Does the Apple Fall Far from the Tree?: Reviewing the Communication of Scientific

Information About GMOs

Lauren Kirby

Dr. Jessica Mudry, Supervisor

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Abstract

Online content is changing the way the public accesses and understands science. The staggering number of often conflicting online sources about science makes it difficult for the lay public to know where to turn in search of accurate scientific information. This project will examine how the nature of online content might be affecting how the public learns about science. Through textual content analyses, it will examine the chain of communication (scientists→online media→public) and document how scientific information evolves. Okanagan Specialty Fruits' Arctic apple, a genetically modified organism (GMO) that has had the polyphenol oxidase (PPO) gene silenced, will be used as a case study. Three primary themes guide my research: the public understanding of science (PUS), the communication of risk and uncertainty, and social epistemology. The primacy of the PUS movement in public venues for science makes it an important theory for my project, while theories of risk/uncertainty and social epistemology will inform my analysis.

My results suggest that: 1) stories about science often include over and understatements of uncertainties and risks; 2) online media stories apply rhetorical frames when reporting scientific information, but the way in which framing is used appears to be reflective of whether the author wishes to persuade their audience; and 3) the rhetorical frames used by online stories about science are not typically integrated into the public's commentary in a meaningful way, supporting the notion that audiences are active rather than passive and that the public seeks out content that complements their pre-existing beliefs.

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Dedication

This Major Research Paper is dedicated to my father, Scott Kirby, who is the inspiration behind all of this. Your career as a wildlife biologist and your general love of nature taught me to be passionate about science and conservation. But it was your experiences talking to the media about complex and controversial scientific issues that highlighted the fact that this kind of research is needed. Science belongs to all of us. Therefore, we must always strive to do better in the realm of science communication and knowledge translation to ensure that scientific information is accessible to everyone.

I want to thank both you and Mom for supporting me every step of the way on this journey. Your love and support got me through.

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Introduction

Online content and media is changing the way the public accesses and engages with science. The number of (often) conflicting online sources about science-based events and stories makes it difficult for media consumers to know where to turn in search of accurate scientific information. This project will examine how the nature of online content might influence how the public learns about science. Through textual content analyses, it will examine a chain of science communication (scientists—online media—public) and document how scientific information evolves discursively. Three primary themes guide my research: the public understanding of science (PUS), the communication of risk and uncertainty, and social epistemology. I will be using GMOs as my case study because they effectively illustrate the intersection of these three concepts. GMOs are a polarising topic and have been the subject of many heated debates (Diep, 2014; Haspel, 2014; Institute of Food Technologists, 2017; Regalado, 2015). This results in a variety of journalistic and public interpretations.

To narrow my research further, I will use Okanagan Specialty Fruits' (OSF) Arctic Apple as a specific case study. Arctic Apples are special because their genetic modification has been made for aesthetic purposes. More specifically, these apples have had the polyphenol oxidase (PPO) gene silenced which is responsible for producing the phytochemicals that cause "browning" after an apple is cut or bruised. The main purpose of this genetic modification is convenience as it allows the apples to be sliced in advance and stored for later, all while maintaining their aesthetic appeal (OSF, n.d.). The fact that this product's modification is aesthetically motivated (as opposed to for nutritional or health benefits) makes it a particularly polarizing example of GMOs. The Arctic Apple is just one of many possible examples I could have chosen for this study, however, apples have a cultural significance that makes them an interesting candidate. Whether they are poisoning a princess, keeping the doctor away, or being compared to oranges, apples are steeped in metaphors and imagery in the Western world. This cultural significance means that, regardless of whether or not a person regularly consumes apples, most people will feel that the product is familiar. While the polarization surrounding GMOs coupled with the cultural relevance of apples make a compelling case study for my research, it should also be noted that this could mean Arctic Apples are not be representative of typical science news coverage or discussions.

This project will take a three-step approach. First, it will examine online media stories about Arctic Apples that refer to scientific studies for support. Second, it will examine the written conclusions of the scientific studies referenced by the online media stories. Finally, it will examine the public's interpretation of these findings through online comment sections. I will identify keywords, themes, and messages to determine how scientific information is interpreted as it moves through the chain. In addition to traditional news media outlets (ie. general news sources that cover a range of topics), I will also be considering alternatives, such as blogs and magazines. This is partly due to the fact that many traditional news outlets have recently disabled their online comments. However, given the current social and political climates, it is also quite pertinent to include these less traditional sources of information in this analysis. With the internet in the palm of everyone's hand, anyone can be a science journalist and, with the public's trust in traditional news sources rapidly dwindling, the popularity of less traditional sources of scientific information is on the rise (Pew Research Centre, 2017). The differences between these media

formats, such as their authors' qualifications, target audience, and reach, are significant and will be noted and considered in the interpretation of my results.

Literature Review

Public Understanding of Science (PUS)

PUS is the study of what is said about science, how science is used, and how scientific knowledge is communicated and received by the general public (Ziman, 1991a). The concept was first introduced to the Western world in a report from The Royal Society (1985) which states that:

Science and technology play a major role in most aspects of our daily lives both at home and at work. Our industry and thus our national prosperity depend on them. Almost all public policy issues have scientific or technological implications. Everybody, therefore, needs some understanding of science, its accomplishments and its limitations. (The Royal Society, 1985, p. 8)

The report highlights the importance of PUS to everyday life, but also demonstrates the vital role it plays in our democracy. Policy decisions that rely on science can only be truly democratic when they are guided by informed public debate (Durant, Evans & Thomas, 1989). This makes PUS even more of a concern when it comes to heavily politicized scientific issues such as GMOs. If the public does not possess accurate knowledge about GMOs, informed debate becomes impossible making how and where we get our scientific information all the more important.

Informed or not, the public debate about GMOs rages on. While this debate is certainly increasing the awareness of GMOs, it is not necessarily increasing the level of scientific knowledge about them (Shaw, 2002). Many members of the public have reported concerns about the long-term health and environmental impacts of GMOs, but feel that they need more information before they are able to establish an opinion (Knight, 2009; Shaw, 2002).

While the traditional news media does remain the public's primary source for scientific information, some members of the public are beginning to move away from it in favour of alternate online sources (Caulfield et al., 2014; Hendriks et al., 2016; Pew Research Centre, 2017). With the rise of the internet, the public now has access to a plethora of sources of scientific information. It is logical to assume that increased access to scientific information would be beneficial to the public's understanding of science. However, with the multitude of questionable and often conflicting accounts of science available online, users can become overwhelmed (Beck, 2009; Nisbet, 2010; Takahashi, Edson & Tandoc, 2016)

In addition to the overwhelming nature of online content, there is also the issue of bias. In a utopian world, science news stories would remain neutral. However, many stories will employ rhetorical framing in an attempt to sway public opinion. For example, science news stories could be framed positively, as a feat of social progress, or negatively, as a case of runaway science (Nisbet, 2010). The use of such rhetorical frames may affect how the public understands scientific issues.

The public's interaction with scientific information about GMOs is at the core of this project, making PUS a crucial theory to guide my research. With the volume of available online content, the public has access to an excessive amount of information from sources of varying credibility. This surplus of information results in conflicting, and sometimes leading, accounts of science, fueling feelings of uncertainty and perceptions of risk. Format and framing are therefore important factors that can affect the public's understanding of science. Both these factors will be considered in my interpretation and analysis of news stories and comment forums about GMOs.

Communicating Risk and Uncertainty

GMOs certainly carry with them risks and uncertainties (Beck, 2009). However, the scientific consensus seems to be that GMOs are generally safe (Health Canada, 2018; NAS, 2016). Why then does this issue remain shrouded in uncertainty for so many consumers?

A simple lack of knowledge about the scientific consensus on GMOs may be increasing the public's perception of risk and uncertainty. However, as was discussed in the previous section, the media also plays a role in shaping the narrative about GMOs. In addition to factors such as rhetorical framing, stories about science are also prone to over and understatements of risk which may also influence the public's interpretation of science. Understatements of risk and uncertainty typically occur when journalists either misinterpret the science on which they are reporting or when they are attempting to simplify science for a lay audience (Guenther & Ruhrmann, 2016). This style of reporting results in stories that are one-sided. If an issue is being debated within the scientific community, but journalists are selectively presenting only one side or the other, conflicting accounts of science emerge (Guenther & Ruhrmann, 2016; Kohl et al., 2016).

Alternatively, science stories may exaggerate risk and uncertainty. This occurs when both sides of a debate are equally represented, even when one side is not well supported by scientific evidence. Overstatements of uncertainty typically occur because journalists have been trained to get both sides of a story in order to avoid bias (Guenther & Ruhrmann, 2016). However, it can also be used as a tool to create conflict and newsworthiness. (Nisbet, 2010; Jensen & Hurley, 2012; Guenther & Ruhrmann, 2016; Kohl et al., 2016).

Perceptions of risk and uncertainty about science understandably increase when no one seems to be telling the same story and unfortunately all of this conflicting information may be

taking a toll on the public's faith in the media. Both the Pew Research Centre (2017) and the Ontario Science Centre (2017) found that a minority of science news consumers feel that the media gets the facts right when reporting on science. In times of scientific uncertainty, the public traditionally turns to the scientists themselves to seek clarification (Shaw, 2002). However, the public's faith in scientists, too, has begun to erode.

Scientists determine risk using probability (Beck, 2009). This means that science is imperfect. Scientific conclusions are sometimes contradictory or will evolve over time and this can make it difficult for the public to trust scientists to evaluate risk on their behalf (Beck, 2009; Hendriks et al., 2016). With regards to GMOs, a common argument from opponents is that there is no way for scientists to definitively know the long-term effects (Beck, 2009). While this is true, it is also the nature of science. As Ziman (1991b) states: "to believe in science is to believe in its predictive powers" (p. 159).

Although science is traditionally considered to be the best means we have to guide our decision making (Hendriks et al., 2016; Ziman, 1991a), a shift has occurred recently in public attitudes. Scientists are being undermined more frequently and their evaluations of risks are being disregarded (Beck, 2009). The dismissal of scientists by the public is indicative of a degradation of trust. With respect to GMOs, it is theorized that a surplus of food crises over the last few decades (eg. BSE, mercury in fish, carcinogenic properties of processed meat) coupled with "anti-intellectual" movements taking hold in the Western world has eroded the public's trust in the science of food safety (Blue, 2010; Takahashi et al., 2016, p. 675).

Risks and uncertainties are an inevitable component of the conversation about GMOs. What will be important to this study is examining how these risks and uncertainties are communicated by scientists and the media and, more importantly, whether or not the public believes them.

Social Epistemology

Whether or not we accept an account of science has very little to do with whether or not we understand it. Constructing knowledge is not as simple as just having access to information. The study of social epistemology demonstrates that knowledge is, in fact, affected by everything from personal ideologies, to history, to culture. This area of study first garnered momentum in the 1960's and 1970's when philosophers such as Rorty (1979) argued that we can only truly "understand knowledge when we understand the construction of belief" (p.170).

Ziman (1991b) states that scientific knowledge should be made up of facts that are accepted "without serious doubts by an overwhelming majority of competent, well-informed scientists" (p. 6). Historically, It was often assumed that when people gave incorrect answers to science questions it was because they lacked knowledge about the scientific consensus (Pasek, 2017). However, social epistemology reveals that incorrect answers to science questions are not always due to knowledge gaps, but rather can be a result of factors such as personal beliefs and values (Pasek, 2017). Individuals construct personal knowledge about science using their own social and political contexts as a framework (Pasek, 2017; Shaw, 2002; Ziman, 1991b). If a scientific finding does not fit within the individual's framework, they may choose to reject that finding. Factors such as religion, personal ideology, and partisanship can all affect how an individual constructs their personal knowledge about science (Pasek, 2017; Takahashi et al., 2016).

Studies show that certain religious groups are more likely to reject scientific knowledge about evolution. Similarly, individuals with "right-wing" political values are more likely to reject

scientific knowledge about climate change (Hart & Nisbet, 2012; Kahan, 2013; Nisbet, 2010). The same can also be seen in the case of GMOs—there are a number of public concerns that have little to do with scientific information and that are instead founded on personal values.

Some GMO opponents feel that we are "playing God" when we splice different species together; others feel the boundaries of science have been pushed too far; some simply find that GMOs are unappetizing (Knight, 2009; Marques et al., 2015; Shaw, 2002). Interestingly, these ideological concerns are not correlated with scientific knowledge about the safety of GMOs (Shaw, 2002). This is likely because concerns such as these are not centred on scientific evidence, but rather on the individual's preconceptions. An individual is not likely to accept the scientific consensus about GMOs as true if the consensus competes with their preexisting personal beliefs.

Social epistemology is valuable to this study as it will provide me with several methodological positions from which to interpret the comments, providing insight into how and why the commenting public is building their knowledge about GMOs. Of particular interest will be the ways in which social epistemology interacts with factors such as rhetorical framing and representations of risk and uncertainty.

Research Questions

My review of the literature demonstrates that the public's understanding of science may be influenced by the media's representation of science, the public's perception of risk and uncertainty, as well as epistemological factors. With this information in mind, I have designed the following research questions:

RQ1: What are the similarities and/or differences between how scientific studies and online media represent scientific risks and uncertainties?

Scientists will typically address the certainty of their conclusions by discussing the limitations of the study. For example, limited resources, time, or sample sizes could all affect the certainty of a study. However, the media is prone to over and understatements of certainty. Therefore, one aspect of my project will be to compare the representations of GMO safety in scientific articles versus online media.

RQ2: Do online media apply rhetorical frames when reporting scientific information? If so, what kind of framing is used?

When journalists report on science they will often use framing. I will examine if and how the frames applied to online stories about science attempt to persuade public opinion in a particular direction. For example, a phrase such as "GMOs solve world hunger" communicates notions of certainty, benefits, and social progress. Alternatively, a phrase such as "is Frankenfood really safe?" communicates notions of uncertainty, risk, and runaway science. **RQ3: Does the public integrate the rhetorical frames used by online stories about science into their commentary? What might this indicate to us about social epistemology?**

Social epistemology and perceptions of uncertainty and risk both influence the public's understanding of science. I will examine if and how the public integrates the narratives constructed by online media into their comments. For example, the use of the term "Frankenfood" by an online story might result in increased references to Frankenstein's monster in the comments section. However, the context in which the reference is used (eg. "Frankenstein was an abomination and so are GMOs" vs. "GMOs are misunderstood, just like Frankenstein") could be revealing as to how the public is constructing their knowledge about GMOs in response to the media's narratives.

Methods

Data Collection

In order to answer RQ1, I will search for and catalogue online media, such as online news stories, blogs, and magazine articles, that report on the Arctic Apple. I will exclude pieces that do not refer to at least one scientific study. I will then identify and catalogue the studies that are referenced in the selected online media sources. These media pieces will also be used in answering RQ2 and RQ3. For this reason, I will also exclude pieces that do not provide a comment forum.

I will primarily rely on Google as a search tool for my online media sources. For scientific studies, I will primarily rely on the Ryerson University Library Archives (RULA) and Google Scholar. Search terms include "Arctic Apples", "GMOs", "gene silencing", "PPO", and "safety". Since Arctic apples were approved for commercial sale in 2015, the time frame for my search will be from 2015 onwards.

I will examine six online media pieces along with their corresponding scientific article. I will select two pieces that are supportive of Arctic Apples, two pieces that are critical of Arctic Apples, and two pieces that are neutral/descriptive towards Arctic Apples. For the purposes of this study "neutral" does not necessarily imply that the author and/or the piece in question will not sway the public's opinion. In science writing, neutrality can be a rhetorical tool in and of itself. Appearing to be impartial may be very persuasive to audiences that value objectivity and evidence-based science. Furthermore, journalists, too, are susceptible to their own epistemological frameworks. This means that even when an author has the genuine intention to remain impartial, their own personal beliefs and values may leak into the piece. A description of

"neutral" in this study refers to pieces in which an attempt to sway public opinion is not overtly present.

Due to time constraints, it will not be feasible to code for more than one hundred comments. Therefore, a maximum of seventeen comments will be analyzed per media piece. In instances where the comment section exceeds seventeen comments, seventeen comments will be randomly selected.

Data Analysis

Guenther and Ruhrmann (2016) state that the question of whether "scientific uncertainty is over-represented, or even hyped and dramatized, can only be answered in comparison with content analyses." (p. 938). Therefore, to answer RQ1, I will perform a textual content analysis of both the scientific journal articles and the online media that report on them. I will use textual content analysis because the use of language in both these publication types is the key to determining the representation of "certainty".

I will code for the presence of a limitations section in the scientific articles. Since the limitations section is where scientists typically discuss the certainty of their results, the presence or absence of this section will be revealing as to the representation of certainty in each paper. I will also code for instances of certain vs. uncertain language in both publication types. The frequency of words that are associated with certainty or uncertainty will provide insight as to how certainty is being represented in both publication types. Examples of some of the words I will be looking for can be found in the coding manuals presented in Appendix A. Finally, I will code for the overall representation of certainty in both publication types. This will be used to examine the latent content. For example, a scientific study may imply that their data is inconsistent or vague in their results section, but may still choose to represent their inferences as

certain in their conclusion. See Tables 1.1, 1.2, 2.1, and 2.2 in Appendix A for full coding schedule and manual.

To address RQ2, I will perform a textual content analysis of the selected online media. Once again, textual content analysis is being used because the use of language will be key in determining the framing of each story. I will follow a similar methodology to that outlined by Caulfield et al. (2014). I will code for the overall tone of each piece, what risks and/or benefits are discussed, as well as for the rhetorical frames used. I will draw on Nisbet's (2010) list of the most common frames applied to science issues as a guide. See Tables 3.1 and 3.2 in Appendix A for full coding schedule and manual.

To address RQ3, I will perform a textual content analysis of the comments sections on each piece of online media using an adapted version of the Caulfield et al. (2014) method. Textual content analysis has been selected for similar reasons as are described in RQ2. I will code for tone, discussion of risks/benefits and the incorporation of rhetorical frames in each comment. I will then compare these results to those of RQ2 in order to determine the similarities or differences. See Tables 4.1 and 4.2 in Appendix A for full coding schedule and manual.

It should be noted that this project will be both inductive and deductive. While Nisbet (2010) and Caulfield et. al (2014) have provided a good base of frames and key words to look for, I will also be open to any new frames, narratives, or wording that may be revealed. An adapted list of Nisbet's (2010) list of the most common frames applied to science can be found below in Table 1.

Frame	Discusses Arctic Apples in terms of:
Social Progress (SP)	Improving quality of lifeSolution to a problem

Table 1. Adapted list of common frames applied to science issues

Economic development (ED)	 Economic investment Market benefits or risks Competitiveness
Morality/ethics (M/E)	Right vs. wrongCrossing boundaries or limits
Scientific (un)certainty (SU/C)	 What is known vs. unknown Invokes or undermines expert consensus Calls on the authority of sound science or it's falsifiability
Frankenstein's monster/Pandora's Box/Runaway Science (FM/PB/RS)	 Call for precaution in the face of possible impacts or catastrophes Runaway or out of control science
Public accountability (PA)	Public good vs. private interestsResponsible use vs. abuse of science
Middle way (MW)	• Finding a possible compromise between polarizing views
Conflict/strategy (CS)	 A game among elites Battle of personalities or groups Who is currently winning the debate

(Nisbet, 2010, p.46)

Results and Discussion

In the following section, I present the results of my research on a case by case basis. For each case, I begin by discussing the online media piece, its use of framing, and its representation of scientific (un)certainty. I then turn to the scientific article referenced by the media piece to examine how the scientists have represented the certainty of their results. Finally, I present my analysis of the comments section and explore the public's interpretation of the issue. A discussion of the results follows each case.

Case 1: The Organic Prepper

Framing.

The first of the six media pieces analyzed for this study is a post from the blog "The Organic Prepper", where author Daisy Luther writes about "preparedness [for disasters and emergencies], health, frugality, and food". The tone of this blog post is critical, which is apparent from the title alone which reads "GMO Apples Hit American Stores This Month: How and Why to Avoid Them". The piece goes on to state that Arctic Apples should be avoided, refers to them as "tampered with", and suggests that it is becoming increasingly difficult for consumers to know "what the heck we're buying" (Luther, 2017, para. 4). The author evokes three of Nisbet's (2010) rhetorical frames: M/E, FM/PB/RS, and PA. M/E is demonstrated when Luther (2017) refers to Arctic apples as "fruity bullets" that need to be "dodged"(para. 5). Likening the apples to bullets evokes images of crime or war and suggests that the creation of these apples is not only wrong, but dangerous.

FM/PB/RS can be seen when Luther (2017) refers to the Arctic apple as "Frankenfruit" (para. 8). This pun is a blatant reference to Frankenstein's monster, implying that the apples are unnatural and potentially harmful. This frame can also be seen more subtly when the words

"what the heck" are repeatedly used seemingly to emphasize the ridiculousness of the Arctic Apple. For example, the author uses the subhead "What the heck did they do to these GMO apples?" before delving into the explanation of how gene silencing works. This use of language again suggests that the author feels that gene silencing is unnatural and possibly out of control. Finally, PA is seen when Luther (2017) suggests that Okanagan Specialty Fruits values profit over safety. She states "when biotech steps in, it's profit over people" (Luther, 2017, para. 21).

Luther (2017) discusses two main risks: that Article Apples are detrimental to human health and to society. She believes the process of gene silencing has reduced the nutritional value of Arctic Apples and compares them to Styrofoam. She also implies that our obsession with convenience is making us lazy. One of the purposes of non-browning Arctic Apples is that they can be purchased pre-sliced, which motivates the author to state that she is taking a "deep sigh for humanity that can't slice an apple" (Luther, 2017, para. 18). The coding data for this section can be seen below, in Table 2.

 Table2. Case 1: Media Framing

Case #	Date	Publication type	Tone	Rhetorical Frame	Risks/Benefits
1	2/3/17	Δ	12	06 05 03	21.28

Representation risk and uncertainty.

Luther (2017) references one scientific study to support her claims about the decreased nutritional value of Arctic Apples. High certainty discourse is primarily used when describing the results of the referenced scientific study. For example, she states that "...*they discovered* that polyphenols and flavonoids *are responsible* for many of the health benefits associated with apples (emphasis added)" (Luther, 2017, para. 17).

One instance of low certainty discourse is noted when Luther (2017) recognizes that the "research was backed by fruit growers in the apple industry" (para 20). This demonstrates that she recognizes possible biases in the referenced study. However, the blog represents the study as conclusive overall, stating that it is indicative of "why [Article Apples are] not a good thing" (Luther, 2017, para. 16). Upon analyzing the study referenced by Luther, I was interested to see that the study does not examine Arctic Apples nor gene silencing, but rather explores the relationship between phytochemicals (the component of an apple that causes browning) and disease prevention (Eberhardt, Lee, & Liu, 2000). Specifically, the study analyzes the antioxidant activity of fresh apples and how this might relate to the prevention of certain cancers. A limitations sections is not included in this study, nor do the authors make any mention of their funding source.

High and low certainty discourse are used fairly equally throughout this study. For example, the authors use high certainty discourse when they state "*we show* that... whole-apple extracts inhibit the growth of colon- and liver cancer cells... (emphasis added)" (Eberhardt, Lee, & Liu, 2000, p. 903). The authors go on to state "almost all of the antioxidant activity in apples *must be* due to phytochemicals (emphasis added)" (Eberhardt, Lee, & Liu, 2000, p. 904). Contrastly, low certainty discourse is used when they write "*we suggest* that this strong inhibition of tumour-cell proliferation in vitro *could be* due to apples' combination of phytochemicals (emphasis added)" (Eberhardt, Lee, & Liu, 2000, 904) and when they state "phytochemicals in apples...*seem* significantly to enhance their antioxidant properties (emphasis added)" (Eberhardt, Lee, & Liu, 2000, 904). Overall, the results of the study are hedged, but represented as conclusive. The coding data for this section can be seen below in Tables 3 and 4 **Table 3.** Case 1: Media representation of certainty

Case #	Date	Publication type	# referenced scientific studies	High certainty discourse	Low certainty discourse	Representation of certainty
1	2/3/17	4	1	3	1	11

Table 4. Case 1: Scientific study representation of certainty

G "		Discussion of	High certainty	Low certainty	Representation of
Case #	Date	minitations	uiscouise		certainty
1	2012	2	4	5	11

Comments.

The blog post has a total of thirty-two comments, seventeen of which are analyzed for this study. All of the comments are, like the blog post, critical of Arctic Apples. One commenter writes "I will be watching for these apples and will make a point not to purchase" (LaurieJDaniel, 2017). Another commented "As for willingly eating anything genetically modified??? Heck NO" (Kate, 2017). Only one comment is not overtly critical, stating:

Well, I always slice my apples and leave them to turn brown before I eat them... now I can leave them to not turn brown. I always take a bite out of an apple and set it away to take another bite tomorrow... so this is great news that I don't have to worry that it will turn brown because I stupidly didn't consume it as I prepared it... science is wonderful, yes???? (countyguard, 2017).

However, it is likely that this comment is meant as sarcasm and therefore is interpreted as critical.¹

Nine of the analyzed comments do not appear to incorporate any frames. Seven comments incorporate one or more of the three frames used in the blog post: six comments

¹ While sarcasm and tone are beyond the scope of this project, the way in which the public uses these devices when discussing scientific findings is a worthwhile avenue of study for future projects

incorporate PA; five incorporate FM.PB/RS; and four incorporate M/E. For example, one commenter wrote "I'm worried that the polyphenol silencing could be contagious... I seriously doubt if the whorprit monsters even tested for that possibility. Another diabolical attack vector against the innocent." (M.L.Clayton, 2017). FM/PB/RS is demonstrated here through the fear of potential contagiousness, indicating that the commenter is worried that the creators of the apples are not fully in control of the science. PA is evoked with the use of the pun "whorprit" (likely a word play on the words "whore" and "corporate"), implying that the creators of the apple have sold themselves for financial gain. Finally, M/E is demonstrated by the phrase "diabolical attack vector against the innocent" as it suggests that Okanagan Specialty Fruits' actions are inherently evil, while the public are inherently innocent.

Six comments discuss one or both of the two risks discussed in the blog post (detriments to human health and society). For example, one comment evokes both these risks by stating "...why are they making it so hard just to live a safe, normal life?" (Lisa, 2017). Nine of the seventeen comments do not refer to any specific risks or benefits and two comments discuss the detriments Arctic Apples might have on the environment. The coding data for this section can be seen below, in Table 5.

Case #	Incident	Tone	Fone Framing discourse Risks/	
1	1	12	-1	-1
1	2	12	-1	21
1	3	12	-1	-1
1	4	12	-1	-1
1	5	12	05	21
1	6	12	-1	-1
1	7	12	-1	-1

 Table 5. Case 1: Comments

1	8	12	-1	-1
1	9	12	01	28
1	10	12	-1	21
1	11	12	-1	-1
1	12	12	06	21, 27
1	13	12	06, 05, 03	-1
1	14	12	06, 05, 03	21, 23
1	15	12	03, 05	23
1	16	12	06	-1
1	17	12	05, 06, 03	21

Discussion

This case demonstrates both similarities and differences between how scientists communicate risk and uncertainty and how the media does. Both the blog post and the scientific article represent the certainty of the study as conclusive overall. However, Luther (2017) almost exclusively uses high certainty discourse while Eberhardt, Lee, and Liu (2000) use some low certainty discourse to hedge their results.

More significant is the differences between how risk is represented in the two formats. Eberhardt, Lee, and Liu (2000) discuss only the benefits of phytochemicals and at no point discuss the risks of silencing the PPO gene. However, despite this, Luther (2017) uses the study to draw conclusions about the safety of Arctic Apples that are not substantiated by the findings. In this case, Luther (2017) has understated uncertainty and overstated risk. As was discussed in the literature review, understatements of uncertainty typically occur when authors either misinterpret the science on which they are reporting or when they are attempting to simplify science for a lay audience. I suspect that in this particular case, Luther (2017) may have simply misunderstood the science leading to the assumption that silencing the PPO gene would result in decreased nutritional value.

Furthermore, it is clear that Luther (2017) uses rhetorical framing throughout her piece. These frames seem to be used very intentionally in an attempt to lead public opinion about Arctic Apples in a critical and disapproving direction. It is clear that Luther (2017) is strongly opposed to the Arctic Apple's commercialization and wishes for her audience to share her views.

The comments in this case indicate that the public may be somewhat influenced by the way Luther (2017) frames the issue of Arctic Apples. The fact that 100% of the comments follow the same tone as the blog could indicate that Luther's (2017) opinion of Arctic Apples acted as an epistemological influence on her audience. However, only 41% of the comments used similar framing and only 35% discussed the same risks as the blog. Furthermore, only one instance was noted where specific language from the blog was taken up and repeated in the comment sections (specifically, Luther's use of the words "what the heck"). This might indicate that the blog did not influence the readers' opinions of Arctic Apples, but rather that the readers had pre-existing critical opinions and therefore sought out a critical blog.

As was discussed in the literature review, individuals will often reject information that does not fit within their epistemological framework. It is logical to assume, then, that individuals would prefer to seek out information that complements their pre-existing beliefs—and, in fact, it has been theorized that audiences do exactly that (Katz, Blumler & Gurevitch, 1973). This type of self affirming behaviour may account for the extremely homogeneous tone of the comment section in this case—readers who already felt critical towards Arctic Apples may have been more likely accept the piece, while readers who were already supportive of the apples may not have been willing to read past the title.

Case 2: Mercola

Framing.

The second media piece analyzed for this study is from the website Mercola.com, which is self-described as "a reliable source of health articles, optimal wellness products, medical news, and free natural newsletters from natural health expert Dr. Joseph Mercola". This article is critical of the Arctic Apple, although not quite as blatantly as the piece from The Organic Prepper.

The piece begins with a neutral title, which reads "GMO Apples Arriving at Grocery Stores". The body of the piece starts with an almost supportive tone, stating "that this is the first Genetically modified organism (GMO) designed to have a perceived benefit for consumers" (Mercola, 2017, para. 2). Mercola (2017) also includes statistics about the high volume of food wastage that occurs due to apples turning brown as well as a quote from OSF's CEO, Neal Carter, who discusses the benefits of Arctic Apples.

However, the tone of the piece begins to shift gradually. Mercola (2017) argues that "there are some variables that don't appear to be particularly well thought out" (para 9) and suggests that the risk of contamination increases the more a food is processed. From here, Mercola continues to become more and more critical of Arctic Apples, implying that there could be "unintended consequences" (para 13). Mercola (2017) wraps things up by warning that Arctic Apples are a health risk for a variety of reasons and provides advice both on how to avoid GMOs and how to keep your apples white without "resorting to a GMO" (para 19).

Three primary frames appear in this article: FM/PB/RS, PA, and CS. FM/PB/RS is used when Mercola (2017) refers to the unintended consequences of the Arctic Apple. He quotes the executive director of Food & Water Watch who states: "it's not only an unnecessary product, but

the risks have not been fully examined ... Regulators have glossed over the possible unintentional effects of this technology" (para. 14). Mercola demonstrates here his concern that this is a case of runaway science, the ramifications of which are unpredictable and possibly hazardous.

PA can be seen in the article's emphasis on labelling (or lack thereof). Finally, CS is apparent in this article as Mercola (2017) attempts to showcase both sides of the debate. He presents quotes and statistics that work both in favour and against Arctic Apples. However, he often uses data and quotes that work against Arctic Apples as a tool to discredit those that support them. While this approach does showcase both arguments, it also makes it clear which side of the debate Mercola believes is winning.

In terms of risks and benefits, Mercola (2017) discusses a wide range. This is likely a result of the CS approach he took. Early on in the article, benefits to both human health and society are touched on. However, as the article progresses, a multitude of risks are discussed including possible detriments to human health, the environment, the economy, and society. For example, Mercola (2017) implies that Arctic Apples are nutritionally subpar to their conventional counterparts; that they create more packaging waste than conventional apples; that they are a "risky wager" (para.12) economically; and that OSF is not being transparent enough with their labelling. The coding data for this section can be seen below in Table 6.

Table 6.	Case	2:	Media	framing	

Case #	Date	Publication type	Tone	Rhetorical Frame	Risks/Benefits
2	11/21/17	9	12	05, 06, 07	21, 22, 25, 27, 28

Representation of risk and uncertainty.

Mercola (2017) refers to one scientific study to backup his claim that silencing the PPO gene reduces the nutritional value of apples. High certainty discourse is primarily used when describing the results of this study. He states "apples with higher levels of phenolic compounds *are best* for your health but also tend to brown faster than apples with lower levels (emphasis added)" (para. 18). One instance of low certainty discourse can be seen in reference to the study when Mercola (2017) states: "One study *suggested* that among the apple varieties studied, Fuji is the best for fresh consumption because of its higher phenolic content at harvest time (emphasis added)" (para. 18).

Upon reading the referenced study, I was surprised to see that the piece opened with the following statement: "Enzymatic browning is one of the most important reactions that occur in fruits and vegetables, usually resulting in *negative effects* on color, taste, flavor, and *nutritional value* (emphasis added)." (Holderbaum, Kon, Kudo & Guerra, 2010). This statement indicates immediately that the authors of the study believe that the browning process can actually *reduce* the nutritional quality of the apple, which seems to be in direct contrast to statements made by Mercola when citing this study.

The study uses almost exclusively high certainty discourse, making statements such as: The *significant* positive correlations *found* in the present work between total phenolic compounds (chlorogenic acid + epicatechin + procyanidin B2) and the enzymatic browning in all cultivars *evidenced* the influence of such compounds on the browning potential in these apple cultivars (emphasis added)" (Holderbaum et. al, p. 1154)

Overall, the study is represented as certain. However, the message it is sending is quite different from Mercola's. While Mercola's claim that the study suggests that "Fuji is the best for fresh consumption because of its higher phenolic content at harvest time" (para 18) is technically

correct, his subsequent claim that this means these apples are inherently healthier is not accurate. What Holderbaum et. al (2010) actually state is:

As a result of the high antioxidant activity of polyphenols, which have shown beneficial effects for human health (Heim et al., 2002), varieties with high polyphenol content are interesting for fresh consumption, whereas low enzymatic browning potential is relevant for apple processing (Podsedek et al., 2000) as a way to avoid the formation of off-flavor and maintain the original pulp color and nutritional value for a longer period of time

(p.1150)

In its full context, we see that there appear to be benefits to apples with both high and low browning potential—namely, that the antioxidants associated with high polyphenol levels are associated with some health benefits, while low polyphenols help to maintain flavour, color, *and nutritional value*. The coding data for this section can be seen below in Tables 7 and 8.

 Table 7. Case 2: Media representation of certainty

Case #	Date	Publication type	# referenced scientific studies	High certainty discourse	Low certainty discourse	Representation of certainty
2	11/21/17	9	1	3	1	11

Table 8. Case 2: Scientific study representation of certainty

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		Discussion of	High certainty	Low certainty	Representation of
Case #	Date	limitations	discourse	discourse	certainty
2	2010	2	15	2	11

Comments.

Twenty five comments appear on this article, seventeen of which are analyzed for this study. Like the article, fifteen of the seventeen comments are critical towards Arctic Apples. For example, one commenter writes:

So why do we HAVE to cut our apples up? We need to use our teeth to bite into an apple and chew it very well. Lack of chewing causes the skull to collapse. This is what is causing sleep disorders, orthodontic problems and oral facial pain... (joymoeller, 2017). The remaining two comments are neutral towards Arctic Apples.

Six of the seventeen comments evoke either or both the frames of FM/PB/RS and PA, both of which are also prominent in the article. For example, one commenter uses both frames, writing:

Just because they can. This is why we now have gmo apples. Not because we need them. Not because the world will be a better place with them. Not because they are more nutritious. Not because they are more hardy for the farmers to grow. We have them only because the technology exists to make them and someone thought their novelty might make them rich... (Krofter, 2017)

This comment suggests that the commenter feels the boundaries of science are being pushed too far and also that private financial interests are being put above all else. None of the comments use the third frame present in the article, CS, while three commenters use the M/E frame, and ten do not use any frame.

As was previously discussed, the article mentions a multitude of risks and benefits associated with the Arctic Apple. However, the comments tend to focus on risks to human health (five comments) and society (four comments). For example, one comment reads:

BOYCOTT! That is what I am doing. Apples are/were one of my favorite fruits, especially in the fall. I will not buy them now. My money, my health. Who is to say how long those sliced apples in a bag that do not turn brown have been on the shelf. NO, not for me. (MyLucky10, 2017)

This comment demonstrates that the writer is concerned for the impact Arctic Apples could have on human health, specifically calling into question one's ability to know if the apples have gone bad. Seven of the seventeen comments do not discuss any specific risks or benefits. The coding data for this section can be seen below in Table 9.

Case #	Incident	Tone	Framing discourse	Risks/Benefits
2	1	12	06	-1
2	2	12	-1	21
2	3	12	-1	21
2	4	12	03	27
2	5	12	-1	-1
2	6	12	03, 06	23
2	7	13	06	-1
2	8	12	-1	-1
2	9	13	05	-1
2	10	12	-1	21
2	11	12	-1	-1
2	12	12	-1	27
2	13	12	-1	21
2	14	12	-1	27
2	15	12	-1	21
2	16	12	05,06	27
2	17	12	06	-1

Table 9. Case 2: Comments

Discussion

This case provides an interesting example of a metaphorical "game of telephone". The issue here is less about how Mercola (2017) represented the certainty of the study and more about the fact that he seems to have generally misrepresented the findings. Considering that
Mercola is a medical doctor and the fact that the opening sentence of Holderbaum et. al's (2010) study states that the apple browning process actually decreases nutritional value, it is difficult to assume that Mercola accidentally misrepresented the data.

Mercola (2017) uses a skewed representation of science to make major overstatements of risk. As discussed in the literature review, overstatements of certainty and risk can be due to a variety of reasons such as misinterpretation, oversimplification, attempting to remain unbiased, or a desire to create a more interesting narrative. Mercola's motivation for misrepresenting risk in his piece is not abundantly clear as it does not seem to fall under any of the above explanations. One possibility is that Mercola is simply trying to cater to his persona as a proponent of "natural" and homeopathic medicine, which he might feel conflicts with the idea of genetically modified foods. This case has also clearly used rhetorical framing. Like the previous case, Mercola (2017) seems to use these frames to foster negative opinions about Arctic Apples. Despite early attempts at appearing unbiased, it is clear by the end of the piece that Mercola (2017) is strongly opposed to the Arctic Apple and encourages his audience to feel the same.

Once again, the comments in this case indicate that the public may be somewhat influenced by how the piece was framed. 88% of the comments followed the same tone as Mercola's (2017) piece which might indicate that the piece did act as an epistemological influence on the audience. However, the specific rhetorical frames and risks discussed in the piece did not seem to have much influence on the comments in terms of their content. Although the most common frame in the comments (PA) was also a prominent frame in the piece, the way in which it was used in the comments was quite different. Mercola (2017) tended to focus on transparency and labelling, while the public tended to focus more on the idea that agribusinesses are more interested in money than safety. Similar to the previous case, this might indicate that

the readers were already against Arctic Apples for their own personal reasons and that Mercola's interpretation of the issue did little to guide their commentary.

Case 3: Growing Produce

Framing.

The third media piece analyzed for this study is from GrowingProduce.com which describes itself as an industry resource for "the latest news and trends in the fruit, vegetable, and citrus sectors". The tone of this piece is neutral. All statements about the Arctic Apple appear to simply be made with the intention of informing readers that the Food and Drug Administration (FDA) has concluded that the apples are safe for consumption. The title follows this neutral tone, matter-of-factly reading "FDA Concludes GMO Crops Innate Potato And Arctic Apple Are Safe For Consumption" (Growing Produce, 2015). In the body of the article, I did not note any instances where the writers blatantly attempt to sway public opinion about Arctic Apples in any particular direction. For example, the writers state "the agency concluded the apples and potatoes are as safe and nutritious as their conventional counterparts" (Growing Produce, 2015, para. 2) and "the FDA has no additional food safety questions concerning food from these plant varieties" (Growing Produce, 2015, para. 8). The writers seem to take care to always clarify that the information they are reporting comes directly from the FDA (rather than from them) and at no point do they include commentary on the FDA's findings.

The piece did not use any obvious framing. The only point at which there seemed to be any framing tactics used was in a poll included halfway through the article. The poll read "True or False? Eventually, all crops will be genetically modified" and provided an opportunity to vote and view the results (which were split 50/50). It is quite possible that the writers only wished to incite user engagement with this poll. However, it could also be viewed as an example of

FM/PB/RS in that it sows the idea that genetically modified crops are an inevitability and that there is little we can do to prevent them.

Continuing the trend of neutrality, the piece does not overtly discuss any risks or benefits associated with Arctic Apples. While the authors do state that the fruit "are genetically engineered to resist browning associated with cuts and bruises" (Growing Produce, 2015, para. 3), they do not make any suggestions as to whether this is a good or a bad thing. The article also makes it clear that the FDA's review found no risks associated with the apples, but this citation is presented observationally (Growing Produce, 2015). The coding data for this section can be seen below, in Table 10.

 Table 10. Case 3: Media Framing

Case #	Date	Publication type	Tone	Rhetorical Frame	Risks/Benefits
3	3/20/15	9	13	-1	-1

Representation of risk and uncertainty.

Growing Produce (2015) references the FDA's² review of the Arctic Apple throughout their piece. They essentially use direct quotes from the FDA (2015), all of which use high certainty discourse. For example, they state "The agency *concluded* the apples and potatoes *are as* safe and nutritious as their conventional counterparts (emphasis added)." (para. 2).

Considering that Growing Produce (2015) quotes the FDA (2015) almost directly, the language and level of certainty used is almost identical to that used by the FDA. For example, the FDA (2015) states that they "*concluded* that these foods *are as* safe and nutritious as their conventional counterparts (emphasis added)" (para. 1) and that they have "*no additional food*

 $^{^{2}}$ For the purpose of this study, reviews performed by regulatory agencies such as the FDA and Health Canada will be treated as scientific studies as they follow a similar procedure to a scholarly literature review.

safety questions at this time concerning food from these plant varieties (emphasis added)" (para.

7). I did not find any instances where quotations used by Growing Produce were taken out of context or manipulated to alter the meaning or intent. The coding data for this section can be seen below in Tables 11 and 12.

Case #	Date	Publication type	# referenced scientific studies	High certainty discourse	Low certainty discourse	Representation of certainty
3	3/20/15	9	1	3	0	11

Table 11. Case 3: Media representation of certainty

Table 12. Case 3: Scientific study representation of certainty

Case #	Date	Discussion of limitations	High certainty discourse	Low certainty discourse	Representation of certainty
3	2015	2	2	0	11

Comments.

A total of nine comments appear on this article, all of which were analyzed for this study. The comments are split quite evenly in terms of tone: four being supportive, four critical, and one neutral. For example, one critical commenter wrote "WHY ARE OUR CHILDREN SO SICK AND MANY AUTISTIC YES YOU GUESSED IT GMO, ROUND UP POISON. HEY BY 2025 HALF OUR CHILDREN IN THE USA WILL BE THIS WAY" (Gary Reid, 2015) While another countered him, writing:

Nonsense! Autism is not caused by a GMO foods! I suppose every advance in science has had their share of "the sky is falling" opponents. I'm not willing to vilify this technology on the word of panicky people who have read an article or two on the internet and now consider themselves authorities on the subject! (Ellen, 2015) Despite the almost non-existent use of framing in the original piece, almost all of Nisbet's frames appear in the comments: two use SP, one uses ED, two use M/E, two use SU/C, two use FM/PB/RS, three use PA, and three use CS. Only one comment did not evoke any frames. For example, one commenter evokes several frames with the comment:

This is good news... The numerous websites generated by people who are looking for scapegoats (Autism, allergies, for example) for problems that have affected people for the sake of stifling technology and advances made in Science, grow tiresome... Yields have improved. Quality has improved, and genetically engineered products will help that to continue... There is a world to feed... Not everyone is as fortunate to be living in a part of the world, where food shortages are relatively rare to non-existent, or has the time to complain about the abundant and safe food supply. (Philip, 2015)

First, CS is seen when the commenter notes both sides of the debate, stating that the anti-GMO side is growing "tiresome", and when they note the privilege that is associate with being able to complain about one's food. Second, SP is evoked when the commenter suggests that GMOs can help solve problems such as starvation. Finally, the frame of ED is present when the commenter claims that GMO food can help to improve the quality and yield of crops.

In contrast, another commenter writes "how can food laced with 2-4D & Glyphosate be safe to eat? They are not. The 6 major [agribusiness] companies...account for more than 76% of all private R&D. Now, that's really letting the fox watch the henhouse" (Vincent P. Colandrea Sr, 2015). Here, the comparison of major agribusiness to "devils from hell" demonstrates the frame of M/E, implying that agribusiness is inherently evil. They then go on to state that we are "letting the fox watch the henhouse", evoking the PA frame in the implication that these agribusinesses will exploit the public for their own gains.

As has been demonstrated in the commentary already showcased above, the risks and benefits discussed in the comment section are also extremely varied. Although four comments do not reference any specific risks or benefits, five of the nine comments mention in some combination the possible benefits and/or detriments to human health, the economy, the environment, and society. The coding data for this section can be seen below, in Table 13.

1 1 1

Case #	Incident	Tone	Framing discourse	Risks/Benefits
3	1	12	05	21
3	2	13	-1	-1
3	3	12	04, 06	21, 27
3	4	12	06	-1
3	5	11	01, 02, 07	22, 24, 26, 28
3	6	11	07	-1
3	7	11	01, 02, 07	22, 24, 26, 28
3	8	12	03, 06	21, 23, 25, 27
3	9	11	04	-1

 Table 13. Case 3: Comments

Discussion.

This neutral case is a stark contrast to the two critical cases previously examined. In this example, the representation of risk and uncertainty remains consistent as scientific information passes through the first link in the chain of communication (scientist→media). While it could be argued that Growing Produce's article is one-sided in that it does not present any countering arguments to the FDA's approval of the apples, it could also be argued that this is how the piece avoids misrepresentations of risk or uncertainty. As discussed in the literature review, misrepresentations of risk and uncertainty can occur when both sides of a debate are equally

represented, even when one side is not well supported by scientific evidence. Growing Produce avoids this by choosing not to include countering opinions to the FDA's findings.

In this case, framing is not overtly used by the authors. Growing Produce (2015) does not seem to have any interest in shifting or guiding opinions about Arctic Apples. Interestingly, this lack of rhetorical frames or discussion of risks/benefits appears to have led to somewhat of a "free-for-all" in the comments. Unlike in the two critical cases—where the tone of the comments are very much in line with the tone of the piece—a fairly even distribution of critical and supportive tones is seen in the comment section. Similarly, the commenters' discussion of risks and benefits is extremely varied.

Keeping in line with the possibility that readers seek out media that validate their preexisting opinions, these results could indicate that media pieces that take a neutral tone attract readers of varying beliefs. As was discussed in the literature review, people may reject information that does not fit into to their pre-existing epistemological frameworks. Since Growing Produce (2015) left the implications of the FDA's findings open to interpretation, readers would have been able to interpret the piece in a way that fit their framework, possibly leading to fewer readers rejecting the piece. This may have resulted in a more diverse group of people reading to the end of the article and ultimately leaving a comment.

Case 4: Smithsonian Magazine

Framing.

The fourth media piece examined for this study is from Smithsonian Magazine, an online magazine that "look[s] at the topics and subject matters researched, studied and exhibited by the Smithsonian Institution—science, history, art, popular culture and innovation—and chronicl[es] them every day for [their] diverse readership". The tone of this piece leans slightly towards

supportive, but overall appears to be neutral. The piece begins with a neutral title reading "The First Non-Browning GMO Apples Slated to Hit Shelves Next Month" (Lewis, 2017).

The body of the article remains mostly impartial, reporting information primarily in an observational way. However, there are a few instances where the author does seem to stray into a supportive tone. For example, Lewis (2017) writes "Once the skin of the apple is broken or bruised, the enzyme goes to work, oxidizing the sweet flesh and turning it brown to the dissatisfaction of many a child" (para. 2). Whether intentional or not, the imagery of sweet, unoxidized flesh juxtaposed with brown, dissatisfying flesh certainly could be considered an attempt to sway public opinion in favour of the non-browning Arctic Apple.

Lewis (2017) also states "Though many people are weary about GMOs, scientists have yet to find evidence that genetically modified foods are actively harmful. But concerns still remain among some growers and GMO opponents" (para 9). Although not much information is provided with regards to what exactly the anti-GMO argument entails, Lewis (2017) is careful here to maintain his neutral tone by mentioning both sides of the debate.

Despite the piece being fairly neutral overall, some frames can still be seen throughout the piece. Most prominent are SP, ED, and CS. SP can be seen when Lewis (2017) writes "there are all kinds of remedies to keep sliced apples from browning: a spritz of lemon, salt and water, even honey and water. But a new apple in town could make that concern a thing of the past" (para. 1). This statement suggests that the Arctic Apple provides a solution to a problem namely, preventing apples from turning brown. However, the mention of simple and natural ways to prevent oxidation keeps the framing fairly neutral by making it clear that the problem already has several perfectly fine solutions.

ED is used with the statement "the company also hopes that the Arctic apples will help reduce food waste from consumers and markets." (Lewis, 2017, para 5). This demonstrates how the apples can help both growers and consumers reduce their losses due to food spoilage. Again, the frame is somewhat neutralized because the author makes it clear that this is simply the company's hope, not a guarantee. Finally, CS can be seen at the end of the piece when Lewis (2017) briefly touches on the ongoing debate between scientists and anti-GMO proponents. As was previously mentioned, Lewis (2017) does present both sides, but backs up the pro-GMO side with a scientific citation while providing no information about the concerns of the anti-GMO side.

Risks and benefits are not discussed in much detail in this piece. Lewis (2017) briefly discusses some potential benefits to society and to the economy when he mentions that the Arctic apple could help reduce losses due to spoilage and when he states that they will make apple oxidation "a thing of the past", but does not discuss any specific risks. The coding data for this section can be found below, in Table 14.

Table 14	Case 4:	Media	Framing
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Case #	Date	Publication type	Tone	Rhetorical Frame	Risks/Benefits
4	1/23/17	3	13	01, 02, 07	26, 28

Representation of risk and uncertainty.

Lewis (2017) references one scientific study—a major literature review performed by the National Academies of Sciences, Engineering and Medicine (NAS). This study is used to support the statement that "scientists have yet find evidence that genetically modified foods are actively harmful" (Lewis, 2017, para 9). This quote is the only mention of the study in the article and

Lewis (2017) does seem to present the study as certain overall. However the use of the words "yet" and "actively" do hedge the statement slightly.

The NAS's (2015) review is a comprehensive literature review of the data on genetically engineered crops. At over six hundred pages, it was not feasible to code and analyze the review in its entirety. Therefore, for the purpose of this study, coding efforts are focused on the executive summary, summary, and conclusion sections of the report.

The most notable issue with Lewis's (2017) interpretation of the NAS's (2015) report is that he applies their findings to the case of Arctic Apples despite the fact that NAS (2015) explicitly states that there was little information available on traits such as non-browning at the time of the report's writing. They state that their data was heavily limited to herbicide and insecticide resistant GMOs and that non-browning apples "had been incorporated into some crops in commercial production in 2015, but... were produced on a relatively small number of hectares worldwide" (NAS, 2015, p. 7). They go on to state that "claims about the effects of existing GE crops frequently assume that the effects of [herbicide and insecticide resistant traits] apply to potential effects of the genetic engineering process generally; however, different traits probably have different effects" (p. 9).

The NAS's (2015) report is extremely hedged and frequently makes use of low certainty discourse. For example, they state that while they "found no conclusive evidence of cause-and-effect relationships between GE crops and environmental problems... the complex nature of assessing long-term environmental changes often made it *difficult to reach definitive conclusions* (emphasis added)" (NAS, 2015, p. 15). They also report that "no differences have been found that implicate a higher risk to human health safety... " but that "the committee *states this finding very carefully*, acknowledging that any new food—GE or non-GE—may have some subtle

favorable or adverse health effects *that are not detected even with careful scrutiny* and that *health effects can develop over time* (emphasis added)" (NAS, 2015, p. 19).

While the NAS (2015) does not include a limitations section perse, they do frequently discuss what the limitations of the review are. Specific limitations mentioned include data availability, geographic restrictions, and source biases. However, despite these limitations and the extreme use of hedging, the NAS does seem to represent their study as conclusive overall, stating:

While recognizing the inherent difficulty of detecting subtle or long-term effects in health or the environment, the study committee *found no substantiated* evidence of a difference in risks to human health between currently commercialized genetically engineered (GE) crops and conventionally bred crops, *nor did it find conclusive* cause-and-effect evidence of environmental problems from the GE crops (emphasis added). (NAS, 2016, p.1). The coding data for this section can be found below in Tables 15 and 16.

Case #	Date	Publication type	# referenced scientific studies	High certainty discourse	Low certainty discourse	Representation of certainty
4	1/23/17	3	1	1	0	11

Table 15. Case 4: Media representation of certainty

Table 16. Case 4: Scientific study representation of certainty

Case #	Date	Discussion of limitations	High certainty discourse	Low certainty discourse	Representation of certainty
4	2015	1	13	16	11

Comments.

The comment section on this piece was quite substantial, with over three hundred comments. However, upon examination it became apparent that the vast majority of the comments were driven by a troll using the username "alex". This individual replies to almost every comment posted on the piece and consistently manages to steer the conversation away from Arctic Apples. For this reason, the seventeen comments selected for this case are not as random in their selection as for other cases because a large number of comments have been rejected due to their irrelevance.

Thirteen of the seventeen comments are critical towards Arctic apples. For example, one comment reads "It's a Trojan horse product to prove "GMOs are yummy" AVOID!" (grinningliber, 2017). Only two comments are positive. For example, one supportive commenter writes "Thanks for the information. You forgot an important point, how does it taste?" (Mary Landrum, 2017).

The frames most prominently featured in the article do not have much of a presence in the comment section—only two comments feature ED. However, unlike the article, these comments imply that Arctic Apples would be damaging to the market rather than beneficial. For example one of the comments reads "it can and will hurt the apple industry in more ways than one. :(" (S.G., 2017). Other frames present in the comment section include PA (six comments), FM/PB/RS (four comments), ME (two comments), and SU/C (two comments).

Six of the seventeen comments discuss neither risks nor benefits. However, when risks are discussed, the most common is the risk to human health (six comments). One commenter states "many health care organizations are recognizing that severe unexplained symptoms that are being reported by their patients get better when GMOs are removed from their diet." (Duncan DeBunkerman, 2017). Other risks discussed in the comments include detriments to society (three

comments), the environment (two comments), and the economy (two comments). The coding data for this section can be seen below, in Table 17.

Case #	Incident	Tone	Framing discourse	Risks/Benefits
4	1	12	06	27
4	2	12	02	25, 27
4	3	13	-1	-1
4	4	12	05	21
4	5	12	03, 05, 06	21, 23,
4	6	12	03, 06	27
4	7	11	-1	-1
4	8	11	-1	-1
4	9	12	06	-1
4	10	12	04, 05, 06	21
4	11	12	02	25
4	12	13	-1	-1
4	13	12	05	21
4	14	12	04	21, 23
4	15	12	-1	-1
4	16	12	06	21
4	17	12	-1	27

Table 17. Case 4: Comments

Discussion.

Despite differences in tone, this case is somewhat similar to the Organic Prepper case in terms of the representation of risk and uncertainty. Like the Organic Prepper case, this case demonstrates both similarities and differences between how scientists communicate risk and uncertainty and how the media does. While Lewis (2017) seems to get the representation of certainty right when representing the NAS's findings (hedged, but certain overall), he uses the

study to make suggestions about the safety of Arctic Apples that are not substantiated by the findings. The NAS makes it clear that their findings cannot necessarily be applied to traits other than herbicide and insecticide resistance, yet Lewis (2017) seems to do exactly that. This results in an understatement of risk. As was discussed in the literature review, understatements of uncertainty typically occur when authors either misinterpret the science on which they are reporting or when they are attempting to simplify science for a lay audience. As with Luther (2017), I suspect that this is the case with Lewis (2017). It is likely that Lewis either misunderstood or oversimplified the science leading to the assumption that the NAS's (2015) conclusions could be applied to the Arctic Apple.

Lewis (2017) indeed uses some rhetorical framing in his piece. However, I do not believe that these frames are used intentionally to persuade public opinion. It appears to me that Lewis (2017) wishes to present the topic as neutrally as possible but strays into slightly supportive rhetorical frames at times, possibly in an attempt to make his writing more eloquent and interesting. It is also possible that Lewis is reinforcing his own epistemological position through his writing. As was previously discussed, authors are also susceptible to their own epistemological frameworks. Therefore, if Lewis personally supports the scientific consensus about GMOs, then this may have influenced his writing.

Given that in the Growing Produce case (also neutral in tone) I saw a diverse range of opinions and discussions in the comments, it is somewhat surprising that 76% of the comments in this case are negative. It could be argued that the fact that the piece did not always remain perfectly neutral might account for the lack of diversity in the comment sections. But, based on what was seen in Cases 1 and 2, if that were the case I would expect that the comments would be predominantly supportive since that was the tone Lewis (2017) tended to stray into.

As was discussed in Cases 1 and 2, individuals may prefer to consume online content that complements their pre-existing beliefs. Also, as was seen in case 3, when presented with content that is open to interpretation, individuals may choose to consume content in a way that validates their pre-existing beliefs. One possible explanation for the critical comments in this case could be that individuals may also deliberately choose to consume content that *contradicts* their pre-existing beliefs—not because they wish to change their beliefs, but as a means to reaffirm them. In fact, one commenter states that she only read the article "to find out which apple to AVOID" (Holly Holst Gamel Masri, 2017) which suggests that she is simply using the article to reinforce her pre-existing beliefs. This self-inflicted reverse psychology may account for the surplus of critical comments on Lewis' (2017) piece.

Case 5: Ottawa Citizen

The fifth media piece analyzed for this study is from the Ottawa Citizen, an online newspaper owned by Postmedia Network (a Conservative Party affiliate) which describes itself as "a trusted source for news and entertainment that helps make sense and meaning of a complex world... [that] is dedicated to inform, enlighten and entertain, while remaining relevant to both readers and advertisers alike". The tone of the piece appears to be an attempt at neutrality. However, whether intentional or not, it does come off as primarily supportive.

The article begins with the title "From tree to table: The Arctic Apple is ready to blossom" (Robin, 2016). The imagery used in this title sets a positive tone immediately. The use of the phrase "from tree to table" draws parallels with the farm to table movement; typically associated with the idea of natural, fresh and local ingredients. Furthermore, the use of the blossom metaphor seems to associate the Arctic Apple further with the concepts of nature as well as birth or purity. This positive imagery extends into the body of the piece as well. For example, Robin's (2016) opening paragraphs reads:

Neal Carter takes two identical-looking apples and bashes them together, hard. Half an hour later, he cuts into them. One has a large brown bruise, while the other remains snowy white inside. Meet the Arctic Apple, a made-in-Canada apple that has been genetically modified so it doesn't brown. (para. 1-2)

The description of the Arctic apple as "snowy white"—another possible allusion to purity contrasts sharply with the description of the "large brown bruise" on the conventional apple. Additionally, Robin (2016) seems to personify the apple with the use of the phrase "meet the Arctic Apple", almost likening the fruit to meeting a new friend.

Despite the overall supportive tone, Robin (2016) does also present some critical viewpoints from both the Canadian Biotechnology Action Group (CBAN) and the U.S. Center for Food Safety (CFS). However, in the case of CBAN, Robin (2016) is quick to point out that their opposition to the Arctic Apple is "not because they believe it to be unsafe or unhealthy" (para 19) but rather because they believe it should be labelled. However, a quick search of the CBAN's (n.d.) website reveals that they do in fact question the safety of the apple and also have concerns about possible cross contamination with organic orchards.

The most prominent frame in Robin's (2016) piece is CS. The article bounces back and forth between the opinions of groups and individuals on opposite sides of the debate. However, as was demonstrated above, when the author inserts negative viewpoints, they are typically followed up with commentary that lessens their impact (which is suggestive as to which side of the debate the author stands with). Another example of this is when Robin (2016) quotes Chris Hall, the owner of an apple market, introducing him by stating "he's on the fence about the issue of genetic modification". However, the selected quote from Hall goes on to read "it's so new we really don't know, but I trust the system of testing. People smarter than me are in charge of it. I think maybe the failure is communicating properly with consumers". This quote implies more that Hall doesn't feel he fully understands the science behind the apples, not that he is wary of them.

SU/C is also fairly prominent in the piece, with Robin (2016) emphasizing the arduous process the apples have gone through to ensure their success and safety. She writes:

After several years of research, in which a Canadian biologist figured out a way to turn off the enzyme that makes apples turn brown, a decade of tests, and government approvals in the U.S. and Canada last year, the Arctic Apple is about to take off. (para. 7)

Finally, the FM/PB/RS frame appears near the end of the piece when Robin (2016) states that "the idea of masking an apple's age and freshness has caused some to dub it 'the Botox apple" (para 25).

The article presents several possible risks and benefits including detriments to human health and society, as well as benefits to the economy and society. For example, Robin (2016) presents possible risks to human health when she states that USF fears that silencing the PPO gene could result in the consumption of spoiled apples. Possible benefits to society are presented when she quotes Neal Carter's statement that Arctic apples will be more convenient for consumers. The coding data for this section can be seen below in Table 18.

Case #	Date	Publication type	Tone	Rhetorical Frame	Risks/Benefits
5	1/22/16	2	11	02, 04, 05, 06, 07	26, 21, 27. 28

Representation of risk and uncertainty.

Robin (2016) quotes Health Canada's³ review of OSF's data using high certainty discourse. She writes "Health Canada *gave it the green light*, saying *it's "safe* for consumption, *still has all* its nutritional value and therefore *does not differ* from other apples available on the market." (emphasis added)" (para. 18).

The quote referenced above was taken from a summary of Health Canada's (2015a) review of Arctic Apples, which can be found on the Health Canada website. The quote does not appear to be out of context, nor has the meaning been manipulated. Like the quote used in Robin's (2016) piece, Health Canada's (2015a) summary uses exclusively high certainty discourse. For example they write "Health Canada also *concluded* that the Arctic apple *would have no impact* on allergies, and that *there are no differences* in the nutritional value of the Arctic apple compared to other traditional apple varieties available for consumption (emphasis added)" (para. 4). However, it is interesting to note that Health Canada's (2015b) full report on Arctic apples does present some of this information slightly differently than in their summary. For example, they write:

"The nutrient composition of Arctic Apple events GD743 and GS784 have been shown to be *similar* to conventional apples. Of all the analytes measured, only the vitamin C and phenolic levels in the GD743 and GS784 apples *were significantly different* (higher) as compared to controls." (para. 14)

Despite this slight difference in language use, Health Canada's (2015b) full report does still present their conclusions as certain overall stating "Health Canada is of the opinion that food derived from Arctic Apple events GD743 and GS784 is as safe and nutritious as food from

³ For the purposes of this study, reviews performed by regulatory agencies such as the FDA and Health Canada will be treated as scientific studies as they follow a similar procedure to a scholarly literature review.

current commercial apple varieties" (para. 23). The coding data for this section can be seen

below, in Tables 19 and 20.

				~		
Case #	Date	Publication type	# referenced scientific studies	High certainty discourse	Low certainty discourse	Representation of certainty
5	1/22/16	2	1	3	0	11

Table 19. Case 5: Media representation of certainty

Table 20. Case 5: Scientific stud	dy representation of certainty
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Case #	Date	Discussion of limitations	High certainty discourse	Low certainty discourse	Representation of certainty
5	2015	2	7	4	11

Comments.

Forty six comments appear on this article, seventeen of which are analyzed for this study. Ten of the seventeen comments are critical towards Arctic Apples, four are supportive, and three are neutral. For example, one critical comment reads:

Label it! I buy less and less from grocery stores. The bio-food industry has undermined confidence in our food supply. Personally I'm not interested in genetically modified foods. Everyone should have the right to decide for themselves if they want to consume GMO/non GMO (Sandra Harris, 2016)

Contrastly, one supportive commenter wrote "Another discussion about 'Frankenfood'... a term proudly coined by Greenpeace, on whose doorstep one can lay the responsibility for countless deaths in their implacable stance against GMOs... " (Ryan Lengsfeld, 2016)

Unlike the piece, the most common frame incorporated into the seventeen comments is PA (six comments). Many commentators call for the apples to be labelled and suggest that money is being valued over safety. For example, one commenter writes "These people will turn the planet into a toxic waste dump, walk away with cash from the people they have killed, so they can float their yachts on the waters they have killed" (Wendy Francisco, 2016).

The next most common frame is SU/C (four comments), which was also prominent in the article. However, while some comments mirror Robin's (2016) confidence in the system, others contradict it. For example, Eric Stephen (2016) wrote "… knowing the stringent standards and testing requirements that new food products such as these are held to, I have every confidence in the assessments and the decisions that have been made", while Ted Miner (2016) states "there have been no studies that show long term consumption of these GMO apples is safe for humans. we need to see some real science before we gamble with our families health". Other frames present in the comment section include M/E (two comments), and FM/PB/RS (one comment). Six comments did not incorporated any obvious frames.

Nine of the seventeen comments did not discuss any specific risks or benefits of Arctic Apples. Detriments to human health and to society were the most common risks discussed (three comments each). Two comments discussed detriments to the environment, and one comment discussed benefits to human health. The coding data for this section can be seen below, in Table 21.

Case #	Incident	Tone	Framing discourse	Risks/Benefits
5	1	12	03	-1
5	2	12	06	27
5	3	12	04, 06	27
5	4	12	04, 06	21, 27
5	5	12	03	-1
5	6	13	-1	-1
5	7	11	-1	-1

Table 21. Case 5: Comments

5	8	13	-1	-1
5	9	12	-1	-1
5	10	12	06	21, 23
5	11	11	05	22
5	12	12	06	21, 23
5	13	12	-1	21
5	14	11	04	-1
5	15	11	06	-1
5	16	12	04	-1
5	17	11	-1	-1

Discussion.

This case provides a more complex example of how the representation of uncertainty and risk can become skewed as it passes from scientists to the media . Similar to Case 3, when Robin (2016) directly discusses Health Canada's findings, she maintains their original representation of uncertainty and risk. However, unlike Case 3, Robin (2016) also chooses to discuss conflicting accounts of the Arctic Apple's safety (though she does seem to support Health Canada's stance overall).

As discussed in the literature review, misrepresentations of risk and uncertainty can occur when both sides of a debate are equally represented, even when one side is not well supported by scientific evidence, and this is typically done in an effort to appear unbiased or to make a story "newsworthy". I suspect that Robin (2016) may be taking the "newsworthy" approach. Her use of rhetorical framing suggests that we should have faith in the stringent testing done by both OSF and Health Canada, and yet she nonchalantly includes viewpoints that contradict this. It's possible that this is merely an attempt at getting both sides of the story, however the tone in which the two sides are presented leads me to believe that this is, in fact, an attempt at creating conflict within the story to make the narrative more exciting to readers. I feel it is also likely that Robin's (2016) personal stance on GMOs (which I suspect is supportive) has influenced her framing of the issue to an extent. Ultimately, this results in an overstatement of uncertainty and risk.

Despite Robin's (2016) overall supportive tone, 59% of the comments are critical of Arctic Apples. This could be another example of readers deliberately choosing to consume content that contradicts their beliefs in an effort to actually reaffirm them. However, given the small margin by which critical comments dominate and considering that Robin (2016) does represent a variety of different viewpoints, it's also possible that many readers simply missed her supportive tone and interpreted the article as neutral. If this is the case, we may in fact be seeing a similar situation to that of Case 3, where readers are able to interpret the piece in a way that fits into their epistemological framework, resulting in a more varied comment section.

Case 6: Slate Magazine

Framing.

The final media piece analyzed for this study is from Slate Magazine, which describes itself as "a general-interest publication offering analysis and commentary about politics, news, business, technology, and culture". The tone of this piece is supportive, at times aggressively so. An interesting approach is taken in this piece that sets it apart from other pieces analyzed for this study—rather than showing support for the Arctic Apple by discussing its benefits, the piece works to discredit those who oppose it. Specifically, Miller and Senapathy (2015) take aim at Dr. Oz, who has openly criticized Arctic Apples on his television show.

The title, "Low-Hanging Fruit: Dr. Oz sows seeds of mistrust on genetic engineering", sets the tone immediately. The use of the phrase "low-hanging fruit" could be indicative of the

authors' belief that Dr. Oz is an easy target. Alternatively, it could also be implying that Dr. Oz's viewers are gullible and easily duped. Either way, the title kicks off the critique of Dr. Oz's viewpoint. Though the attack on Dr. Oz does make up the vast majority of the piece, we do see some commentary that directly supports Arctic Apples. For example Miller and Senapathy (2015) write "the reason the Arctic Apple doesn't discolor involves ingenious but simple biology" (para. 2). This quote demonstrates that the authors believe that apples are a well designed and useful product.

Miller and Senapathy's (2015) primary strategy of attacking opponents of the Arctic Apple does not fit into any of Nisbet's (2010) rhetorical frames. Therefore, I have dubbed this rhetorical frame "Scoffing". The authors frequently make disparaging comments about Oz, referring to him as a quack, a proponent of pseudoscience, and implying that he lacks a basic understanding of science, and they use this to support the idea that Arctic Apples are safe. Essentially, Miller and Senapathy (2015) seem to believe that the fact that Dr. Oz thinks these apples are dangerous is inherent proof that they are not.

Also present is the M/E frame. Miller and Senapathy (2015) seem to feel that opponents of the Arctic Apple, as well as the regulatory agencies that eventually approved it, have behaved unethically. For example, they state "the proposed commercialization of this new variety was met with unconscionable, irresponsible, and lengthy regulatory delays" (para. 3) and that "now that this remarkable fruit has jumped through the required regulatory hoops, Dr. Oz and other fear-mongers are trying to elicit totally unwarranted consumer apprehension about it" (para. 4). Less prominent in the article are the SP and SU/C frames.

Since the authors choose to focus their efforts on Dr. Oz, there is not much mention of the risks or benefits of the apples themselves. There is some mention of benefits to society when

Miller and Senapathy (2015) state "the new molecular techniques for accomplishing this are far more precise, predictable, and conservative than older, unregulated techniques for genetic improvement" (para 19), implying that GMOs may in fact be safer than their conventional counterparts. Benefits to the economy are also briefly touched upon when the authors use a quote from Neal Carter to imply that the Arctic apples will result in higher apple sales. The coding data for this section can be seen below, in Table 22.

 Table 22. Case 6: Media Framing

Case #	Date	Publication type	Tone	Rhetorical Frame	Risks/Benefits
6	4/10/15	3	11	01, 03, 04, 08 (scoffing)	26, 28

Representations of risk and uncertainty.

Two references are made to scientific studies in this piece. The first is made when Miller and Senapathy (2015) counter one of Oz's guests who claimed silencing the PPO gene could inadvertently turn off other genes. They write "Testing has shown that it doesn't, and that the Arctic apple is indistinguishable from its unmodified cohorts..." (para 13). Unfortunately, here they cite a broken link. Due to this, it is not possible to perform a comparative content analysis of this statement with the source material.

The second reference to a scientific study occurs when Miller and Senapathy (2015) move to discredit another one of Oz's guests, Zen Honeycutt, described as the "founder of the anti-genetic engineering organization Moms Across America" (para. 8). According to the article, one of Honeycutt's main criticisms of GMOs (presumably including the Arctic Apple) is that they are often used in conjunction with the herbicide glyphosate, which Honeycutt believes is linked to autism (Miller & Senapathy, 2015). To counter this, Miller and Senapathy (2015) cite the New York State Integrated Pest Management's (NYSIPM) list of Environmental Impact Quotients (EIQ), a data set calculated using the formula put forward by Kovach, Petzoldt, Degni, and Tette (1992) to measure the environmental impacts of different pesticides. Using high certainty discourse, Miller and Senapathy (2015) state "glyphosate *has lower overall* health impacts than white vinegar (aka the chemical acetic acid) when used as a herbicide" (para. 9).

At this point, it is important to recognize that Arctic Apples have not been engineered to be herbicide resistant, thus making these arguments about glyphosate essentially moot. However, since Miller and Senapathy (2015) seem to be using this argument to support their discrediting of Oz, and subsequently their support of the Arctic Apple, it seems pertinent to include it in this content analysis.

Kovach et al. (1992) devised an equation to calculate the environmental impact of over 120 pesticides. Pre-existing data is inputted into the equation in order to calculate a given pesticide's ecological impact, its impact on farm workers and on consumers. These calculation are then used to generate an environmental impact quotient, or EIQ, for the pesticide. However, calculating a pesticide's EIQ is only the first step in determining how harmful it is. In their paper, Kovach et. al (1992) state very clearly that the EIQ is representative of the *active ingredient only* and does not take into consideration factors such as the percent of active ingredient in a formulated product, nor the dosage required for the pesticide to be effective. They assert that "field comparisons should not be made with [the EIQ]" (para. 4) and that field comparisons can only be made once a secondary calculation is performed that takes these additional factors into account. That is to say, a pesticide that has a higher EIQ does not necessarily make it more harmful than a pesticide with a lower EIQ. Kovach et. al (1992) use primarily high certainty discourse throughout their study, but they are careful to explain the limitations of what EIQ can be used for.

The most notable misrepresentation of Kovach et. al's (1992) work is the fact that Miller and Senapathy (2015) appear to be using the EIQ data to make direct comparisons between the health impacts of acetic acid and glyphosate. While it's true that the EIQ data does indicate that pure acetic acid is more harmful to farm workers than pure glyphosate is, no data is provided as to which pesticide is more harmful once it has been formulated for commercial use. Furthermore, Miller and Senapathy's (2015) referral to acetic acid as "white vinegar" (para. 9) is also fairly misleading as this terminology likely makes the average reader think of household vinegar, a common kitchen staple. However, household vinegar is typically no more than 5% acetic acid, compared to the 10-20% typically found in an herbicide (Smith-Fiola & Gill, 2014). At 11% concentration, acetic acid becomes corrosive enough to "burn the skin and cause severe eye injury, including blindness" (Smith-Fiola & Gill, 2014, p.4)—side effects that are, of course, not typical of household vinegar. The coding data for this section can be seen below in Tables 23 and 24

abic	23. Case 0	. Micula lepi	esentation of cert	unity		
Case #	Date	Publication type	# referenced scientific studies	High certainty discourse	Low certainty discourse	Representation of certainty
6	4/10/15	3	2	2	0	11

 Table 23
 Case 6: Media representation of certainty

 Table 24. Case 6: Scientific study representation of certainty

Case #	Date	Discussion of limitations	High certainty discourse	Low certainty discourse	Representation of certainty
6	1992	1	6	1	11

Comments.

Three hundred and forty comments are present on this piece, seventeen of which are

coded and analyzed. Nine of the seventeen comments are critical towards arctic apples, six are

supportive, and two are neutral. For example, one critical commenter writes "Senapathy works for a genomics company, and Miller worked for the FDA... And they're claiming Oz has a conflict of interest? I used to respect Slate--but this one-sided gibberish is highly disappointing..." (CEV12, 2015), while one supportive commenter writes "very good article. Thank you... SHEESH. seriously, there's conventional hybridizing every year that's more alarming than this." (nerdpocalypse, 2015).

Like the article, Scoffing has a strong presence in the comments section as well, with ten of the seventeen comments using this frame. This frame was present amongst supportive, critical and even neutral comments. For example, Lizncats (2015) writes "Hasn't Dr. Oz been thoroughly discredited at this point? What fools even pay attention to what he says anymore?", while wlthaya (2015) writes ""the fallacy that there is some sort of 'right to know."" Ha, spoken like a true "scientist.""

Eight of the seventeen comments do not discuss a specific risk or benefit associated with Arctic Apples. However, when they are discussed, the most common are detriments to human health and to society. For example, one commenter discusses both these risks, writing:

The angry authors have a problem with woman who questioned glyphosate? Is that the same glyphosate the WHO recently said "probably causes cancer?" And the same one found in mother's breast milk? Silly woman! And, regardless of whether or not these authors truly believe GMOs to be harmless, people should have the right to know how their food is being grown and processed so they can decide whether to eat it or not. This is still a free country, isn't it? (liveandletlice, 2015)

Also discussed are detriments to the environment (one comment) and benefits to the economy (one comment). The coding data for this section can be seen below, in Table 25.

Case #	Incident	Tone	Framing discourse	Risks/Benefits
6	1	12	03, 05, 06	21
6	2	11	04	26
6	3	12	06	27
6	4	12	04, 06, 08 (scoffing)	21, 27
6	5	12	03, 05	21
6	6	12	06, 08 (scoffing)	21, 27
6	7	11	08 (scoffing)	-1
6	8	12	05, 06	23
6	9	13	-1	-1
6	10	11	08 (scoffing)	-1
6	11	12	04, 05, 06, 08 (scoffing)	21, 27
6	12	11	08 (scoffing)	-1
6	13	13	03, 06, 08 (scoffing)	-1
6	14	12	06, 08 (scoffing)	27
6	15	11	-1	-1
6	16	12	06, 08 (scoffing)	-1
6	17	11	08 (scoffing)	-1

 Table 25. Case 6: Comments

Discussion.

Miller and Senapathy's (2015) article provides another example of major differences between how scientists communicate risks and uncertainties and how the media does. Similar to Case 4, a misapplication of the study seems to be occurring here. Miller and Senapathy (2015) dedicate several paragraphs to the discussion of Honeycutt and glyphosate despite the fact that Arctic Apples are not an herbicide resistant GMO, which is typically what glyphosate is used in conjunction with. Because the products are unrelated, arguments about the safety of glyphosate are not relevant to the safety of Arctic Apples.

It is possible that Miller and Senapathy's (2015) focus on glyphosate is simply an attempt to point out Dr. Oz's and his guests' past fallacies in order to prove that their views on Arctic Apples can be disregarded. However, even if that is the case, it is somewhat misleading to present the lay public with arguments about glyphosate in an article about Arctic Apples and expect them to understand that the two cases are unrelated. This has resulted in an understatement of uncertainty and risk.

Furthermore, Miller and Senapathy also misrepresent the study's findings. As was described in the previous section, the assertion that glyphosate is less dangerous than acetic acid when used as an herbicide is not substantiated by the cited data. Additionally, referring to acetic acid as "white vinegar" also appears to be a deliberate attempt to mislead the public. It could be argued that Miller and Senapathy (2015) misunderstood the data and the study which they were citing, but considering that Miller is a former employee of the FDA with known ties to Monsanto (the company behind the herbicide Roundup, whose active ingredient is glyphosate), this seems unlikely. Once again, Miller and Senapathy (2015) have understated both uncertainty and risk.

An interesting use of rhetorical framing is present in this piece. Rather than focusing their article on the risks and benefits of the Arctic Apple, the authors choose to discredit Dr. Oz. If nothing else, this strategy seems to influence the commentary more than any other case. 59% of the comments analyzed incorporate the frame of Scoffing, which is by far the highest instance of a recurring frame in the comment section across all six cases.

Furthermore, while there were instances in the other five cases where the most prominent frames, risks and benefits from the piece were also prominent in the comments, the *way* in which

the public discussed these things did not appear to be influenced by the authors. For example, as was seen in Case 2, despite the most common frame in the comments (PA) also being a prominent frame in the piece, the way in which it was used in the comments was quite different, with Mercola (2017) focusing on transparency and the public focusing on private interest over public safety. However, in this case, the comments appear to be made in direct support or opposition to Miller and Senapathy's (2015) piece. Commenters evoking the Scoffing frame did so either to join the authors in their attacks on Oz or to turn the tables and attack Miller and Senapathy themselves. Similarly, Miller and Senapathy's (2015) statement that consumers do not have the right to know if the products they are purchasing are genetically modified is directly and heavily countered in the comments.

The fact that so many comments seem to be directly influenced by the way Miller and Senapathy (2015) framed their piece could indicate that this is an instance in which the media is in fact influencing how the public thinks about scientific issues. While this piece did not seem to actually alter the readers pre-existing beliefs (the comments were, after all, primarily critical) it did seem to influence the way in which they expressed those beliefs. Perhaps Miller and Senapathy's (2015) unabashedly aggressive approach roused more emotional responses from the public, which could account for why this seems to be the only case that actually influences the public's commentary.

Conclusion

Given the small data sample, time constraints, and limited resources of this study, it is difficult to make any conclusive statements about my findings. It is also important to note that, since this study did not conduct interviews, I must rely on the pre-existing literature to make assumptions about how and why scientists, reporters and the public talk about science. With this in mind, I present the following possible conclusions:

RQ1: What are the similarities and/or differences between how scientific articles and online media represent scientific risks and uncertainties?

This study primarily reveals the *differences* between how scientists and the media represent risks and uncertainties. My findings suggest that stories about science often include over and understatements of uncertainties and risks, and that these misrepresentations may often be a result of misunderstanding and oversimplifications on the part of reporters. These occurrences could likely be reduced if media organizations make an effort to ensure that their reporters receive adequate scientific literacy training. However, in the case of independent bloggers and in the more insidious case of *deliberate* misrepresentations of science, this solution would not be feasible. Therefore, more research is needed as to how we can better educate the public to find and critically evaluate reliable sources of scientific information.

RQ2: Do online media apply rhetorical frames when reporting scientific information? If so, what kind of framing is used?

My findings suggest that online media stories do apply rhetorical frames when reporting scientific information. The kind of framing used and the way in which it is used varies and appears to be reflective of whether the author wishes to persuade their audience, and, if so, in which direction they wish to persuade. In pieces that are overtly critical or supportive, framing

seems to be used very deliberately and with the intention of leading public opinion. Contrastly, in more neutral pieces, framing is still present but appears to be used more as a tool to create an interesting and eloquent story.

RQ3: Does the public integrate the rhetorical frames used by online stories about science into their commentary? What might this indicate to us about social epistemology?

My findings suggest that, in general, the rhetorical frames used by online stories about science are not typically integrated into the public's commentary in a meaningful way. This supports the notion that audiences are active rather than passive (Katz et al., 1973) and that—rather than online content influencing the public's opinions—the public is seeking out content that complements their pre-existing beliefs. My findings indicate that online content may not be a powerful enough epistemological influence to alter the way individuals learn and talk about GMOs. It appears that when the public consumes online content about GMOs, they show up with a preconceived set of beliefs that are firmly established and not easily shaken.

Overall, there was a trend towards unsupportive comments regarding GMOs. As was discussed in the literature review, one possible explanation for this could be the current trend towards "anti-intellectual" movements in the Western world resulting in more people rejecting the scientific consensus about GMO safety. More research is needed in two primary directions. First, practical research is needed regarding user demographics in order to gain a better understanding of the relationship between a user's comment and factors such as age, socio-economics, education, gender, etc. Second, more theoretical research is needed to better understand what these comments can tell us about the epistemological process of making knowledge among various demographics and which factors (eg. politics, religion, etc.) are influential in the inception of beliefs about GMOs.

Appendix A: Coding Schedules and Manuals

Table 1.1 Coding schedule 1 (scientific studies representation of certainty)

Case #	Date	Discussion of limitations	High certainty discourse	Low certainty discourse	Representation of certainty

 Table 1.2 Coding manual 1 (scientific studies representation of certainty)

Discussion of Limitations	Low Certainty Discourse
01. Present	Record number of instances (-1 if
02. Absent	none). Examples:
09. Other	• Uncertain
	• Questionable
High Certainty Discourse	• Unsure
Record number of instances (-1 if	• Doubtful
none). Examples:	• Refutable
• Certain	• Unclear
• Unquestionable	• Unreliable
• Definite	• Inconsistent
• Undeniable	• Unknown
• Irrefutable	• Vague
• Confident	
Satisfied	Representation of Certainty
• Determined	Overall, the scientists represent their
• Established	results as:
• Reliable	11. Conclusive
	12. Inconclusive
	99. Other

Case #	Date	Publication type	High certainty discourse	Low certainty discourse	Representation of certainty

Table 2.1 Coding schedule 2 (online media representation of certainty)

 Table 2.2 Coding manual 2 (online media representation of certainty)

Publication Type:	Low Certainty Discourse
1. National news story	Record number of instances (-1 if
2. Local news story	none). See Figure 1.2 for examples
3. Magazine article	
4. Blog	Representation of Certainty
9. Other	Overall, the author represents science
	about GMOs as:
High Certainty Discourse	11. Conclusive
Record number of instances (-1 if	12. Inconclusive
none). See Figure 1.2 for examples	99. Other

Case #	Date	Publication type	Tone	Rhetorical Frame	Risks/Benefits

 Table 3.1 Coding schedule 3 (online media use of framing)

Table 3.2 Coding manual 3 (online media use of framing)

Publication 7

- 1. National news story
- 2. Local news story
- 3. Magazine article
- 4. Blog
- 9. Other

Framing

Code for all that apply, -1 if none (see Table 1 for definitions):

01. Social progress

- 02. Economic development
- 03. Morality/ethics
- 04. Scientific (un)certainty
- 05. Frankenstein's monster
- 06. Public accountability
- 07. Conflict strategy
- 09. Other

The overall tone of the piece is:

- 11. Supportive of GMOs
- 12. Critical of GMOs
- 13. Neutral/descriptive
- 19. Other

Risks/Benefits Discussed

Code for all that are applicable, - 1 if none:

- 21. Detrimental to human health
- 22. Beneficial to human health
- 23. Detrimental to the environment
- 24. Beneficial to the environment
- 25. Detrimental to the economy
- 26. Beneficial to the economy
- 27. Detrimental to society
- 28. Beneficial to society
- 99. Other

Tone

 Table 4.1 Coding schedule 4 (comment forums)

Case #	Incident	Tone	Frame	Risks/Benefits

Table 4.2 Coding manual 4 (comment forums)

Tone

The tone of the rhetoric used is:

- 11. Supportive of GMOs
- 12. Critical of GMOs
- 13. Neutral
- 19. Other

Frame

Code for all that apply. The discourse incorporates the frame of: (see Table 1 for definitions):

- 01. Social progress
- 02. Economic development
- 03. Morality/ethics
- 04. Scientific (un)certainty
- 05. Frankenstein's monster
- 06. Public accountability

- 07. Conflict strategy
- 08. Other

Risks/Benefits Discussed

Code for all that are applicable:

- 21. Detrimental to human health
- 22. Beneficial to human health
- 23. Detrimental to the environment
- 24. Beneficial to the environment
- 25. Detrimental to the economy
- 26. Beneficial to the economy
- 27. Detrimental to society
- 28. Beneficial to society
- 99. Other
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