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The signaling effect of mandatory labels on genetically engineered food

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ABSTRACT

It has been suggested that the adoption of mandatory labeling for genetically engineered food might send a signal to consumers that foods produced with biotechnology are unsafe or should be avoided. To date, however, there is little empirical evidence to substantiate this claim. This paper utilized data from two studies to explore whether consumers exposed to labels on genetically engineered foods expressed greater aversion to genetic engineering than consumers in control groups, who were exposed to decoy labels unrelated to the technology. We find little evidence of a signaling effect resulting from the mere exposure to labels. However, in Study 1, we find signaling operating in another fashion: there were stark differences in the implied willingness-to-pay to avoid genetically engineered foods when consumers were exposed to mandatory "contains" labels vs. voluntary "does not contain" labels. In study 1, we also find aversion to a non-GE technology – ethylene ripening – that is comparable to aversion to biotechnology.

Introduction

Ballot initiatives in California and Washington in 2012 and 2013 have re-ignited the debate over mandatory labeling of foods containing genetically engineered (GE) ingredients in the United States. Although the GE food labeling initiatives in these states failed, legislatures in Connecticut and Maine have recently passed mandatory labeling laws that will go into effect if a threshold number of other states pass similar measures, and in 2014 Vermont was the first state in the U.S. to pass an outright mandatory GE food labeling law. It appears the debate has just begun. The organization "*Just Label It*" coordinates groups aiming to pass mandatory labeling in at least 30 U.S. states, while groups such as Grocery Manufacturers Association and the American Farm Bureau have supported a newly introduced federal bill, the "Safe and Accurate Food Labeling Act" which would preempt state-level mandatory initiatives and reassert the authority of the Food and Drug Administration to determine whether mandatory labeling is required.

These current events have served to open up old empirical and conceptual arguments about the potential effects of mandatory GE labeling. Advocates of labeling point to a "right to know" argument and highlight the popularity of labeling in opinion polls (Pino, 2012; Boxer, 2012). They also tend to argue that the costs of adding a labeling represent a trivial expense relative to typical labeling changes that food companies routinely incur. Opponents of labeling tend to consider the dynamic effects of such a policy on firm-level decision making. A mandatory label might cause firms to eschew GE ingredients, switch to non-GE ingredients, and drive up costs in the process (Alston and Sumner, 2012; Carter et al., 2012). The example of the European Union seems to support the argument that companies will substitute away from GE food if labels are mandatory (Carter et al., 2012).

A more subtle argument made by some opponents of GE labeling relates to the potential signaling effect of the label. In most economic models (e.g., Crespi and Marette, 2003; Fulton and Giannakas, 2004; Giannakas and Fulton, 2002; Lapan and Moschini, 2004; Lence and Hayes, 2005) and empirical analyses (Hu et al., 2005; Lusk et al., 2005b; Rousu et al., 2004) on the topic, a GE label simply serves as an identifier, which is used by consumers to select the product they most prefer, given labeling costs and relative prices. In these models, preferences for GE vs. non-GE foods are fixed. They are assumed exogenous to whatever labeling policy is in place. Some academic research has questioned this assumption. For example, Artuso (2003) constructed a conceptual model in which the addition of a mandatory label sends a signal about the relative safety of GE food, and Lusk and Rozan (2008) provided some empirical support for the supposition. If labels are signals, they not only sort consumers according to their relative willingness-to-pay, the labels potentially shift preferences, and change the resulting welfare consequences of the policy.

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Although there is, to date, relatively little empirical support for the labels-as-signals hypothesis, the signaling arguments seem to have gained traction among many GE labeling opponents. For example, the chemical and biotechnology company Monsanto (2013) argued that "mandatory labeling could imply that food products containing these ingredients are somehow inferior to their conventional or organic counterparts." Of course, such arguments could be dismissed since they arise from self-interest. However, major scientific organizations such as the American Association for the Advancement of Science (2012) have also asserted that "Legally mandating such a label can only serve to mislead and falsely alarm consumers." Cass Sunstein, University of Chicago Law Professor and former head of the White House Office of Management and Budget's Office of Information and Regulatory Affairs for President Obama, similarly asserted that (2013): "GM labels may well mislead and alarm consumers, especially (though not only) if the government requires them. Any such requirement would inevitably lead many consumers to suspect that public officials, including scientists, believe that something is wrong with GM foods – and perhaps that they pose a health risk." Such an effect would be problematic because, as Sunstein (2013) notes, most major scientific organizations have actually argued that foods produced through genetic engineering are no riskier than foods produced through conventional breeding techniques.

Despite these conceptual arguments, there is relatively little empirical research on the potential signaling effects of mandatory GE labels. However, the research that does exist suggests that a signaling effect might well exist. Lusk and Rozan (2008) found that consumers who believe a mandatory GE labeling policy exists are also more likely to believe GE food is unsafe to eat; however, their approach leaves some doubt as to whether the relationship is causal. Kanter et al. (2009) present experimental evidence that organic and non-rBST labeling in milk sends a signal about the relative desirability of conventional milk; the mere presence of organic milk serves to reduce willingness-to-pay for conventional milk. Hu et al. (2006) present survey evidence and Liaukonyte et al. (2013) present experimental evidence that adding a "contains" label generates different willingness-to-pay values than adding a "does not contain" label; these different labels appear to send different signals about the quality of the unlabeled food.

This paper aims to more definitively ascertain the potential signaling effect of GE labels. Two studies are conducted in which we compare treatment groups (exposed to GE labels) to control groups (exposed to other labels unrelated to GE content) in terms of subsequent stated risk perceptions and willingness-to-pay to avoid GE food. The two studies are used to provide a more robust investigation into the issue, and to determine the extent to which choice of products (apples, a fresh fruit vs. Cheerios, a processed food) and design issues (making active choices vs. simply visually evaluating labels) affects how GE labels influence beliefs about the safety of GE food. To the extent that similar results are found across study 1 and study 2, we can be more confident in the overall finding.

The first study entails consumers making choices between apples that have, depending on the treatment, "does not contain" or "contains" GE labels, in addition to a control group where consumers are instead shown labels indicating whether the apples have been ripened with ethylene. We find little evidence to suggest that the mere exposure to GE labels in decision making tasks alters subsequent appraisals of the safety or desirability of GE foods relative to people exposed to ethylene labels. However, analyzing the choices people actually made, we corroborate the results of Hu et al. (2006) and Liaukonyte et al. (2013), finding evidence that the implied willingness-to-pay to avoid GE is about 140% higher in the presence of mandatory "contains GE" labels than in the presence of voluntary "does not contain" GE labels. Interestingly, aversion to the "decoy" attribute, ethylene ripening in apples, is as great as aversion to GE food.

In study 2, respondents are shown a picture of a box of Cheerios that either does or does not contain a claim about GE content, and are asked to click on the area of the box that is most and least desirable. There was no significant difference in subsequent appraisals of the safety or desirability of GE foods among people who had seen a Cheerio box with a GE label as compared to people who had seen a Cheerio box without a GE label.

The next section describes the methods and procedures for Study 1, which is followed by the results of that study. Then we present the methods, procedures, and results for Study 2. The last section concludes.

Study 1

Overview

Study 1 consists of a between-subject design with two treatments and one control group. Data were collected from responses to online questionnaires. Participants were recruited by the online survey software provider, Qualtrics, and their associated partners, and were randomly assigned to one of three groups. In total, 647 subjects participated in study 1, with 213 randomly assigned to the control, 217 randomly assigned to Treatment 1, and 217 randomly assigned to Treatment 2. The sample was almost perfectly split between males and females, and there was adequate representation across all age categories: 15% were between 18 and 26 years old, 27% were between 25 and 34 years old, 16% were between 35 and 44 years old, 19% were between 45 and 54 years old, 15% were between 55 and 64 years old, and 8% were 65 years or older. About 45% of the sample had attained a bachelor's degree from a university or college. There were no significant differences across the treatments with respect to these demographic variables.

Methods

Study 1 entailed an examination of whether exposure to GE labels in market-like choices subsequently affected beliefs about the safety of GE foods. If the idea is that if the presence of GE labels sends a signal about relative safety and quality, then exposure to GE labels should affect subsequent safety and quality evaluations.

After reading a statement about rights as human subjects involved in research, participants proceeded to answer eight choice questions. For each question, subjects indicated which of two apples they preferred. The eight questions varied according to the prices of the apples ($1.40/lb or $2.80/lb), the color of the apples (Red or Green), the presence or absence of damage (bruised nor not bruised), and the presence or absence of a technology label. Attribute levels varied across options so that the level or presence/absence of each attribute is uncorrelated with the level or presence/absence of other attributes within and across choice options.

The treatments varied according to which technology label was utilized in the choice experiment. As shown in Fig. 1, the control utilized the technology "ripened with ethylene"; we were not interested in the technology *per se*, but rather it is a "decoy" attribute.[1] Treatment 1 utilized a "contains" labeling similar to what

[1] The identifying assumption is that signaling about GMOs, which (potentially) causes increased concern for GMOs, does not also increase concern for an unmentioned technology like ethylene. To the extent that changes in concern for GMOs and ethylene are positively correlated, we may fail to find a significant treatment effect even if signaling exists. We address this concern in two ways. First, as will be described momentarily, we use a trade-off question that forces people to indicate concern for GMOs *relative* to ethylene and other issues (i.e., all issues cannot be rated as more concerning). Second, study 2 utilizes a control in which no other technology is mentioned.

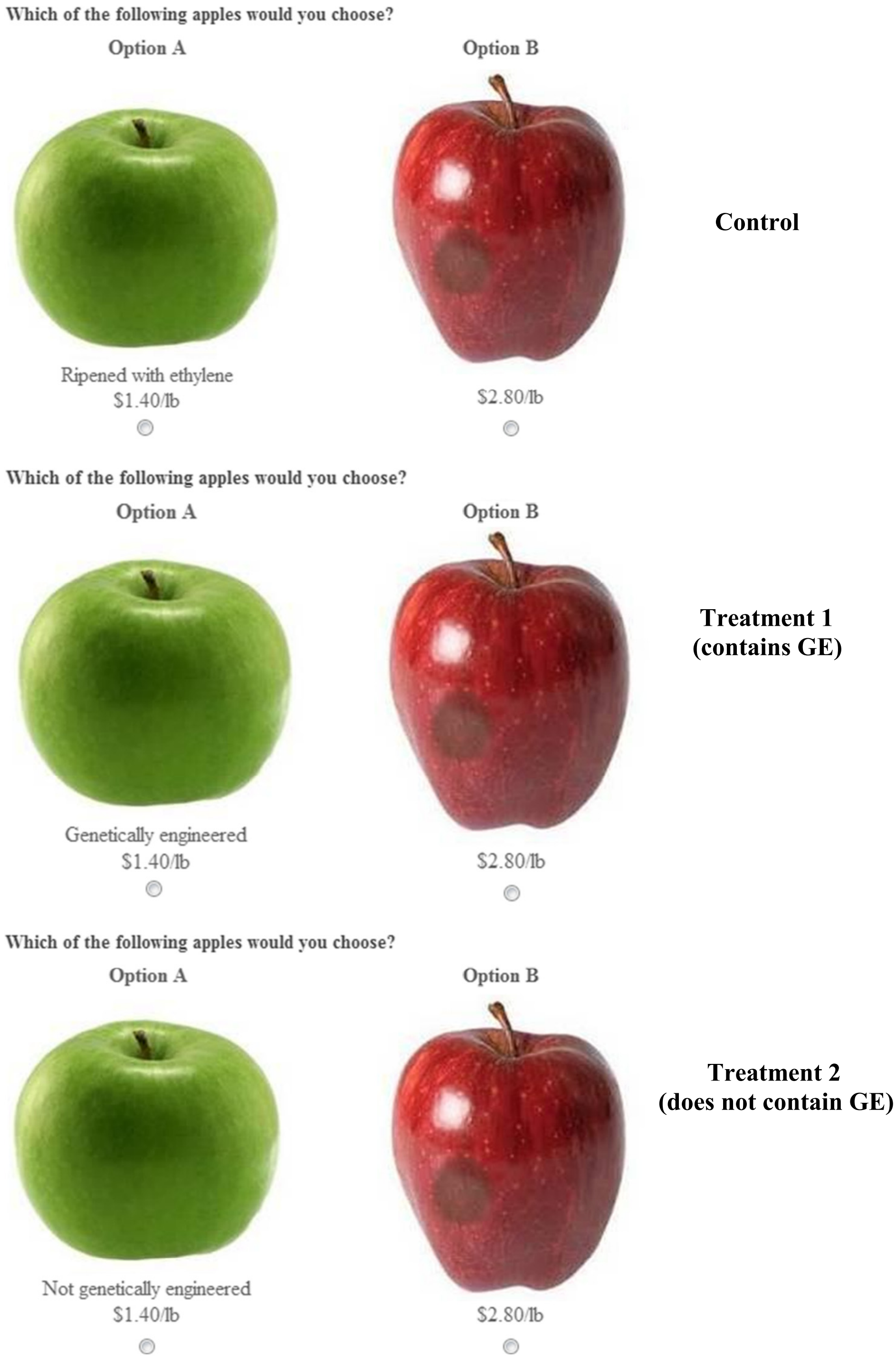

Fig. 1. Example questions used in the treatments and control in study 1.

would be the case in a mandatory labeling policy, and apple options varied according to whether they had a label indicating "genetically engineered." We used the term "genetically engineered" rather than "genetically modified" because GE is the terminology that has been used in the recent mandatory labeling ballot initiatives in California and Washington. Treatment 2 utilized a "does not contain" label similar to a voluntarily labeling environment, and apple options varied according to whether they had a label indicating "not genetically engineered." Other than these differences, the apple choices were identical in the treatments and control.

At least initially, *we were not interested in the actual choices people made between apples*. Rather, the respondents were asked to answer the apple choices for the express purpose of exposing them to different labels while making choice akin to those that would occur in a marketplace. If the presence of a GE label in the apple choice tasks sends a signal to the participant about relative safety or quality, then we would expect individuals in Treatments 1 or 2 to subsequently indicate greater concern for biotechnology and GE than individuals randomly assigned to the control. The hypotheses we test are:

H1. Individuals in Treatments 1 who made choices between apples with "mandatory" GE labels will believe GE foods are more risky and will indicate greater willingness to pay to avoid GE food than individuals in the control who made choices between apples with ethylene labels.

H2. Individuals in Treatments 2 who made choices between apples with "voluntary" GE labels will believe GE foods are more risky and will indicate greater willingness to pay to avoid GE food than individuals in the control who made choices between apples with ethylene labels.

To test these hypotheses, after subjects completed the eight apple choice questions, a series of questions were asked to gauge subjective beliefs and willingness to pay for GE food. Subjects were first presented with nine statements for which they had to indicate the extent to which they agreed or disagreed; the statement of interest was "genetically engineered foods are safe to eat", which was intermixed with statements on perceived safety of ethylene ripening, antioxidants, polyphenols, cholesterol etc. (the order of appearance was randomly varied across respondents). Then, subjects were directly asked to state a subjective belief about the safety of GE foods; they were asked, "What is the chance of eventually becoming ill from repeatedly consuming genetically engineered food", and responses were recorded on a continuous slider scale that varied from 0% (labeled "no chance") to 100% (labeled "absolutely certain to cause illness"). A similar question was asked regarding ethylene ripening.

In addition to these absolute measures of perceived concern, we also posed two questions that required trade-offs. First, respondents were asked "How concerned are you about the following issues when eating food" and six issues were listed (the order randomly varied across respondents). Respondents had to allocate 100 points across the six issues (the total had to sum to 100) by clicking and dragging bars next to each issue. Among the six issues listed were "use of genetically engineered ingredients", "use of ethylene", "added sodium", "use of antioxidants", etc. Finally, subjects were asked a willingness-to-pay question using the so-called payment card format (e.g., Rowe et al., 1996). They were asked, "How much extra are you willing to pay for foods that have not been genetically engineered and contain no genetically engineered ingredients" and they were provided categories that started with "I am not willing to pay anything extra" and then proceeded with ranges from "0.1% to 4.9%" up to "I am willing to pay an extra 100% or more."

Previous research has identified a number of potential problems with the payment card format, such as starting point bias, centering bias, and others (Rowe et al., 1996), and there is a tendency for mean willingness-to-pay from payment card questions to be lower than those from discrete choice questions; however, payment card questions are easy for people to answer, and we are mainly interested here not in the mean willingness-to-pay *per se*, but rather differences across treatments, which each use the same question format. Additionally, given the literature on hypothetical bias (e.g., Murphy et al., 2005), we expect the estimate value to be greater than what people would actually pay if money were on the line. For our purposes, however, we are interested in the *difference* in estimated willingness-to-pay across the treatments and control. The maintained assumption is that there is no interaction effect between hypothetical bias and the labels. We utilize the responses to estimate an interval censored regression, assuming a Normally distributed willingness-to-pay, which provides an estimate of the mean willingness-to-pay premium. For people who responded with "I am not willing to pay anything extra", we assume their lower bound is negative infinity and upper bound is zero, because it may well be the case that some people have a negative willingness-to-pay premium for non-GE food (for example, if they believe GE food uses less pesticides). We find similar differences across treatments if we instead estimate a model where willingness-to-pay is assumed non-negative (though, of course the overall means are higher).

After testing the aforementioned hypotheses, we revisit the choice data to determine what the apple choices imply about consumer preferences for GE food when framed in a "contains" vs. "does not contain" manner. In particular, we estimate an attribute based random utility model, where the indirect utility for each option is a function of apple price, color, presence/absence of damage, and presence/absence of technology. We are interested in the implied willingness-to-pay to avoid GE, which is calculated as the ratio of the estimated technology parameter to the estimated price parameter. In the case of Treatment 1, the unlabeled product is non-GE by implication, and in the case of Treatment 2, the reverse is true. Based on prior research previously discussed, we hypothesize:

H3. Implied willingness-to-pay to avoid GE food in Treatments 1 involving "mandatory" labels will be greater than implied willingness-to-pay to avoid GE food in Treatment 2 involving "voluntary" labels.

The hypothesis conjectures that the negative framing of the mandatory "contains" label sends a different signal about the relative safety of GE foods relative to the positive framing of the voluntary "does not contain" label. While one can interpret the hypothesis through the lens of signaling, it is also consistent with the large literature on the asymmetrical negativity effect (Taylor, 1991) in which negative events and frames prompt greater reactions than positive ones, a phenomenon also related to loss aversion (Tversky and Kahneman, 1991).

Results

Table 1 reports the mean responses to the GE safety belief and willingness-to-pay questions in each treatment. For comparison, we also show the results from the questions related to ethylene. The stated belief that GE food is safe to eat is slightly lower in the control relative to the treatments (the opposite of what was hypothesized), but the differences are not statistically significant (ANOVA p-value = 0.30; Wilcoxon Rank sum p-value = 0.30). Similarly, there are no significant differences in the stated belief about the probability of eventually becoming ill from consuming GE food (ANOVA p-value = 0.22; Wilcoxon Rank sum p-value = 0.25). In terms of relative concern ascertained by allocating 100 points to six food issues, there were, again, no significant differences across the treatments and control related to GE food (ANOVA p-value = 0.35; Wilcoxon Rank sum p-value = 0.37).[2]

Only for the willingness-to-pay question was a significant effect observed. In Treatments 1 and 2, individual stated a greater willingness to pay a premium to avoid GE food (about 9% on average) as compared to the control (premium was about 6.5%). A likelihood ratio test applied to the interval censored regression estimates

[2] There is likely heterogeneity in concerns about GE food, and it is possible that the signaling effect exists for certain types of consumers (i.e., there may be interactions between the treatment effect and certain respondent characteristics). If we estimate regressions with safety beliefs or willingness-to-pay as the dependent variable, however, we do not find the treatment effect dummies to be significant even after controlling for gender, age, education, income, race, and political ideology, nor are we able to reject the null that the interactions between these individual-specific characteristics and the treatment dummies are different from zero. Thus, at least among the demographic variables we collected, we have no evidence of a signaling effect on the overall mean or on any of the sub-groups.

Table 1
Beliefs about and willingness-to-pay for genetically engineered and ethylene ripened food by treatment in study 1.

Variable		Treatment 1 contains GE	Treatment 2 does not contain GE	Control Ethylene
"Genetically engineered foods are safe to eat" (1 = strongly disagree; 5 = strongly agree)	Mean	3.055	2.972	2.892
	(s.e.)	(.072)	(.074)	(.077)
	N	217	217	213
"Fruits ripened with ethylene are safe to eat" (1 = strongly disagree; 5 = strongly agree)	Mean	2.862	2.783	2.972
	(s.e.)	(.064)	(.065)	(.072)
	N	217	217	213
"What is the chance of eventually becoming ill from repeatedly consuming genetically engineered food?" (0 = no chance; 100 = absolutely certain to cause illness)	Mean	39.580	43.474	44.066
	(s.e.)	(1.918)	(1.948)	(2.064)
	N	212	215	211
"What is the chance of eventually becoming ill from repeatedly ethylene ripened fruit?" (0 = no chance; 100 = absolutely certain to cause illness)	Mean	42.024	45.460	43.611
	(s.e.)	(1.884)	(1.961)	(2.120)
	N	212	215	211
"How concerned are you about the following issues when eating food?" Points (out of 100) allocated to "use of genetically engineered ingredients" vs. other six issues	Mean	20.222	19.325	22.130
	(s.e.)	(1.401)	(1.342)	(1.467)
	N	212	212	208
"How concerned are you about the following issues when eating food?" Points (out of 100) allocated to "use of ethylene" vs. other six issues	Mean	15.340	16.363	15.678
	(s.e.)	(1.051)	(1.216)	(1.102)
	N	212	212	208
"How much extra are you willing to pay for foods that have not been genetically engineered and contain no genetically engineered ingredients" (% price premium estimated from interval censored regression)	Mean	9.301	9.463	6.473
	(s.e.)	(3.099)	(2.590)	(2.109)
	St. dev.	40.888	34.915	27.552
	(s.e.)	(2.881)	(2.339)	(1.910)
	N	212	212	208

rejects the null of the equality of the mean willingness-to-pay *and* the associated standard deviations across the treatments and control (log-likelihood function value of the restricted model is −1401.58, the sum of the likelihood function values from the three models (the unrestricted model) is −1392.2, yielding a Chi-square value of 18.75 at the $p < 0.01$ level). However, additional analysis reveals that a model that allows for treatment-specific standard deviations but a common mean (yielding a log-likelihood function value of −1392.8) is not significantly different than the completely unrestricted model reported in Table 1 with treatment-specific means and treatment-specific standard deviations; a likelihood ratio tests cannot reject the null of identical means across treatment, given treatment-specific standard deviations (Chi-Square value of 1.19; p-value = 0.55). This implies that, if anything, the label affected the variance of willingness-to-pay but not the mean. Thus, of the four measures related to GE aversion tested, none yields results supportive of H1 and H2.

Table 2 reports multinomial logit models fit to the apple choice data. In each treatment, the results reveal intuitive results related to price and damage effects. On average respondents preferred red apples over green apples. The more interesting results relate to the estimated preferences for the technology labels. Treatment 1 reveals a utility discount for GE vs. unlabeled apples of −0.797, or an implied willingness-to-pay to avoid GE of 0.797/0.402 = $1.98/lb. By contrast, Treatment 2 reveals a utility premium for "non GE" apples vs. unlabeled apples of only 0.363, or an implied willingness-to-pay to avoid GE of only 0.363/0.447 = $0.81/lb. The implied willingness-to-pay to avoid GE is, thus [(1.98–0.81)/0.81] ∗ 100 = 144% higher in the treatment 1 (mandatory labeling condition) than in the treatment 2 (voluntary labeling condition). The difference in willingness-to-pay is statistically significant at the $p < 0.001$ level according to the test suggested by Poe et al. (2005).

Table 2
Multinominal Logit Models Fit to Apple Choice Data in Study 1.

	Treatment 1 contains GE	Treatment 2 does not contain GE	Control ethylene
Price	−0.402*[a]	−0.447*	−0.367*
	(0.040)[b]	(0.039)	(0.040)
Bruise/Damage vs. No Damage	−0.648*	−0.717*	−0.790*
	(0.056)	(0.055)	(0.057)
Red vs. Green	0.163*	0.145*	0.167*
	(0.055)	(0.053)	(0.055)
Genetically engineered vs. unlabeled	−0.797*	–	–
	(0.057)		
Not genetically engineered vs. unlabeled	–	0.363*	–
		(0.054)	
Ripened with ethylene vs. unlabeled	–	–	−0.700*
			(0.057)
Number of choices	1752	1736	1712

[a] One asterisk indicates statistical significance at the 0.01 level.
[b] Numbers in parentheses are standard errors.

Interestingly, willingness-to-pay to avoid ethylene ripening (0.7/0.367 = $1.91/lb) is not significantly different than implied willingness-to-pay to avoid GE in treatment 1 ($p = 0.41$ according to the Poe et al. (2005) test). Despite the fact that willingness-to-pay to avoid ethylene ripening is on par with that to avoid GE food, it heretofore appears to have attracted scant consumer, media, or regulatory attention, raising questions about how one issue has captured national attention while the other is essentially ignored.

The juxtaposition of the willingness to pay results in Table 1 and those implied by the results in Table 2 also suggests another curious phenomenon. As indicated, the apple choices in treatments 1 and 2 imply a willingness-to-pay premium of \$1.98/lb and \$0.81/lb to avoid GE content. If these values are expressed in percentage terms (relative to the mid-point of the prices used in the choice experiment, \$2.10), they imply willingness-to-pay premiums of 94.2% and 38.6%. These values are markedly higher than the mean willingness-to-values reported in the last row of Table 1, which range from 6.5% to 9.5%. The differences are not a result of the particular distributional assumption underling the econometric model fit to the interval censored, payment card data; if we look at the raw payment card data, only about 15% of respondents checked a box indicating a willingness-to-pay amount greater than a 25% premium.

It is unclear why such a large discrepancy exists. There are differences in question format (payment card vs. choice experiment) that could well account for differential willingness-to-pay values. In addition, the willingness-to-pay values in Table 1 result from a question about GE food in general, whereas the results implied from Table 2 relate to apples specifically. Moreover, the payment card question directly asked people to state their willingness-to-pay, whereas in the choice experiment, willingness-to-pay was inferred (or revealed) from the apple choices people made. Recognizing that it is impossible with our data to conclusively determine why the large differences exist, the results suggest the possibility that people may be surprised to learn what their choices imply about their underlying willingness-to-pay. It is also noteworthy that the willingness-to-pay value from the voluntary ("does not contain") label in the apple choice experiment is more similar to the answer people give for their general willingness-to-pay to avoid GE food in the payment card question.

Study 2

Overview

Study 2 consists of a between-subject design consisting of one treatment and one control group. Data are collected from

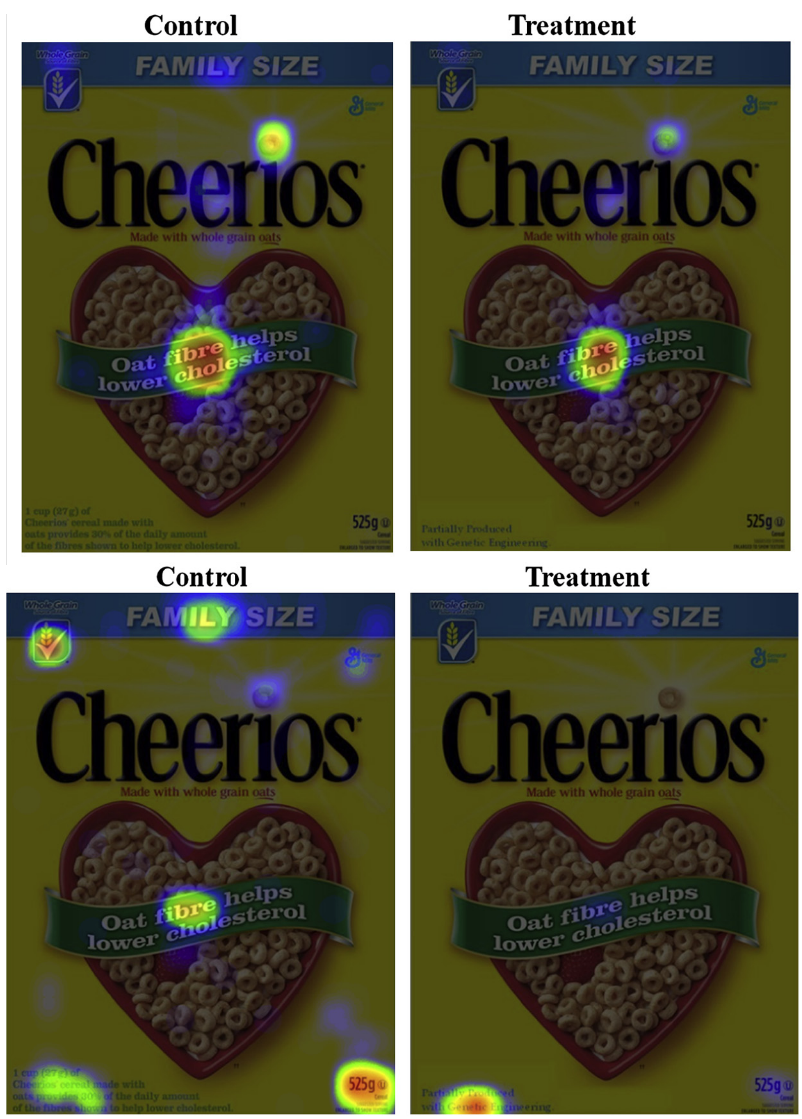

Fig. 2. Results from heat-map in study 2 (top panel indicates click frequencies associated with "most appealing" area; bottom panel shows the same for the "least appealing" area).

responses to online questionnaires. Participants for study 2 were recruited in the same way as study 1. In total, 419 subjects participated in study 2, with 205 randomly assigned to the control and 214 randomly assigned to the treatment. The characteristics of the sample were very similar to that described in study 1. There were no significant differences across the treatment and control with respect to the demographic variables.

Methods

After reading a statement about rights as human subjects involved in research, participants were told, "We are studying new package design concepts. Please look carefully at the following images of a cereal package and indicate what you find most and least appealing." They were then shown an image of a box of Cheerios. (Note: the study occurred prior to the news and announcement that Cheerios had decided to refrain from using GE ingredients). Participants were first asked, "Which area of the box do you find most appealing? (*please click with your mouse the part of the package you find most appealing*)." Once this task was completed, the image was repeated and participants were asked to click on the area of the box they found least appealing.

Participants randomly assigned to the control group were shown an unaltered image taken from an actual Cheerio box. The treatment group was shown the exact same image except the original text on the lower left-hand corner of the box, which said "1 cup (27 g) of Cheerios' cereal made with oats provides 30% of the daily amount of the fibers shown to help lower cholesterol" was replaced with the text "Partially Produced with Genetic Engineering." The phrasing used in the treatment group was taken from the text of the California mandatory labeling ballot initiative that would have been required on process food potentially containing GE ingredients. Fig. 2 shows "heat maps", which illustrate the images used in the treatment and control groups overlaid with the click-rates observed for the questions related to most and least appealing areas on the images. The most frequently clicked areas are shown in red followed by yellow, green, and blue.

The purpose of the preliminary task was not to analyze where people clicked *per se*, but rather to explore whether exposing people to a mandatory GE label alters attitudes, beliefs, and preferences about GE relative to the control. As Fig. 2 shows, respondents noticed the GE label and frequently clicked it as a least appealing area of the box.

After clicking on the images, respondents answered the exact same set of questions related to GE safety and willingness-to-pay as in study 1. The hypothesis is as follows:

H4. Individuals who observed the cereal box with the "mandatory" GE label will believe GE foods are more risky and will indicate greater willingness to pay to avoid GE food than individuals in the control who observed the cereal box without a GE claim.

Results

Table 3 reports the mean responses to the GE safety belief and willingness-to-pay questions in the treatment and control. Responses to the agree/disagree question about the safety of GE foods were virtually identical in the treatment and control and were not statistically different (two-tailed t-test p-value = 0.73; Wilcoxon Rank sum p-value = 0.60). The same was true for the question about the perceived likelihood of becoming ill from eating GE food (two-tailed t-test p-value = 0.80; Wilcoxon Rank sum p-value = 0.66).

When asked to allocate 100 points related to concern when eating food, participants in the treatment group assigned 22.44 points on average to GE food, whereas the mean in the control was only 19.24. Statistical tests reveal some support for H4 in that there was a higher level of concern in the treatment than the control (two-tailed t-test p-value = 0.07; Wilcoxon Rank sum p-value = 0.04). Similar to this finding, individual indicate a greater willingness-to-pay a premium to avoid GE food (about 9.52% on average) as compared to the control (premium was about 6.38%). However, a likelihood ratio test applied to the interval censored regression estimates fails to reject the null of the equality of the mean willingness-to-pay and the associated standard deviations across the treatments and control (p = 0.65).

Discussion and conclusions

When the U.S. Food and Drug Administration mandated the labeling of trans-fats on the nutritional facts panel, the food industry responded by drastically reducing the use of trans-fats across all food product categories (Rahlovky et al., 2012). Although the issue of trans-fats and genetic engineering are very different in many ways (e.g., the science is relatively clear that one is

Table 3
Beliefs about and willingness-to-pay for genetically engineered food by treatment in study 2.

Variable		Treatment 1 contains GE	Control
"Genetically engineered foods are safe to eat" (1 = strongly disagree; 5 = strongly agree)	Mean	2.850	2.888
	(s.e.)	(.074)	(.079)
	N	214	205
"What is the chance of eventually becoming ill from repeatedly consuming genetically engineered food?" (0 = no chance; 100 = absolutely certain to cause illness)	Mean	43.194	42.490
	(s.e.)	(1.877)	(2.064)
	N	214	205
"How concerned are you about the following issues when eating food?" Points (out of 100) allocated to "use of genetically engineered ingredients" vs. other six issues	Mean	22.445	19.240
	(s.e.)	(1.285)	(1.248)
	N	208	200
"How much extra are you willing to pay for foods that have not been genetically engineered and contain no genetically engineered ingredients" (% price premium estimated from interval censored regression)	Mean	9.520	6.377
	(s.e.)	(2.323)	(2.823)
	St. dev.	31.109	35.867
	(s.e.)	(2.068)	(2.595)
	N	208	200

unhealthy and the other is safe), this example illustrates how food companies can dramatically respond to mandatory labels in light of potential consumer reactions. As our results show, many consumers are skeptical of the safety of food. If mandatory labeling for GE food has an analogous effect as did mandatory trans-fat labeling, implementation of a mandatory label could have significant effects on the continued use and future adoption of seeds produced with the technology.

The main question addressed in this article is whether this outcome would simply reflect *a priori* consumer preferences or whether it is the result of a self-fulfilling prophecy, where labeling induces concern about the technology. We conducted two studies, one with a fresh fruit and another with a processed food, and used two different approaches to study whether the introduction of GE labels might induce heightened concern. Study 1 had subjects make a series of apple choices that, depending on treatment, had GE labels or not. Study 2 had subjects make visual appraisals of Cheerios boxes that, depending on the treatment, had GE labels or not. After subjecting subjects to GE labels (or not, depending on treatment), both studies then gauged respondents' beliefs about the safety of GE foods and their concern and willingness-to-pay to avoid GE food.[3]

Of the eight tests (four questions measuring aversion to GE foods in study 1 reported in Table 1 and the same four questions measuring aversion to GE foods in study 2 reported in Table 3) comparing GE label treatments groups to controls, only one detected a significant increase in the level of concern about GE food when exposed to GE labels. We interpret the evidence as suggesting (at least in the context of our studies) that any signaling effects, should they exist, are likely small and below the ability to consistently detect given our sample sizes of approximately 200 participants per treatment. Nevertheless, we do not believe the results completely rule out the possibility of a signaling effect.

A true labeling mandate imposed by law may well send a different signal about the nature of scientific and public concern than labels shown by researchers on a survey. It is likely impossible for a researcher to impersonate governmental authorities (and the media and culture surrounding a "real world" label implementation) required to fully reproduce the potential signaling effect of a labeling requirement. Our approach – exposing consumers to GM labels via a choice experiment or modified packaging – only simulates exposure to GM labels in a market-like setting, and it must be acknowledged that "real world" effects are possibly more pronounced.

There are at least two other reasons to believe that some forms of signaling are alive and well. First, study 1 reveals that mandatory "contains" labels generated significantly higher implied willingness-to-pay to avoid GE food than voluntary "does not contain" labels. The differences in responses to mandatory vs. voluntary labels may result from the asymmetric negativity effect, which may in turn result from differences in what these two labels signal about the relative desirability of the unlabeled product. The differences in the "contains" vs. "does not contain" may also send different signals and change beliefs about the likelihood that the unlabeled product is GE or non-GE. Second, in study 1 we found aversion to our "decoy" attribute – ethylene ripening – in the control that is on par with aversion to GE food. During fruit storage, atmospheric ethylene is often controlled to slow or accelerate the ripening process (see Sinha et al., 2012), but we are not aware of any significant controversy over its use. Ethylene is a natural plant hormone, and many consumers use the same mechanism when they put a banana in a fruit bowl to induce ripening. Should produce ripened with ethylene also be required to be labeled? Did the mere presence of the attribute on our survey signal consumers that it is an attribute that should be avoided?

The issue is complex. The numerous food crises and media scandals in recent decades seem to have affected consumers' confidence in the food system and its ability to reliably deliver safe and healthy food. Decreased connection with the food production system implies that the average consumer is unlikely to possess much information on a whole host of issues and technologies such as irradiation, cloning, rBST, sulfites, biotechnology, ethylene, and lean fine textured beef, just to name a few. Absent detailed knowledge of the scientific literature on these technologies, it is not unreasonable to assume that consumers readily adopt information signals related to these foods, whether they arise from friends' Facebook posts or from labels in the grocery store. The results presented herein suggest the signaling effect of labels is likely complex, and future research will be required to fully understand when and under what conditions labels not only sort people according to *a priori* preferences but signal what products should be purchased.

[3] An interesting issue for future research is whether aversion to GE food differs for whole, fresh food vs. a processed food. Our study was not designed to test this issue because our questions about GE concerned are framed in a general way and are not specifically related to a particular food type. Previous meta-analyses have suggested the possibility that willingness-to-pay to avoid GE food differs by the type of food studied (Lusk et al., 2005a).

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