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Arguments and actors in recent debates over US genetically modified organisms (GMOs)

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Abstract The American public remains divided on the issue of genetic modification. A 2014 Pew Research Center survey revealed that 57 % of 2002 respondents consider genetically modified organisms generally unsafe. In comparison, 88 % of 3748 scientists consider GMOs generally safe. To understand this divergence in opinion related to GMOs, I analyzed 200 headlines and articles from the *Los Angeles Times*, *New York Times*, *Wall Street Journal*, and *Washington Post* published between 2011 and 2013. I focused on the key arguments and who is making them. The results showed that newspapers presented 207 favorable and 250 unfavorable mentions of GMOs. The findings revealed the arguments "GMO technical performance" and "potential for environmental harm," along with actors described as the "biotechnology industry" and "U.S. government," received more media attention, measured by the frequency of mentions in articles. The arguments, and the actors that drive them, play a vital role in public opinion forming and affect ethical, practical, political, and scientific considerations of GMOs. This research provides insight into arguments influencing public opinion on genetic modification and actors with the potential to change the GMO debate.

Keywords Biotechnology · Genetic modification · GMO · Media content analysis · Public debate

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Introduction

Genetic engineering produced the first genetically modified organism (GMO) in 1973 (Johnson 1995). In the 1980s, the USA allowed the commercialization and market release of GMOs into the food system (Nelson 2001; Hossain et al. 2003). Rather than traditional crossbreeding methods, GMOs are the result of transplanting genes from one organism into another. The technology is most popularly known for its applications in agriculture, although it can be used for medical research and energy developments. In 1982, the US Food and Drug Administration (FDA) approved the first commercial GM product, Humulin™, or human insulin (Kinch 2014), followed 2 years later by the first GM food product—the FlavrSavr™ tomato (McHughen and Smyth 2008). In these early stages, the US public indicated little resistance to GM technology. Americans associated GMOs with benefits, such as increased productivity, decreased pesticide use, and diminished food costs (Finucane and Holup 2005). A 1987 study found that 67 % of US respondents "said that they would either approve or not care if a genetically engineered product were field-tested in their community" (Ezzell 1987; Finucane and Holup 2005), indicating favorable views of genetic modification.

The US public showed little resistance towards GMOs until the late 1990s, when a GMO controversy erupted over a study indicating modified Bt corn harmed Monarch butterflies (Losey et al. 1999; Kuntz 2014). Dramatic headlines warned, "Butterfly Deaths inked to Altered Corn" and "Gene Spliced Corn Imperils Butterflies" (Pringle 2003). Following the Monarch incident, the debate picked up momentum in the USA amidst efforts from both sides and media attention in the early 2000s (Siang 2002). A series of papers published in 2001 quelled the scientific debate by discrediting the original paper (Kuntz 2014; Minorsky 2001), but the controversy's

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media coverage raised awareness of GMO risks among the public. Soon after, international environmental groups with US presence (e.g., Greenpeace International, Friends of Earth International) began spearheading aggressive GMO labeling campaigns (Paarlberg 2014; Siang 2002). Some of the public viewed the Monarch butterfly as a metaphor for the destructive consequences of GMOs. The majority of the public remained divided over biotechnology and its applications to agriculture.

Around the same time, Europe faced an outbreak of mad cow disease, or BSE. This event changed the way the European public saw food regulators and marked a sharp decline in public trust (Kreibohm 2013). With events like literiosis outbreaks in the 1970s and 1980s (Lunden et al. 2004), the European public formed an opinion of GMOs amid a loss of confidence in the food regulatory system (Bonny, 2003). By 2002, only 12 % of Europeans trusted food safety regulation (Cantley and Lex 2011). In comparison, the American public remained confident in US food regulation. Politically, in the late 1990s, the European green parties allied with anti-GMO NGOs and gained enough seats to become the forth-largest party in the European Parliament. This action, enabled by the political structure of the European Union, contributed to the political focus, and consequently public action, on GMOs in Europe (Kreibohm 2013). The USA, with a two-party system, saw intense lobbying action by biotechnology companies. Coupled with a lack of majority support from politicians for GMO action, the political structure in the USA kept GMOs from gaining the same momentum with the American public compared to the European public. Since the early 2000s, Europeans have remained strongly against GMOs. Europeans have, it appears, decidedly made up their mind. But Americans have not. Consequently, it is important to analyze the influential factors in how Americans form opinions on GMOs.

A 2002 study of US consumer attitudes towards GMOs found that 35 % of the surveyed population opposed GMOs, while others felt favorably or ambivalently (Ganiere et al. 2006). The results suggested consumers formed opinions based on perceived risks and benefits of GMOs. In 2003, ABC News conducted a survey that showed 46 % of respondents considered GMOs unsafe for consumption (Funk and Rainie 2015a). Both promises of serious dangers and unprecedented benefits failed to convert the American public into a singular force adamantly for or against GMOs. By 2014, the USA planted 73.1 million hectares of GM crops, representing 40 % of global GM plantings. Maize, soybean, and cotton accounted for 90 % of the 73.1 million hectares of GM crops, with canola, sugarbeet, alfalfa, papaya, and squash accounting for the rest (James 2014). Almost all of US planted maize (93 %), soybean (94 %), and cotton (96 %) are a GM variety (Fernandez-Cornejo 2014), which are largely grown for animal feed or non-food uses. The contentious public debate failed to limit the expansion of agricultural biotechnology, and GMOs are almost ubiquitous in the American food system.

While around 90 % of Americans expressed desire for GMO food product labeling (Marchant and Cardineau 2013), a 2014 Pew Research Center survey reported that 37 % of 2002 respondents considered GMOs generally safe (Funk and Rainie 2015a). The same survey found that 57 % of respondents considered GMOs generally unsafe. In comparison, the American Association for the Advancement of Science scientists survey revealed 88 % of the 3748 surveyed scientists considered GMOs generally safe. Of the scientists surveyed, the majority's (1802) primary discipline is bio/medical sciences, followed by chemistry (429), earth sciences (270), engineering (243), math/computer sciences (182), physics and astronomy (328), social sciences and policy (333), and other (158). By discipline, belief in the safety of GMOs ranged from 91 % (bio/medical sciences) to 79 % (social sciences and policy). Analysis by discipline found that regardless of "how AAAS members are categorized, their views starkly differ from the public's on key scientific issues such as … the safety of eating genetically modified foods" (Funk and Rainie 2015b). The Pew survey revealed a dramatic difference in public and scientific opinion and a consistency in the public's views of GMOs. Various GMO debates play an important role in the opinions formed by the public. To begin to understand why the US public remains divided—in contrast to the unified majority of the American scientific community or their anti-GMO European counterparts—we must first understand these debates and how they are presented to the US public. This research seeks to identify the debates surrounding GMOs by analyzing the American media's portrayal of GMOs.

Perceived risks and benefits

The discourse over GMOs revolves around perceived consequences and benefits derived from the use of biotechnology. Berg et al. (1974) discussed potential dangers of genetic engineering and introduced the concept of GMO health risks by speculating about increased incidences of cancer and other diseases. A series of papers indicated GM foods might toxically impact various organs and systems, which led to concerns over GMO-caused toxicity in humans (Dona and Arvanitoyannis 2009). Other concerns revolve around the possibility of inadvertently introducing new allergens to the food system. Super pests and weeds resulting from the use of GM crops compel the use of pesticides and herbicides (Beckwith et al. 2003; Lundquist 2015). The long-term effect on wild plants, insects, and birds is still unknown (Pinstrup-Andersen and Schioler 2001). Genetic drift from transgenic plants to other species may unleash modified organisms that outcompete their native counterparts and cause an immeasurable loss of genetic information (Beckwith et al. 2003). Indeed, a major fear is the impact of GM crop use on biodiversity (Beckwith et al. 2003; Scuro 2007). Ecologists have identified three critical impacts of biodiversity loss: (1) loss of variety of agricultural products, (2) loss of support provided by biodiversity for human life and the environment, and (3) loss of the non-scientific esthetic and intrinsic value of biodiversity (Scuro 2007). International bodies also potentially share the consequences of GMOs—plants have no regard for human-made boundaries—whether they approve or disapprove GMO use.

Additional problems arise in international trade relations, as when one nation with a GMO ban receives GMO contaminated crops imported from another nation. Some opponents argue that GMOs are ethically unsettling, claiming biotechnology is like "playing God" (Hossain et al. 2003). Risks associated with GMOs may have nothing to do with the technology, but rather the profit-driven nature of the biotechnology industry (Beckwith et al. 2003). A non-technological risk of GMOs includes forms of biotechnology—such as heavily patented seeds—that increase farmers' dependency on large corporations (Hansson and Joelsson 2013). Farmers face serious financial consequences if they improperly use patented seeds; biotechnology corporations indiscriminately use their legal resources to protect their technology.

Despite the possible consequences, the potential environmental benefits of GMOs are hard to ignore. The adoption of some GM technology, such as Bt corn, can reduce chemical pesticide use, increase crop yields, and increase farmer profits (James 2014). Specially designed GM crops are also better able to withstand environmental stressors, such as weather events, like droughts or floods (Font 2011), and diseases (Beckwith et al. 2003; Potrykus 2001; Moore 2000). GM foods are lauded for enabling improved nutrition in staple foods (Beckwith et al. 2003; Potrykus 2001) and promoting health by making wholesome food more affordable (Hossain et al. 2003). One such crop is the GM Golden Rice, modified to contain more vitamin A to prevent blindness in malnourished children (Potrykus 2001). These traits in turn benefit the developing world, which faces "drastic changes in the environment … as a result from climate change [that] may make [GMOs] necessary to stave off human suffering" (Scuro 2007).

Although small farmers in developed nations tend to reject GMOs for fear of corporate control, another benefit of GM crop use is the reduced chemical use, which makes the crops safer for farmers (Beckwith et al. 2003). Esthetic values are attributed to GM products too, with their ability to appear more appetizing and maintain longer shelf-lives (Beckwith et al. 2003). Aside from crop-related benefits, GM technology offers the promise of medical innovation. Perhaps biotechnology may even aid in rapidly advancing green technologies, like biofuel. The many potential benefits of GM technology make it an appealing opportunity. The presentation of these risks and benefits in the media is key to understanding the public's polarized view of GMOs.

Methods

Media content analysis is an established research method appropriate for analyzing topics presented in the media (Krippendorff 2012; Macnamara 2011). My specific approach follows on Dunlap and Elsasser (2013), who used media content analysis to identify the influence of key climate policies and events on conservative columnists engaged in climate change denialism. I identified newspapers as appropriate subjects because television, radio, and newspapers are sources of information most often used by consumers (Nelson 2001). I chose to analyze newspaper records because they are more easily and reliably accessible compared to television or radio. While only 9 % of Americans turn to newspapers for news (Saad 2013), national newspapers set the news agenda for other newspapers, media outlets, and television (Thomson and Dininni 2005; Gitlin 1980). Consequently, the impact of major newspapers extends far beyond the immediate readership base. For example, if the *New York Times* reports on a certain GMO story, other news outlets will follow with coverage. For this reason, newspapers are an appropriate focus for the study of information accessed by and influential to the public.

To identify arguments used by and actors familiar to the public, I conducted a media content analysis of articles published over the period of January 2011 to December 2013 in four national US newspapers: *Washington Post*, *Wall Street Journal*, *New York Times*, and *Los Angeles Times* (the same outlets examined in other studies for their geographical diversity, high circulation, and reliable access; Boykoff et al. 2015). I selected 2011–2013 to analyze the most recent news while accounting for the information that the American public consumed in the years prior to the 2014 Pew survey, which showed evidence of Americans' divided views of GMOs contrasted with a broad scientific consensus. I aimed to represent the information that would have been consumed by respondents to the Pew survey and potentially influenced the split opinion.

I searched the ProQuest Central database to collect articles published from 2011 to 2013 using the key term "genetically modified." I identified this key term through a preliminary reading of GMO articles in the four newspapers. I initially browsed articles on the website of each respective newspaper and noted that "genetically modified" most often came up in relevant articles. The term allows me to collect all articles related to GMOs, without limiting results to crops or animals. In the ProQuest Central database, I excluded "general information" articles, as these may be too broad for analysis. My initial search yielded 227 *Washington Post* articles, 169 *Wall Street Journal* articles, 134 *New York Times* articles, 97 *Los Angeles Times* articles, or 622 total articles. For each publication, I sorted results by "relevance" and eliminated articles with only one instance of "genetically modified." After the elimination of duplicates and single instances, I collected the first 50 articles generated by the relevance search for a total of 200 articles (32 % of the 622 total), with 50 from each publication. This approach sought to eliminate bias from my selection. The database ordered the articles by an internal mechanism that determines which articles are most relevant. This way I did not preview any article before selecting it for analysis and had not control over the distribution of publication dates, ensuring that my sample is representative of the 622 total articles for the period 2011 to 2013.

I outlined broad themes from a precursory overview of 20 articles, supplemented by Cook (2004), such as distrust, resistance, international development, playing God, contamination, health, and biodiversity. These broad themes established an approach for hand coding the articles. They ensured that results from articles were standardized and aided in eliminating individualized analysis. I refined these themes after an initial coding of 10 articles from each newspaper and divided them into categories "favorable arguments" and "unfavorable arguments." Favorable arguments included the following: economic benefits, non-food benefits, food production demand, sustainability, health benefits, benefits outweigh risks, aid to developing nations, historical technique, proven safe, and resistance. Unfavorable arguments included the following: anti-science, insufficient research, distrust, environmental harm, harm to humans, ethical issues, precautionary principle, unnatural, better alternatives, contamination, and trade consequences.

Once I established a standardized approach, I began to hand code the 200 articles. I identified mentions of the favorable or unfavorable arguments and counted them for each article. After my first review, I revised the categories to make certain that they encompassed all the arguments mentioned in the articles. From this process of reading and coding a second time, I refined the initial categories to 11 favorable and 13 unfavorable arguments, which I detail in my results. These are the broadest categories that represent distinct arguments made in the articles. While the number of categories is not equal, I avoided combining categories to evenly distribute them, as this could give undue weight to some categories over others. I also noted all mentions of relevant parties, such as biotechnology companies, government organizations, and universities. The full list of actors and their mention frequencies are listed in the supplementary materials. I counted mentions of actors and arguments only once. That is, an article could mention the application of the precautionary principle to GMOs three times, but this would only count as a signal instance of that argument. So, if every article mentions the precautionary principle, that would be coded as 200 total mentions. This ensured that no article would get extra weight purely based on word count. I marked my coding in Excel and used text-parsing tools in Stata to output organized counts by theme, actor, and year. I then used these counts to create Tables 1 and 2. I created Fig. 1 by inputting the data on each newspaper article (the outlet and year) in Stata. To ensure accuracy in my coding, I checked my coding against coding by six individuals' coding of four randomly selected articles each (24 articles total). I detail the outcomes of this coding in my results.

Results

My analysis identified 11 favorable and 13 unfavorable arguments about GM technology presented in the media. In 200 articles, I found 444 total mentions of these 24 arguments. Out of 444 identified mentions of GM arguments, 44.6 % are favorable and 55.4 % are unfavorable. The random 24 article coding resulted in 117 identified arguments, with 61 (52.1 %)

Table 1 Favorable and unfavorable argument mentions by year

Category	2011	2012	2013	Total
Favorable (total)	30	60	108	198
GMO performance in resistance and yield	4	11	34	49
Environmentally sustainable	4	5	13	22
Health benefits	1	8	11	20
Economic benefits	6	5	8	19
GMOs have been proven safe	2	5	11	18
GMOs can help meet world food demand	4	5	9	18
Non-acceptance is ignorant	1	5	9	15
Gene modification is a historical process	3	5	6	14
Benefits outweigh the risks	1	6	2	9
GMOs can aid developing nations	1	3	5	9
Non-food benefits	3	2	0	5
Unfavorable (total)	57	74	115	246
Environmental harm	11	14	22	47
Distrust of the biotechnology industry	7	8	26	41
Contamination of non-GM crops	11	7	17	35
Insufficient knowledge	5	14	8	27
Harmful to human health	3	10	9	22
Better safe than sorry	1	8	4	13
GMOs are unnatural	0	5	7	12
Detrimental to farmers	6	2	3	11
There are better alternatives	3	2	5	10
Negative impacts on trade	3	0	5	8
Distrust of government	4	0	3	7
Increased pesticide use	0	1	5	6
Distrust of technology	2	2	0	4

Table 2 Actor category mentions by year

	2011	2012	2013	Total
Actor category mentions (total)	158	244	486	888
Biotechnology industry	35	52	116	203
US Government	41	28	71	140
Food retail and processing industry	11	36	73	120
Universities	21	42	44	107
Scientists and research institutions	13	22	68	103
Organic companies and interest groups	14	36	38	88
Environmental advocacy groups and activists	8	21	51	80
Farmers and farming interest groups	15	7	25	47

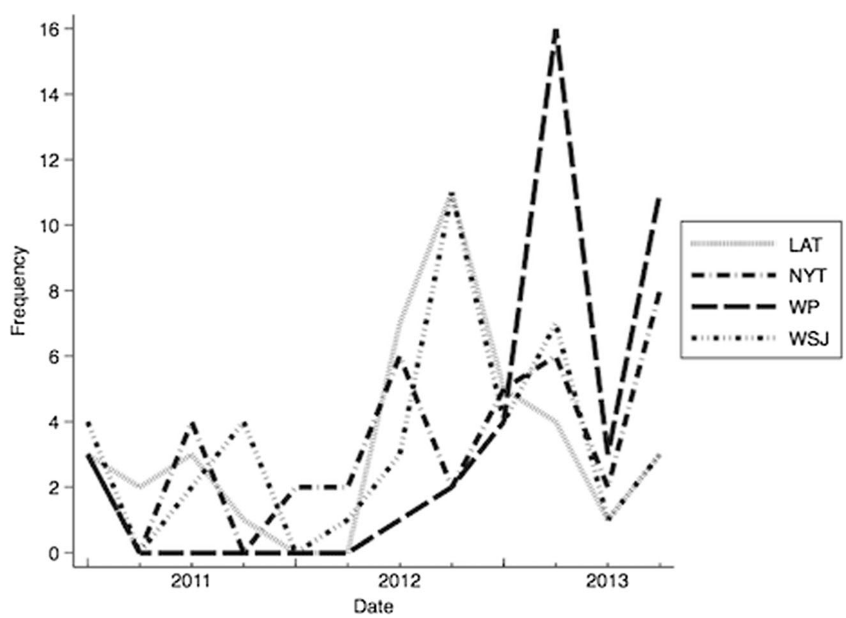
favorable mentions and 56 (47.9 %) unfavorable mentions. While the random 24 article coding indicated a slight majority in favorable mentions, unlike my findings, there exists even reporting in both results. That is, the results of the random coding reinforce my results in identifying two-sided reporting of GMOs.

The mid-2013 spike in GM coverage that I analyzed was caused by two events: Whole Foods Market's involvement with Proposition 37 in California and the discovery of unapproved Monsanto GM wheat in an Oregon field (called the "CP4 event"). Farmers sued Monsanto over the event. Japan and South Korea suspended US wheat imports, and the EU urged member-states to test imports. Monsanto caused additional furor by claiming the CP4 event to be suspicious, suggesting the event would not occur under normal farming practices. This event also accounted for some of the instances of the argument "negative impact on trade." The Proposition 37 events occurred in late 2012, corresponding to the first peak, and the CP4 event occurred in spring 2013, corresponding with the highest peak of events. These events contributed to the increase in frequency of the contamination argument, with 10 more mentions in 2013 compared to 2012. The frequency of the distrust of biotechnology also increased significantly, with 18 more mentions in 2013 than 2012.

The increase in media coverage of GMOs due to these events is further evidenced in an analysis of individual groups and companies mentioned in relation to GMOs. From 2012 to 2013, coverage of these individual groups increased by 116 mentions (153 %). Monsanto, the USDA, FDA, and farmer mentions increased with the CP4 event. Whole Foods Market mentions increased with its involvement in the labeling movement from five mentions in 2012 to 18 mentions in 2013. Some articles described Whole Foods as the voice for consumer choice and the non-GMO movement.

The most frequent favorable argument reflected GM technology performance in increasing yields and providing pesticide and herbicide resistance. Resistance was more strongly emphasized, with 34 of 49 (69.4 %) mentions about GM technology performance specifying resistance as a favorable quality. Environmental sustainability of GMOs, the second most

Fig. 1 Frequency of GMO articles by newspaper outlet over time



frequent argument with 22 mentions, cited reduced water usage and tillage as benefits over traditional agriculture practices; however, comparisons to organic agriculture were rarely made. The most frequent argument against GMOs referenced the potential for environmental harm. The largest specific concern was super pests and weeds, accounting for 17 of 47 (36.2 %) environmental harm mentions. However, fears of biodiversity loss followed closely with 14 mentions, or 29.8 % of environmental harm mentions. Distrust of the biotechnology industry included no sub-categories, making it the only high-frequency mention category with such a high number of references to a specific argument. Consequently, out of all highly specific favorable and unfavorable mentions, distrust of biotechnology ranks first, with fears of contamination (unfavorable) and the benefits of resistance (favorable) ranking second and third, respectively.

My analysis shows the newspapers emphasized corporate and government actors, with the biotechnology industry accounting for the most mentions. The frequency of biotechnology mentions is unsurprising; the more striking result is the low frequency of mentions for farmers and farming interest groups, such as the American Soybean Association. I initially anticipated farmers and farming interest groups would have a stronger presence in the media. The tale of American farmers makes a good story, and they play a critical role in biotechnology. Biotechnology industries are often farmer-facing as well. Given this reasoning, farmers and farming interest groups are surprisingly low in mention frequency; however, this may be due to the sheer volume and variety of groups in other categories, such as universities and the food retail and processing industry. There were only 21 individual groups or companies mentioned for farmers and farming interest groups (e.g., Iowa Soybean Association), compared to 58 individual university mentions and 46 individual food retail and processing company or group mentions.

Of the 888 actor mentions, farmers and farming interest groups account for only 47 (5.3 %) of actor mentions. Within “Farmers and Farming Interest Groups,” I identified individual farmers mentioned as “farmers.” The articles mention this specific group 23 times, making farmers the sixth most frequent individual actor mention out of 267 individual actors. With analysis of individual actors, there are more notable results for understanding the stakeholders in the GM technology. The most frequently mentioned specific actor is Monsanto. Out of 86 mentions of Monsanto, 27 (31.4 %) were associated with distrust of the biotechnology industry. Monsanto overshadowed other biotechnology companies in mentions and was often identified as the icon for all the purported wrongdoings of the industry (Haspel 2013). Monsanto was the most mentioned individual actor, identified in 43 % of the 200 articles. The top ten mentioned individual actors, detailed in Table 3, represent just 3.7 % of the 267 identified actors, yet account for 36.8 % of all actor mentions. That is, a small portion of stakeholders account for a large portion of the news that the American public receives. This media focus on a few actors may have a number of reasons, such as that these are the most vocal groups (via public relations, social media, etc.). However, the occurrence is well worth studying to better understand how certain actor mentions can affect public perception. Overall, the results indicate that there are two sides GM technology presented in American media, much like with climate change coverage.

Table 3 Ten most frequent group or company mentions by year

	2011	2012	2013	Total
Group or company mentions (total)	59	76	192	327
Monsanto	17	20	49	86
US Food and Drug Administration	8	14	32	54
US Department of Agriculture	14	8	21	43
DuPont Pioneer	2	11	13	26
Whole Foods Market	3	5	18	26
Farmers	6	4	13	23
Center for Food Safety	4	2	16	22
Syngenta	5	2	13	20
Grocery Manufacturers Association	0	6	8	14
Pepsi	0	4	9	13

Discussion

The American media possesses the ability to transform and shape the public opinion (Macnamara 2011). For this reason, understanding the media’s position on GMOs is a fundamental component of comprehending why the American public is divided on the technology. My analysis demonstrates that media gives two sides to the story, evenly citing favorable and unfavorable arguments for GMOs. This media practice, as Boykoff and Boykoff (2004) found for climate change, can cause polarized public debate regardless of a scientific opinion. While my analysis does not establish that coverage of GMOs does in fact have this polarizing impact, it does provide motivation for further study of media impact on public opinions of GM technology. To understand such potential impacts, I briefly discuss three factors that may shed light on how the public interprets GM news coverage: proxy issues with GMOs, risk perception and evaluation, and cultural cognition.

Arguments often use GM technology as proxy for larger issues, such as institutionalized agricultural practices and, more broadly, neoliberal practices and intellectual property (Thompson 2014). The issue with GMOs as a proxy is that, regardless of scientific opinion on the safety and agricultural applications of GM technology, GMOs are socially situated as symbols of concepts that represent other issues. Separating the potential benefits, and even risks, from other proxy issues, such as distrust of biotechnology, is a difficult task imbued with conflicting values. However, there is no strong evidence that suggests that technical claims, such as resistance performance and increased yield, about GMOs are more important than social claims, such as trustworthiness. For example, farmers' heavy dependence on large corporations can cause serious financial consequences if they improperly use patented seeds. Six biotechnology companies dominate the seed industry: Monsanto, DuPont, Syngenta, Bayer, Dow, and BASF. These six companies share cross-licensing agreements, which allow them to consolidate the proprietary seed market (Howard 2009). In my results, much of the distrust of the biotechnology industry is rooted in this issue. This reasoning may indicate why the media covers such a broad range of arguments associated with GMOs, rather than being concerned with purely technical aspects. As Kloor (2015) succinctly states, "the truth about GMOs, it turn[s] out, mean[s] different things to different people."

The public's perception of risk is different from scientists' perception of risk. Starr (1969) found that the perception of voluntary or involuntary nature of a risk significantly impacted individuals' willingness to take on that risk. In one study, the League of Women Voters and college students ranked nuclear power as the number one risk out of 30 possibilities. Scientists ranked nuclear power 20th, behind police work and surgery (Slovic et al. 1985). Slovic et al. (1985) mapped 81 hazards across two axes: factor one and factor two. Factor one represented a spectrum of uncontrollable, dread, global reach, catastrophic, or involuntary risk factors. Factor two represented a spectrum of not observable, new, unknown, or delayed effects risk factors. The study found that studied groups linked DNA technology, or GM technology, to dread risk and a lack of familiarity, much like nuclear power (Slovic et al. 1985). Hazards high on the dread risk factor (factor one), such as DNA technology, were seen as certain to be fatal, often for a large number of people. DNA technology also fell high on the unknown risk factor (factor two), indicating that the studied groups viewed the technology as an unknown and involuntary risk (Slovic et al. 1985). The public views benefits of technology as unknowable or takes them for granted but associates the risks of technology with involuntary, catastrophic, or dangerous consequences (Renn and Benighaus 2013). The public also differs in understand and accepting uncertainty. In the case of GM foods, many individuals will not accept the risks of the technology without the guarantee of little to no uncertainty about possible side effects (Renn and Benighaus 2013). I found the unfavorable argument "insufficient knowledge" occurred 27 times in my analysis, reflecting the media's concern with—and questioning of—scientific uncertainty. Renn and Benighaus (2013) argue that high media coverage of small risks can contribute to such asymmetrical risk perceptions by the public.

Shrader-Frechette (2003) discussed how scientists or experts relying on probabilities can misjudge risks as seriously as laypeople. In fact, differences in expert and public risk evaluation are not caused by differences in estimations of risk probabilities. Differences in expert and public risk evaluation are caused by a distrust of government risk estimates, a belief that the risks outweigh benefits, a claim that the risk is involuntary and unfair, or the absence of a right to full compensation from industry risks (Shrader-Frechette 2003). Risk assessments published by government or the biotechnology industry hold little influence over individuals' evaluations of risk when they distrust those institutions. Instead, individuals may be wary of any risk-free portrayal of GMOs. This factor must be considered in relation with compensation issues. The agricultural biotechnology giants offer no guarantee of compensation in the instance that a risk becomes reality. The lack of compensation, in turn, can reinforce distrust of the industry, and even the government. Consequently, GMOs can be seen as an industry-imposed risk, rather than a choice. Unlike eating unhealthily or driving—both have their own associated risks—GM technology entered the public sphere without individual consent. Individuals believe they choose, with relative ease and autonomy, eating and fitness habits. In contrast, they may feel powerless over GM technology research, development, agricultural applications, and market use. Understanding how the public reacts to risk that is new, unknown, and involuntary is key to identifying why a debate exists. However, risk evaluation alone may not be sufficient enough to explain the influence media has on the GMO debate.

Cultural cognition, the tendency to conform beliefs to values defined by cultural identities, plays a significant role in how individuals evaluate risks (Kahan 2011). The GMO debate, like climate change, nuclear power, and gun control, is subject to this tendency. The presence of a scientific consensus alone would not be enough to influence public opinion towards a unified view of GMOs. The public, or laypersons, evaluate risk differently not just from experts, but also as individuals (Kahan 2011). For this reason, preexisting values and risk judgments in individuals may influence their disagreement with a scientific consensus (Kahan 2011). That is, what is considered a scientific consensus varies among individuals based on their cultural identities. Cultural cognition also influences an individual's perception of credibility (Kahan 2011). For example, if an individual feels distrustful of government regulation, they are more likely to disagree with GM use (Hossain et al. 2003). Their stance against GMOs can be reinforced if an expert who shares their values is linked to an unfavorable stance towards GMOs. Individuals' cultural identities shape their views of and attitudes towards GMOs.

Articles I reviewed ranged from simply noting changes in biotechnology to long form narratives of farmers saved by

GMOs to coverage of anti-GMO protests. These articles can serve to link GMOs to messages that signal different values and risks. Understanding how the public reads these risks and the way their cultural identity views the different arguments and actors provides insight into the influence of media coverage. For example, my results show that the media more prominently features some actors over others. When people share values with these groups, they trust information associated with that group more (Kloor 2015). When Monsanto is heavily reported on in connection to GMOs (in my results 27 of 86 Monsanto mentions were linked to distrust), an individual's stance against GMOs may derive more from their distrust of the biotechnology industry than the technology itself. On the other hand, individuals who trust scientists and the government are likely to approve of GMOs (Hossain et al. 2003). We see cultural cognition in effect as an individual's perceptions of and trust in the biotechnology industry, scientists, activists, and government have a significant impact on approval of GMOs (Hossain et al. 2003; Lang and Hallman 2005). Consequently, the presence of these actors and the narrative presented in media coverage of GM technology requires further study to establish the effects on public opinion.

This paper serves as a foundation for further inquiry into the relationships between the American public, relevant actors, and the GMO debate. Further research is needed to better understand the motivating arguments and key actors that play a significant role in the media and how they impact American public opinion. Research may include more vigorous and extensive media content analysis, extending to television and radio shows. Additional studies may involve surveys, interviews, behavioral experiments, coding within a cultural cognition framework, and opinion dynamics modeling. More research is also needed to establish a scientific consensus on the safety of GMOs, as Oreskes (2004) evidenced for scientific consensus on climate change. The results of such research should provide comparable results for cross-analysis of discourse in the media versus the scientific community (Boykoff and Boykoff 2004).

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References

Beckwith M et al. (2003) Public perceptions of plant biotechnology—a focus group study. New Genet Soc 22(2):93–109

Berg P et al. (1974) Potential biohazard of recombinant DNA molecules. Science 185(4148):303

Bonny S (2003) Why are most Europeans opposed to GMOs? Factors explaining rejection in France and Europe. Electron J Biotechnol 6(1). http://www.ejbiotechnology.info/content/vol6/issue1/full/4. Accessed February 20, 2015

Boykoff M et al. (2015) World newspaper coverage of climate change or global warming, 2014–2015. Center for Science and Technology Policy Research, Cooperative Institute for Research in Environmental Sciences, University of Colorado. http://sciencepolicy.colorado.edu/icecaps/research/media_coverage/usa/index.html. Accessed February 12 2015

Boykoff MT, Boykoff JM (2004) Balance as bias: global warming and the US prestige press. Glob Environ Chang 14:125–136

Cantley M, Lex M (2011) Genetically modified foods and crops. In: Wiener J et al. (eds) The reality of precaution: comparing risk regulation in the United States and Europe, 39. RFF Press, Washington, DC

Cook G (2004) Genetically modified language. Routledge, London

Dona A, Arvanitoyannis IS (2009) Health risks of genetically modified foods. Crit Rev Food Sci Nutr 49:164–175

Dunlap RE, Elsasser SW (2013) Leading voices in the Denier Choir: conservative columnists' dismissal of global warming and denigration of climate science. Am Behav Sci 57(6):754–776

Ezzell C (1987) U.S. attitudes to biotechnology show qualified support. Nature 327:453

Fernandez-Cornejo J (2014) Genetically engineered varieties of corn, upland cotton, and soybeans, by state and for the Unites States, 2000–14. USDA's NASS June Agricultural Survey for 2000–2014

Finucane ML, Holup JL (2005) Psychosocial and cultural factors affecting the perceived risk of genetically modified food: an overview of the literature. Soc Sci Med 60:1603–1612

Font MC (2011) Mapping social and environmental concerns and the acceptability of genetic modified organisms in the European Union. J Socio Econ 40(6):903–908

Funk C, Rainie L (2015a) Public and scientists' views on science and society. Pew Research Center, Washington, DC. http://www.pewinternet.org/2015/01/29/public-and-scientists-views-on-science-and-society. Accessed February 9, 2015

Funk C, Rainie L (2015b) An elaboration of AAAS scientists' views. Pew Research Center, Washington, DC. http://www.pewinternet.org/2015/07/23/an-elaboration-of-aaas-scientists-views/. Accessed October 25, 2015

Ganiere P et al. (2006) A continuum of consumer attitudes toward genetically modified foods in the Unites States. J Agr Resour Econ 31(1):129–149

Gitlin T (1980) The whole word is watching: mass media in the making and unmaking of the new left. California Press, Berkeley

Hansson SO, Joelsson K (2013) Crop biotechnology for the environment? J Agr Environ Ethic 26:759–770

Haspel T (2013) Genetically modified foods: what is and isn't true. The Washington Post. http://www.washingtonpost.com/lifestyle/food/genetically-modified-foods-what-is-and-isnt-true/2013/10/15/40e4fd58-3132-11e3-8627-c5d7de0a046b_story.html. Accessed March 20 2015

Hossain F et al. (2003) Public perceptions of biotechnology and acceptance of genetically modified food. J Food Distrib Res 34(3):36–50

Howard PH (2009) Visualizing Consolidation in the Global Seed Industry: 1996–2008. Sustain 1:1266–1287

James C (2014) Global status of commercialized biotech/GM crops: 2014. ISAAA Brief No. 49. ISAAA, Ithaca, NY

Johnson G (1995) How scientists think: twenty-one experiments that have shaped our understanding of genetics and molecular biology. William C, Brown, Dubuque, IA

Kahan D (2011) Cultural cognition of scientific consensus. J Risk Res 14:147–174

Kinch MS (2014) An overview of FDA-approved biologics medicines. Drug Discov Today 20(4):393–398

Kloor K (2015) The tricky terrain for GMO communication. Discover Magazine. http://blogs.discovermagazine.com/collideascape/2015/01/16/tricky-terrain-gmo-communication/#.VTgEj5TF-PU. Accessed April 1, 2015

Kreibohm L (2013) Who's afraid of GMOs? Understanding the differences in the regulation of GMOs in the United States and European Union. American Institute for Contemporary German Studies Issue Brief. http://www.aicgs.org/site/wp-content/uploads/2013/08/Issue-Brief-44_GMOs1.pdf. Accessed March 10, 2015

Krippendorff K (2012) Content analysis: an introduction to its methodology. Sage Publications, Inc., London

Kuntz M (2014) Is it possible to overcome the GMO controversy? Some Elements for a philosophical perspective. In: Ricroch A et al. (eds) Plant biotechnology: experience and future prospects. Springer, New York, pp. 107–111

Lang JT, Hallman WK (2005) Who does the public trust? The case of genetically modified food in the United States. Risk Anal 25(5): 1241–1252

Losey JE et al. (1999) Transgenic pollen harms monarch larvae. Nature 399:214

Lunden J et al. (2004) Human listeriosis outbreaks linked to dairy products in Europe. J Dairy Sci 87(E Suppl):E6–E11

Lundquist KA (2015) Unapproved genetically modified corn: it's what's for dinner. Iowa Law Rev 100(2):825–851

Macnamara J (2011) Media content analysis: its uses; benefits and best practice methodology. Asia Pac Public Relat J 61(1):1–34

Marchant GE, Cardineau GA (2013) The labeling debate in the United States. GM Crops Food 4(3):126–134

McHughen A, Smyth S (2008) US regulatory system for genetically modified [genetically modified organism (GMO), rDNA, or transgenic] crop cultivars. Plant Biotechnol J 6(1):2–12

Minorsky PV (2001) The monarch butterfly controversy. Plant Physiol 127(3):709–710

Moore JA (2000) Frankenfood or doubly green revolution: Europe vs. America on the GMO debate. AAAS Science and Technology Policy Colloquium, Washington, DC

Nelson CH (2001) Risk perception, behavior, and consumer response to genetically modified organisms. Am Behav Sci 44(8):1371–1388

Oreskes N (2004) The scientific consensus on climate change. Science 306(5702):1686

Pinstrup-Anderson P, Schioler E (2001) Seeds of contention: world hunger and the global controversy over GM crops. The Johns Hopkins University Press, London

Potrykus I (2001) Golden rice and beyond. Plant Physiol 125(3):1157–1161

Pringle P (2003) The butterfly flap. Prospect Magazine. http://www.prospectmagazine.co.uk/features/thebutterflyflap. Accessed March 12, 2015

Renn O, Benighaus C (2013) Perception of technological risk: insights from research and lessons for risk communication and management. J Risk Res 16(3–4):293–313

Saad L (2013) TV is Americans' main source of news: preferred news source varies by age, education, and politics, among other factors. Gallup, Inc., Princeton NJ. http://www.gallup.com/poll/163412/americans-main-source-news.aspx. Accessed March 10, 2015

Scuro A (2007) Are GMOs good or bad seeds in the developing world?: a discussion of the growing role of developing countries in the debate over climate change and the loss of biodiversity. Fordham Environ Law Rev 18(2):369–398

Shrader-Frechette K (2003) Risk and reason [review of the book Risk and reason by C. Sunstein]. Notre Dame philosophical reviews. https://ndpr.nd.edu/news/23381-risk-and-reason. Accessed May April 15, 2015

Siang S (2002) Ethics, law and public policy of genes and modified foods: US policy developments on GMOs in 2000. Prof Ethic Rep 13(2):6–10

Slovic P et al. (1985) Characterizing perceived risk. In: Kates RW et al. (eds) Perilous progress: managing the hazard of technology. Westview, Boulder, CO, pp. 91–125

Starr C (1969) Social benefit versus technological risk. Science 165(3899):1232–1238

Thompson PB (2014) The GMO quandary and what it means for social philosophy. Soc Philos Today 30:7–27

Thomson J, Dininni L (2005) What the print media tell us about agricultural biotechnology: will we remember? Choices: The Magazine of Food, Farm, and Resource Issues 20(4):247–252