments ($3.00, $3.50, $4.00, etc.). The order of prices, technology, or combinations was randomized within each block.

Functional scans involved two repetitions of each block of each stimulus type (price labels, technology labels, combined labels), alternated between blocks of blurred images. Stimulus presentation time was 2.5 seconds with an interstimulus interval of 0.5 seconds. The two functional scans consisted of 13 blocks of stimuli presentation. The order of category presentation was counterbalanced across participants. Visual images were back-projected to a screen mounted on the back of the magnet, and participants viewed the images through a mirror on the head coil. Foam cushions were placed around the participants' heads to minimize movement.

2.3.2 Phase II – Choice Task

The second phase of the research is designed to answer the questions: *Can the data from Phase I be used to predict/explain people's choices between multi-attribute products? Can "choice utilities" be constructed from brain activation?*

While in the scanner, respondents made 84 choices between two milk products that differ in terms of their price and use/non-use of controversial technology. The set-up was similar to that used in the choice experiment (or choice-based conjoint analysis) literature. See figure 2 for an example. The choices were made non-hypothetical by informing respondents that one of their choices will be randomly selected as binding and will actually be given to them at the conclusions of the experiment. The tasks involved choices between (i) a product with a low vs. high price and (ii) a product with a controversial food technology vs. one without, and (iii) a trade-off between price and the technology.

3. Data Analysis

3.1 Analysis of Phase I – fMRI Cognitive Activation Data

fMRI data was analyzed using the BrainVoyager QX 2.4 statistical package (Brain Innovation, Maastricht, Netherlands, 2012). Preprocessing steps include trilinear 3D motion correction, sinc-interpolated slice scan time correction, 3D spatial smoothing with 4-mm Gaussian filter, and high pass filter temporal smoothing. Functional images were realigned to the anatomic images obtained within each session and normalized to the BrainVoyager template image, which conforms to the space defined by the Talairach and Tournoux's (1988) stereotaxic atlas. Only one functional run out of 60 was discarded due to motion greater than 3mm along any axis (x, y, or z). Activation maps were analyzed using statistical parametric methods (Friston et al 1995) contained within the BrainVoyager QX software. Statistical contrasts were conducted using multiple regression analysis. Regressors representing the experimental conditions of interest and regressors of non-interest (e.g. head motion) are modeled with a hemodynamic response filter. Next, group analysis is performed by entering data into the multiple-regression analysis using a random-effects model. Contrasts between conditions of interest are assessed with t statistics and ANOVA. Statistical parametric maps are then overlaid on three-dimensional renderings of an averaged-group brain (after stripping the skull).

3.2 Analysis of Phase II – Choice Task Data

The choices made in phase II were used to estimate a traditional discrete choice model based on random utility theory. In particular, let the i^{th} respondent's utility of choosing option *t* be given by $U_{it} = V_{it} + \xi_{it}$, where V_{it} is the systematic portion of the utility function determined by the choice attributes and ξ_{it} is a stochastic element. Assuming V_{it} is linear in parameters, the functional form of the utility function for alternative *t* can be expressed as:

$$V_{it} = \pi_1 Price_t + \pi_2 Clone_t + \pi_3 Hormone_t,$$

where $Price_t$ is the price of alternative *t*, $Clone_t$ is a dummy variable equal to 1 if alternative *t* is from cloned cow, $Hormone_t$ is a dummy variable equal to 1 if alternative *t* is artificial growth hormones added, and π_1, π_2, π_3 are coefficients representing the marginal utility of price, cloning, and hormone use. Willingness-to-pay to avoid cloning technology is given by π_2/π_1, and willingness-to-pay to avoid added hormone use is similarly given by π_3/π_1.. If the *it*'s are independently and identically distributed across the *t* alternatives and *N* individuals with an extreme value distribution, Louviere, Hensher, and Swait (2000) show that the probability of consumer *i* choosing alternative *t* is given by the multinomial logit model:

$$\text{Prob}\{t \text{ is chosen}\} = \frac{e^{V_{it}}}{\sum_{q=1}^{Q} e^{V_{qk}}},$$

which can be used to formulate a likelihood function to estimate the parameters of interest.

To determine whether the brain activations in phase I (the passive viewing phase) are related to consumer choice in phase II, the variables of the random utility model, $Price_t$, $Clone_t$, and $Hormone_t$, were interacted with the percent signal change variables in blood flow to selected brain regions resulting from the phase I block design. Let ΔBF_{ij} represent the percent change in blood flow occurring in response in the j^{th} region of subject *i*'s brain ascertained via fMRI resulting from a passive viewing of price versus technology or combination versus contrast. Given these variables, the parameters in the indirect utility function, π_1, π_2, and π_3 can be specified to be a function of ΔBF_{ij}. For example, the single parameter π_2 can be replaced with the equation:

$$\pi_{2i} = \lambda_0 + \sum_{j=1}^{J} \lambda_j \Delta BF_{ij} .$$

Testing whether the λ_j parameters are jointly equal to zero (using a likelihood ratio test) will provide insight into whether brain activations affect choice; we can also compare the percent of choices correctly predicted with/without the blood flow variables to determine the relative explanatory power. The size and magnitude of the λ_j parameters will indicate which regions of the brain that are activated in the *passive viewing task* (phase I) are also involved in choice (phase II). This analysis will provide insight into how the brain integrates different attributes into an overall evaluation/utility, an issue which has heretofore been largely unexplored. In addition, although it might not be directly obvious, the parameters λ_j indicate whether people who have higher activation in brain region *j* are more likely to avoid choices that have controversial technologies. Such information allows one to determine whether differences in choices made by different people are correlated with differences in brain activations.

The percent signal change variables are defined and interpreted in Table 1.

4. Results

4.1 Phase I – fMRI Cognitive Activation Results

4.1.1 Price Label versus Technology Label

Participants demonstrated significantly greater brain activation to price vs. technology in right anterior insula (Brodmann Area 13), and right dorsolateral prefrontal cortex (BA 46), right middle temporal gyrus, right occipital cortex, right precuneus and right supramarginal gyrus. Participants demonstrated significantly greater activation to technology vs. price in left lingual gyrus and left middle temporal gyrus (results are reported in the appendix Table A.1).

Insula and dorsolateral PFC were *a priori* regions of interest and we extracted the percent signal from the maximum voxel in each cluster. fMRI results from the price versus technology contrasts, co-registered with average structural MRI data from the participants are displayed below. Maps are presented in the coronal perspective. The significance thresholds for display are set at p <.01, cluster threshold corrected (16 voxels). The arrows highlight greater activation in the right dorsolateral PFC (figure 3) and in the right insula (figure 4) to price versus technology.

The first two rows of results in table 1 report the percent change in blood flow resulting from the contrast between price and technology labels occurring in the two *a priori* regions of interest showing statistically significant contrasts: the right insula, a brain region which previous research as shown to be related to self-monitoring, emotions (e.g. disgust) and taste-processing, and in the right middle prefrontal cortex, which previous research has shown to be related to decision-making and cognitive/self-control. Both the right insula and the right middle prefrontal cortex showed increased activation to price labels compared to cloning/growth hormone labels. Changes in blood flow to these two regions resulting from the price vs. technology contrast were saved and used in the choice modeling, to be described shortly.

4.1.2 Combination Label versus Price Label

The combination of technology and price versus price-only labels revealed significant activations in three *a priori* regions of interest as well as additional areas (results are reported in the appendix Table A.2). Participants demonstrated significantly greater brain activation to *price vs. combination* in right dorsolateral prefrontal cortex, right middle prefrontal cortex, and right anterior cingulate cortex. We extracted the percent signal from the maximum voxel in each of these clusters. fMRI results from the combination vs price contrasts, co-registered with average structural MRI data from the participants are displayed below. Maps are presented in the sagittal perspective. The significance thresholds for display are set at $p < .01$, cluster threshold corrected. The arrows highlight *greater* activation to price labels versus combination labels (shown in blue) in dorsolateral PFC (figure 5) and anterior cingulate cortex (figure 6).

The last three rows of results in table 1 report the percent change in blood flow resulting from the contrast between the combination of price and technology labels vs. price-only labels occurring in the three *a priori* regions of interest with revealed statistically significant contrasts: (i) the right superior prefrontal cortex, a brain region which is thought to relate to decision-making and cognitive/self-control, (ii), the left medial prefrontal cortex, a brain region often associated with cognitive control, self-monitoring, and self-discipline, and (iii) the left anterior cingulate, a brain region often associated with decision making, choices, and reward anticipation. Changes in blood flow to these three regions resulting from the combination vs. price contrast were saved and used in the choice modeling, to be described shortly.

4.1.3 Combination Label versus Technology Label

The combination label compared to the technology label revealed significant areas of activation in bilateral middle temporal gyrus, bilateral cuneus and precuneous, and occipital cortex (results are reported in the appendix Table A.3). None of these were *a priori* regions of interest and were therefore not used in the choice models.

4.2 Phase II – Choice Task Results

The results of the multinomial logit estimation without the blood-flow activation variables are provided in Table 2. All of the estimates are statistically significant at the $p < 0.01$ level. The estimation results indicate that participants are willing to pay 2.66/1.55=$2.31 to have a gallon of milk from a non-cloned rather than a cloned cow. Participants are willing to pay 2.96/1.15=$2.57 to have a gallon of milk from cows not administered added growth hormones relative to milk from cows that have.

The results of the multinomial logit estimation *with* cognitive activation interactions are provided in Table 3. The estimates for *Price*, *Clone*, and *Hormone* (which show the effects of these variables when the percent change in blood flow variables are zero) remained statistically significant at $p < 0.01$ level. With the exception of *Hormone*RI*, all of the cognitive activation interactions with *Clone* and *Hormone* are significant at 0.05 significance level. However, none of the cognitive activation interactions with *Price* are statistically significant.

The largest effect related to interaction between relative activation in the left anterior cingulate (ACC) when passively viewing combined labels vs. price-only labels and the preference for avoiding cloning and hormones in the choice tasks. The results indicate that the same people whose ACC demonstrated greater activation to milk with combined labels vs. price labels were more likely to make choices to avoid cloning and hormone technologies even in the presence of higher prices. These results suggest correspondence between the phase I and phase II tasks and suggest some that the fMRI data can be used to predict subsequent choice. It is revealing that activation in anterior cingulate is the best observed predictor of choices. The ACC is associated with decision making, conflict monitoring, and reward anticipation, and these are precisely the activities involved in the phase II choice task.

To provide some sense of the economic magnitude of the effects in question, figure 1 plots the relationship between activation in the ACC in the phase I task and willingness-to-pay to

avoid cloned milk in the phase II task. The figure reveals a large positive correlation between the two variables of non-trivial economic magnitude. Table 2 estimates imply that moving from the lowest change in blood flow to the ACC observed in our sample (-0.22%) to the highest (0.37%) in the passive viewing phase, led to an increase in willingness-to-pay for non-cloned milk from $1.21 to $4.18, a $2.98 increase in willingness-to-pay.

Another way to assess the economic magnitude of the fMRI variables is to investigate the model's fit with and without the brain activation signal change. The multinomial logit models without the fMRI variables correctly predicted choices 83.9% of the time (note: random choice would imply a 50% success rate). When the fMRI interactions were included, prediction success increased to 86.2%. Thus, the inclusion of the fMRI variables increased prediction success by 2.3%. Despite the marginal improvement in prediction success, the model with the fMRI variables does provide a significantly better fit to the data. The full un-restricted model yields a log-likelihood function value of -815.34 whereas the likelihood function for the restricted model (without fMRI variables) is only -900.6. A likelihood ratio test of the null hypothesis that coefficients associated with the fifteen fMRI-price, fMRI-clone, and fMRI-hormone interactions are zero is rejected at the 0.01 level of significance (the test statistic is 2*(815.34+900.6)=170.52, which is distributed chi-square with fifteen degrees of freedom; the 0.01 critical chi-square value with 15 degrees of freedom is 30.58).

5. Conclusions

This study used a multi-phase research design to: i) identify how consumers' brains respond to the controversial food technologies of animal cloning and added artificial growth hormones using fMRI, and ii) determine whether and how brain activations predict consumer choice.

As hypothesized, brain regions thought to be associated with risk processing and decision-making were activated when participants viewed price labels rather than technology (i.e., cloning or hormone) labels. However, brain regions that are often associated with emotion processing, self-awareness, and disgust were also observed to respond to price. Some of the price labels may have seemed unrealistically high to participants. These preliminary data suggest that while more "rational" brain regions were active when viewing price labels as expected, we also observed some "emotional" brain regions becoming active for prices. If corroborated in further scans this finding has implications not only for understanding consumer response to price information but also methodological implications for the field of experimental survey research where price responses are elicited.

Participants were willing to pay more than two dollars, on average, to avoid purchasing a gallon of milk with controversial food technologies. Surprisingly, participants were willing to pay more to avoid milk with added artificial growth hormones than milk from a cloned cow.

Nearly all the interaction variables between the fMRI variables from hypothesized brain regions of interest (from phase I) were significantly correlated with preferences for the controversial food technologies variables elicited via choice tasks (from phase II). Thus, there seems to be a relationship between brain activation when passively viewing varying price and controversial food technology product labels and subsequent choice decisions made about preferences for price and controversial food technologies. Activation in the left anterior

cingulate in the passive viewing stage when viewing combined levels instead of price labels had a relatively large impact on the preference for both controversial food technologies as expressed in discrete choices. The left anterior cingulate is generally thought to be involved with decision making and reward anticipation. The results are suggestive of the idea that although subjects were passively viewing milk with various labels, there were some who were evaluating the relative desirability and tradeoffs involved in the combination labels relative to the pre-only labels tasks, and it was these same individuals who made also made choices for non-cloned milk even at higher prices. Indeed, the change in willingness-to-pay premium for cloned vs. non-cloned milk was almost $3 for those with the least vs. most activation in the left anterior cingulate cortex.

This research analyzed the ability of functional brain changes, assessed by fMRI, in a passive viewing task to predict subsequent choices. We find that the fMRI variables are significantly related to choice preferences, and that inclusion of the variables can (slightly) improve the prediction success of the choice model. Our ongoing research will study brain activation *during* the choice task, and will investigate the extent to which such measures further improve the ability to explain choice.

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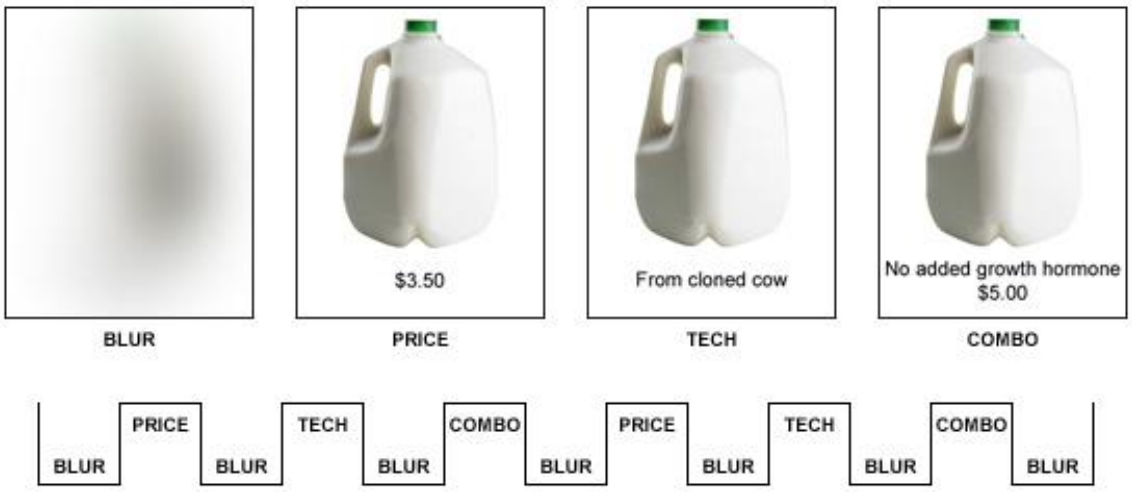

Figure 1. Phase I – fMRI Cognitive Activation Paradigm

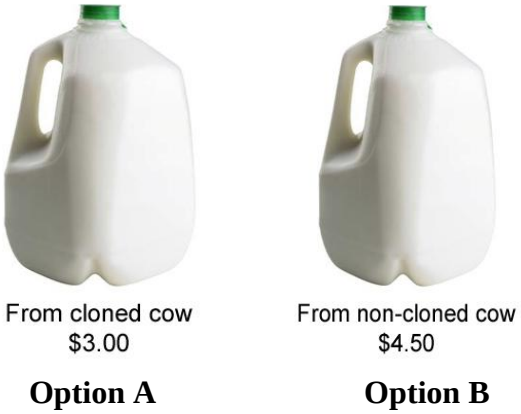

Figure 2. Phase II – Choice Task

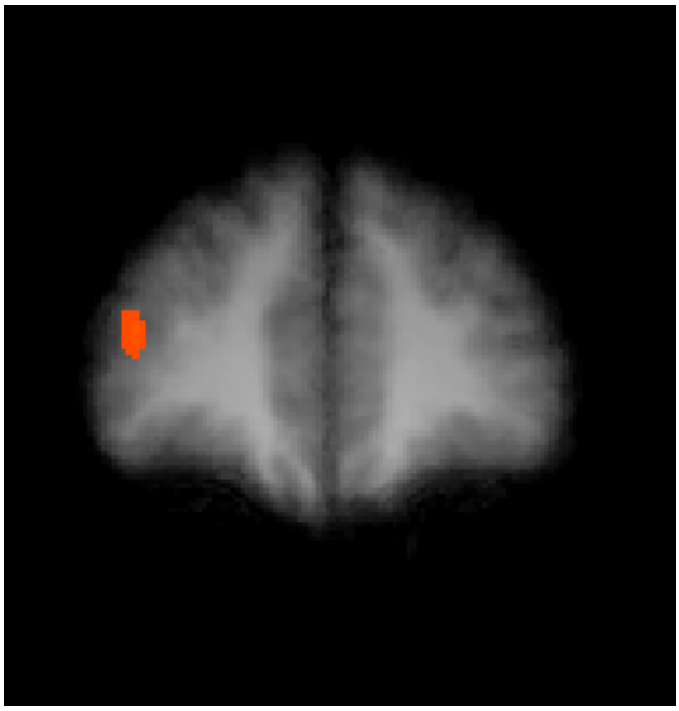

Figure 3. Price versus Technology; Dorsolateral Prefrontal Cortex.

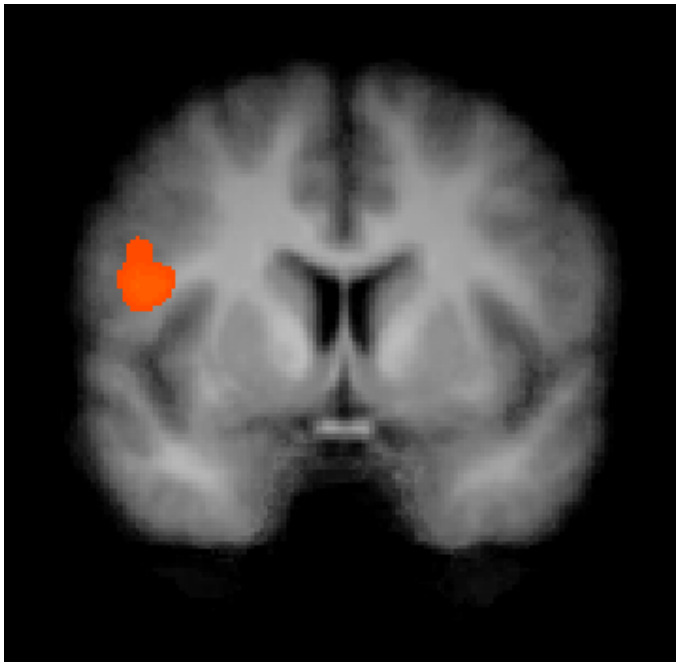

Figure 4. Price versus Technology; Anterior Insular Cortex.

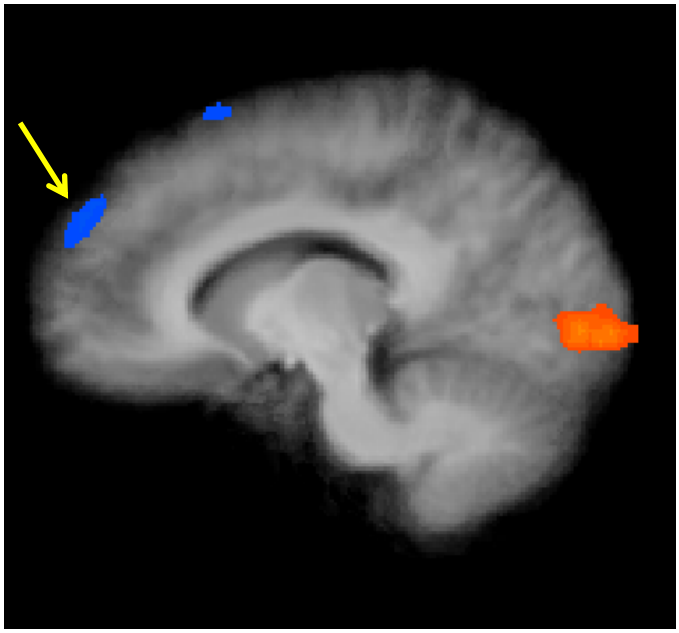

Figure 5. Combination versus Price; Dorsolateral Prefrontal Cortex

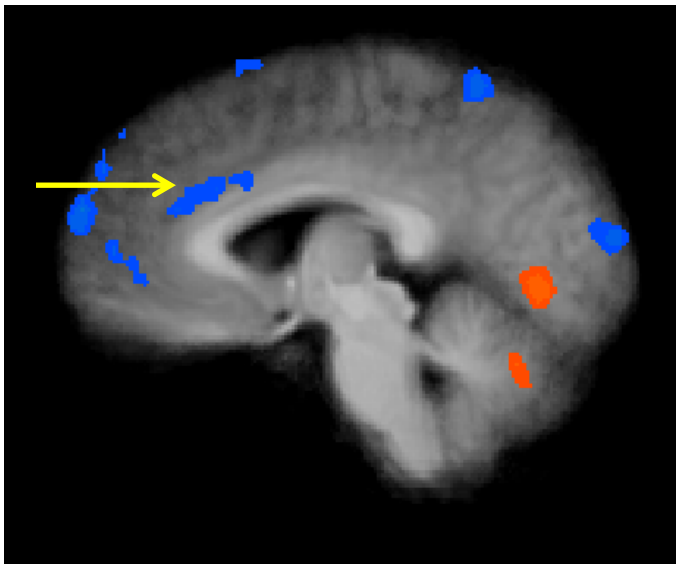

Figure 6. Combination versus Price; Anterior Cingulate Cortex

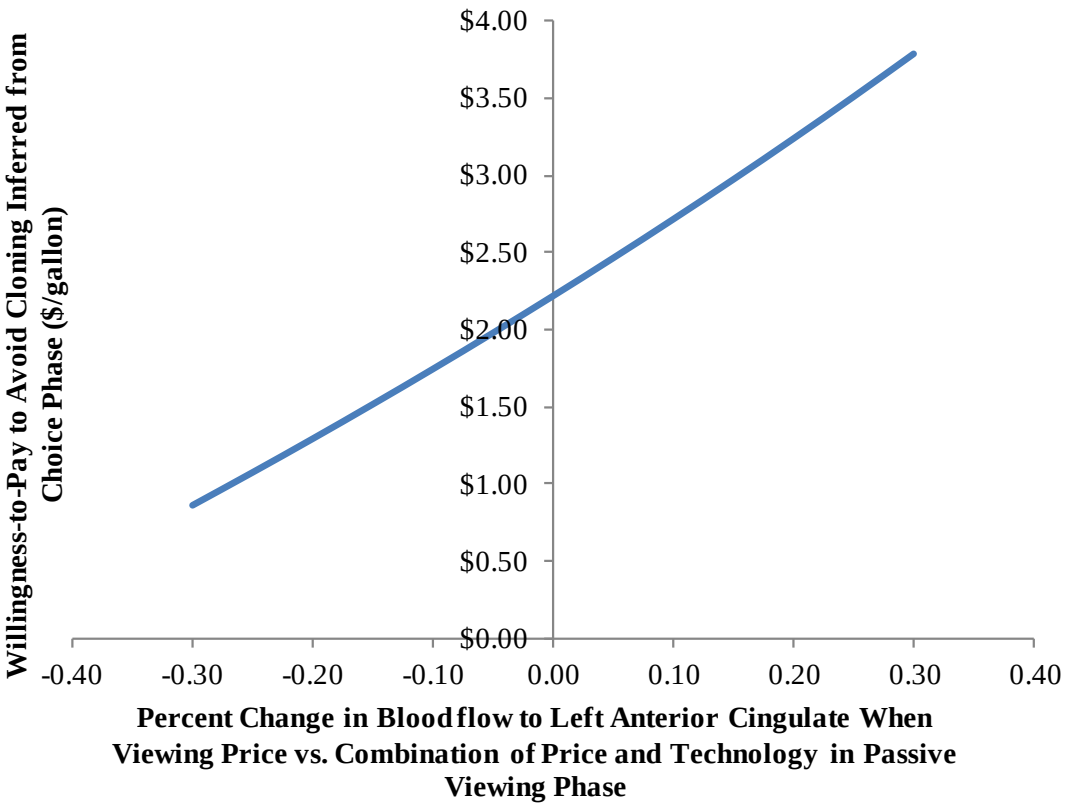

Figure 7. Relationship between fMRI scan variables obtained in passive viewing phase and willingness-to-pay to avoid cloned milk in the choice phase

Table 1. Brain Activation (Percent Signal change) Variable Definitions and Descriptive Statistics

Variable	Brain Region	Function	Mean % Change	Min, Max % Change	Interpretation
Price vs. Technology					
RI	Right Insula	Self-monitoring, emotions (e.g. disgust); taste-processing	.0503%	-.09% , .19%	Right insula showed increased activation to price labels compared to cloning/growth hormone labels
RC	Right Middle Prefrontal Cortex	Decision-making Cognitive/self-control	.0583%	-.09% , .22%	Right mPFC showed increased activation to price labels compared to cloning/growth hormone labels
Price vs. Combination of Price and Technology					
RG	Right Superior Prefrontal Cortex	Decision-making Cognitive/self-control	.0666%	-.05% , .36%	Right PFC showed increased activation to price labels compared to combination labels
LG	Left Medial Prefrontal Cortex	Cognitive control, self-monitoring, self-discipline	.1197%	-.15% , 1.11%	Left mPFC showed increased activation to price labels compared to combination labels
ACC	Left Anterior Cingulate	Decision making, choices, and reward anticipation	.0414%	-.22% , .37%	Left ACC showed increased activation to price labels compared to combination labels

Table 2. Results of Multinomial Logit Model without Cognitive Activation Interactions

Parameter	Estimate	Standard Error	*p*-Value
Price	-1.15	0.05	<.01
Clone [a]	-2.66	0.12	<.01
Hormone[b]	-2.96	0.13	<.01
Log-Likelihood	-900.60		
Number of Observations	2,436		

[a] Parameter estimate compared to a gallon of milk from a non-cloned cow

[b] Parameter estimate compared to a gallon of milk without artificial growth hormones added

Table 3. Results of Multinomial Logit Model *with* Cognitive Activation Interactions

Parameter	Estimate	Standard Error	*p*-Value
Price	-1.23	0.08	<.01
*Price*RI*	-0.27	0.75	0.72
*Price*RC*	-0.18	0.67	0.79
*Price*RG*	0.22	0.54	0.68
*Price*LG*	-0.35	0.26	0.17
*Price*ACC*	0.31	0.42	0.46
Clone	-3.21	0.22	<.01
*Clone*RI*	4.64	1.87	0.01
*Clone*RC*	4.81	1.74	<.01
*Clone*RG*	4.96	1.34	<.01
*Clone*LG*	-3.96	0.79	<.01
*Clone*ACC*	-5.51	1.14	<.01
Hormone	-3.21	0.23	<.01
*Hormone*RI*	-0.60	2.03	0.77
*Hormone*RC*	3.90	1.84	0.03
*Hormone*RG*	3.23	1.49	0.03
*Hormone*LG*	-2.76	0.82	<.01
*Hormone*ACC*	-4.61	1.22	<.01
Log-Likelihood	-815.34		
Number of Observations	2,436		

Appendix

A.1 Technical Information on fMRI Scanning

Scanning was performed at the University of Kansas Medical Center's Hoglund Brain Imaging Center (HBIC) on a 3-Tesla Siemens Skyra (Siemens, Erlangen, Germany) scanner. Participants' heads were immobilized with head cushions. Following automated scout image acquisition and shimming procedures performed to optimize field homogeneity, a structural scan was completed. T1-weighted 3D MPRAGE anatomic images were acquired (TR/TE = 23/4 ms, flip angle = 8, FOV = 256 mm, matrix = 256 x 192, slice thickness = 1 mm). This scan is used for slice localization for the functional scans, Talairach transformation, and coregistration with fMRI data. Following structural scans, two gradient echo blood oxygen level dependent (BOLD) scans were acquired in 50 contiguous oblique 40º axial slices (repetition time/echo time [TR/TE] = 3000/25 ms, flip angle = 90, field of view [FOV] = 220 mm, matrix = 64 x 64, slice thickness = 3 mm, 0.0 skip, in-plane resolution = 2.9 x 2.9 mm, 176 data points). To optimize signal in ventromedial prefrontal regions (a region of interest in this study) by minimizing susceptibility artifact, all participants are positioned in the scanner so that the angle of the AC-PC plane is between 17 and 22 in scanner coordinate space. The angle is verified with a localization scan. This careful positioning ensures that the 40º acquisition angle will be applied in the same way for all subjects. Thus, in addition to minimizing susceptibility artifact, this procedure acts to standardize head positioning between subject groups of divergent body size.

Table A.1. Price versus Technology; Regions reaching significance for the contrasts between price and technology labels ($p < 0.01$, cluster corrected at 16 voxels)

	Coordinates of Max Voxel				
Region, Brodmann Area	x	y	z	*t*	Contiguous voxels
Right Middle temporal gyrus, BA 20	56	-44	-9	4.38	1999
Right Precuneus, BA 19	41	-74	42	5.07	3224
Right Supramarginal gyrus, BA 19	41	-41	30	4.29	1551
Right Insula, BA 13[a]	**44**	**7**	**15**	**4.77**	**757**
Right Dorsolateral PFC BA 46	**41**	**37**	**18**	**4.09**	**488**
Right Occipital cortex, BA 18	26	-92	3	3.62	797
Left Lingual gyrus, BA 19	-22	-68	0	-6.00	12,381
Left Middle temporal gyrus, BA 21	-55	-44	6	-4.15	723

[a] *A priori* areas of interest are bolded.

Table A.2. Combination versus Price; Regions reaching significance for the contrasts between combination and price labels ($p < 0.01$, cluster corrected at 16 voxels)

	Coordinates of Max Voxel				
Region, Brodmann Area	x	y	z	*t*	Contiguous voxels
Right inferior parietal cortex, BA 40	59	-35	33	-5.24	861
Right superior temporal gyrus, BA 22	59	-32	15	-3.80	572
Right occipital cortex, BA 19	47	-77	6	-4.87	3118
Right cerebellum	47	-71	-21	-4.19	480
Right cuneus, BA 19	17	-89	30	-5.02	865
Right inferior occipital gyrus, BA 17	23	-95	-6	5.54	3639
Right superior frontal gyrus, BA 9[a]	**14**	**55**	**30**	**-4.68**	**1533**
Right superior frontal gyrus, BA 6	14	22	60	-3.43	581
Left middle frontal gyrus, BA 10	**-4**	**61**	**21**	**-3.96**	**1245**
Left cerebellum	-1	-65	-24	3.98	447
Inferior occipital gyrus, BA 17	-16	-92	-6	9.70	11,993
Left anterior cingulate gyrus, BA 24	**-1**	**13**	**33**	**-3.63**	**746**
Left cuneus	-7	-92	9	-4.46	649
Left precuneus, BA 19	-7	-53	60	-4.16	765
Left parietal/precuneus, BA 19	-34	-65	39	4.59	780
Left superior temporal gyrus, BA 38	-37	13	-27	3.74	467
Left fusiform gyrus, BA 37	-40	-41	-15	5.09	1505
Left superior occipital cortex, BA 19	-40	-77	27	-4.18	1078

[a] *A priori* areas of interest are bolded.

Table A.3. Combination versus Technology; Regions reaching significance for the contrasts between combination and technology labels ($p < 0.01$, cluster corrected at 16 voxels)

	Coordinates of Max Voxel				
Region, Brodmann Area	x	y	z	*t*	Contiguous voxels
Right middle temporal gyrus, BA 20	53	-44	-9	4.85	901
Right precuneus, BA 7	26	-59	33	6.30	8331
Right cuneus, BA 18	17	-101	-3	5.05	3046
Left cuneus, BA 18	-4	-86	12	-6.70	7597
Left precuneus, BA 7	-1	-50	54	-4.23	662
Left occipital cortex, BA 18	-28	-101	-3	7.37	5385
Left precuneus, BA 19	-34	-68	39	4.40	1203
Left middle temporal gyrus, BA 39	-52	-68	12	-3.77	547